Idenfication of Food Security Regions in North Karnataka: A Spatial Study

Naik Rohit[1], Dr. L.T. Nayak[2]
[1]*Research Scholar, Department of Geography, Karnatak University Dharwad*
[2]*Professor, Department of Geography, Karnatak University Dharwad*

***Abstract*—This paper investigates food security in northern part of Karnataka (13 districts) over the period of 2011-2021. For this we have used "food balance sheet and Zscore" methods. The result suggests that the food security of the region has grown over the period e.g the average Production of food grains (kg per head per annum) was 335.15 in 2011 which rose to 472.42 which is 40.94 percentage. Not only food production had gone up Yield of food grains, irrigated area and milk production. Though result indicates the growth in over all food security, still there are certain districts which has huge gap between indicators like Raichur had average Production of food grains (kg per head per annum) was 1052.5 in 2021 but Bidar had only 84. This was enormous or steep gap between two districts. There are some districts in region e.g., Bidar, Kalaburagi and Koppal these districts have shown below average growth compare to remaining districts. This is what article is about, what is food security of region and its distribution.**

***Index Terms*—Availability, Accessibility, Fod security, Hunger, Stability, Utilization and Zscore**

I. INTRODUCTION

Food is one of the essential human needs, akin to air and water. It is a human right, and everyone should have access to it without discrimination. Sufficient and balanced food intake is crucial for basic human growth, development, and the maintenance of health throughout life. However, it is a well-known fact that people are deprived of sufficient intake of required nutrients due to wide regional variations in food availability. Food security is currently one of the most important global issues. The first goal of the Millennium Development Goal (MDG) from 2000 to 2015 aimed to "eradicate extreme poverty and hunger," and the second aim of the Sustainable Development Goal (SDG) is "Zero Hunger." The term 'food security' was defined at the 1974 World Food Conference with an emphasis on supply.

In 2022, the Global Hunger Index ranked India 101th out of 116 countries. According to the United Nations, nearly 200 million people in India are undernourished, constituting a quarter of the world's undernourished population. Additionally, approximately 43 per cent of children in India suffer from chronic undernourishment.

Climate change has a profound impact on natural resources (water and land) used in agricultural production, making it a critical issue for agriculture and food security. It is one of the most pressing challenges facing humanity. According to the FAO (2016), both biophysical and social vulnerabilities determine the net impact of climate change on food security. As temperatures rise, the yields of food and cash crops in South Asia are expected to decline, putting pressure on food security in the region. India, with a population of 1.4 billion, is ranked 101 out of 116 countries in the Global Hunger Index, highlighting a serious problem. Scientists and researchers project that a 2.5 to 4.9 degrees Celsius increase in temperature across the country could lead to a decrease of 41 per cent to 52 per cent in wheat yield and 32 per cent to 40 per cent in rice. Classic ethnographies from various parts of the world note the connections between food availability and sociability, emphasizing the importance of ritual hospitality and distribution in times of scarcity. More specialized psychological anthropological studies have presented seasonal hunger as a motivation for behaviour (Du Bois 1941; Holmberg 1950) related to food choices and eating styles, including ordinary abstemiousness and ritual gorging (DN Shack 1969, W. Shack 1971). In addition, socioeconomic studies have explored the linkages between seasonality and the sexual division of labour in agriculture and in

child care arrangements (White, Burton, and Dow 1981; Burton and White 1984).

Study Area

North Karnataka is situated in the northern part of the Karnataka state, covering an area of 98,652 square kilometres. The study area extends between 13° 21' North to 18° 25' North Latitude and 74° 08' East to 77° 42' East Longitude. It is bordered on the North-West by Goa state, on the North by Maharashtra state, on the North-east by Telangana state, on the east and south-east by Andhra Pradesh, and on the south by Chitradurga, Davanagere, Shimoga, and Udupi districts. The western part is bordered by the Arabian Sea (Fig.1). Administratively, the North Karnataka Region is divided into two divisions: Gulbarga (Hyderabad or Kalyan Karnataka) and Belgaum (Bombay Karnataka). It comprises 13 districts (out of the total 30 districts in Karnataka), namely Bagalkot, Belagavi, Bellary, Bidar, Dharwad, Gadag, Haveri, Kalaburagi, Koppal, Raichur, Uttara Kannada, Vijayapura, and Yadgiri, with 80 taluks. The study area has a population of 26,116,177, contributing 42.75 per cent of the state population.

Among the 13 districts in the study area, Belgaum district is the largest in terms of area, covering 13,415 sq. km, while Dharwad is the smallest district with an area of 4,260 sq. km. The study region encompasses 351 hobalies (745) and 9,571 villages (29,736). Geographically, the region is referred to as North Karnataka (unofficially known as Karu Nadu).

II. LOCATION OF NORTH KARNATAKA

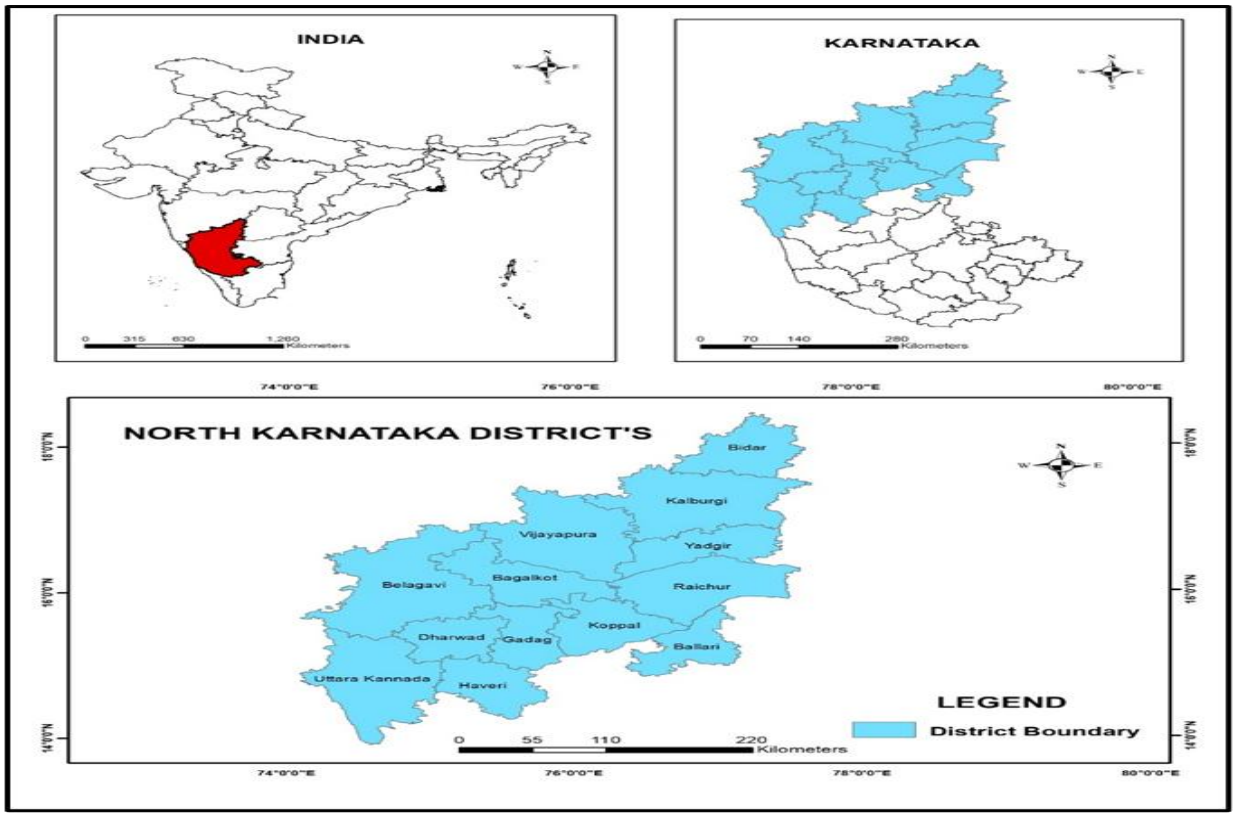


Fig: 1

Objectives of the study

The primary objectives of the present study are:

- To identify food security regions by considering the interplay of four components of food security, namely food availability, food accessibility, food utilization, and food stability based on food balance sheet and Z score, utilizing a standardized technique.

- To evaluate the spatial pattern of food availability, food accessibility, food utilization, and food stability, thereby determining food security in North Karnataka.
- To examine the interrelationship between the interplay of four components of food security in the study region.
- To analyse the various factors contributing to the emergence and growth of food insecurity regions in the study area.
- To suggest measures for the improvement of food security in the study area.

Hypothesis:

To strengthen the objectives of the study following hypotheses have been formulated and tested with the help of techniques.

- There is a direct relationship between livestock population and agriculture; the greater the proportion of land dedicated to farming, the higher the livestock population tends to be.
- Districts with irrigation facilities show food sufficiency, while districts with less or no irrigation facilities indicate food insecurity.
- There is direct relationship among Fair price shops, Employment and per capita. The more the income, people will less likely to fall under poverty category

Review of Literature

The literature on climate change and food security highlights significant challenges across various regions and agricultural systems. Aditi Srivastava et al. (2010) analysed the vulnerability of sorghum production in India, finding that climate change disproportionately impacts winter crops in central and south-central zones, emphasizing the need for adaptive strategies. Ajay K. Singh (2015) explored the influence of carbon emissions on global food security, introducing a Global Food Security Index (GFSI) that highlights disparities across income groups.

Several studies focus on India, such as those by Chandrashekhar Konda (2018) and Malancha Chakrabarty (2016), who both underscore the complexity of climate change's impact on India's food security, advocating for sustainable agricultural practices and urban food security measures. Cynthia Rosenzweig (1994) and Husen Yesuf Sirba (2022) extend this analysis globally, noting that developing regions, particularly in Africa, are more vulnerable to climate change's effects on food supply.

Ecilia Tacoli et al. (2013) and Muhammad Shahbaz Farooq et al. (2022) further discuss the broader socio-economic impacts, highlighting the role of climate variability in exacerbating food insecurity, especially in urban areas and low-income countries. Overall, the literature emphasizes the need for comprehensive adaptation strategies to mitigate the adverse effects of climate change on food security

Research Methodology

The present study is conducted with the help of secondary data collected from the Department of Agriculture (Government of Karnataka), the Food, Civil Supplies and Consumer Affairs Department, the World Food Programme, and the Food and Agriculture Organization for the years 2011 and 2021. A multi-step approach has been adopted for this research, focusing on the year 2021. To identify food security regions in North Karnataka, the study considers four pillars or components: food availability, accessibility, stability, and utilization.

In this study, an attempt has been made to identify food security regions in North Karnataka using methods such as estimating net food availability and employing the Food Balance Sheet suggested by FAO (1957). Other referenced methodologies include Shafi (1960), Sukhante (1962), Dube and Mishra (1984), R.P. Mishra (2002), Negatu (2005), and Sunceta, P, and others (2010), with slight modifications according to the nature of the data. The modified Food Balance Sheet method and other approaches are considered to understand the food security situation in the study area.

To measure the Food balance sheet

Nij (Pij+Bij -Sij+Mij)

Where Nij is net food available for districts

Pij is total grain produced

Bij is total grain purchased

Sij is total crop utilized for seeds

Mij is market out put

J refers to year

To measure Z-score:

In order to standardize the raw data of all the variables, the method of z-score has been used

(Smith, 1973). Z-score quantify the departure of individual observations, expressed in a comparable form. The formula is thus;

Zi = xi-xi

SD

Where, Zi is the standard score of the variable;

xi is the original value of individual observation;

xi is the mean of variable and

SD stands for the standard deviation. In first step district wise Z-score of each indicator is calculated.

Selection of the variables:

To identify the spatial variation of food security in any region a set of variables are required. Therefore, in the present investigation 20 variables have been taken in to account according to the availability and nature of the data. The selected indicators have been broadly divided in to four groups namely Food availability (five components), Food stability (three components), Food accessibility (six components) and Food utilization (six components) (Table.1). Since the study depends upon secondary data it was difficult to gather information about the food calorie, therefore, it has not been considered.

Table. 1: List of Variables, Definition, Mean and Standard Deviation

Table: 1

Code No. for variables	Name of the variable and group	Definition	2011			2021		
			Mean	S. D	Z score	Mean	S. D	Z score
I	Food Availability							
1	Production of food grains	kg per head per annum	335.15	177.46	1.25	471.42	247.36	1.69
2	Population per livestock	livestock per head per annum	0.33	0.2	3	0.58	0.23	3.26
3	Production of meat	kg per head per annum	301.31	203.77	1.73	2.97	3.31	2.05
4	Production of milk	kg per head per annum	25.61	6.8	4.63	46	18.25	2.09
5	Percentage of net irrigated area to net cropped area		16.61	8.51	2.1	28.19	12.31	3.59
II	Food Stability							
6	Area under food grains	in 1000 ha	1869.42	1110.28	1	451.57	279.93	1.44
7	Fertilizer consumption	in kg/ ha	199.04	124.37	1.87	157.51	108.26	1.06
8	Yield of food grains	kg/ha	693.78	423.15	0.96	1949	1601.46	1.39
III	Food Accessibility							
9	Percentage of main workers to total population	per 1000 population	30.01	3.31	8.97	36.1	6.266	5.71
10	No. of person per fair price shop	to the total population	3159.38	530.63	5.45	3066.69	453.73	6.83
11	Literacy rate (2011)	to the total population	70.16	8.41	8.25	75.69	8.09	8.51
12	Per capita income		31267.1	12525.6	2.41	109398	29112.3	5.19
13	Length of the roads per lakh population	in km	272.92	77.44	3.20	327.11	154.48	1.7
14	Urbanization	to the total population	28.07	11.37	2.78	28.07	10.92	2.9
IV	Food Utilization							
15	Drinking water	to the total population	59.21	4.77	11.69	67.976	5.114	11.89
16	Infant mortality rate	the number of deaths in the first year of life per 1000 live births	8.54	7.19	0.84	5.795	5.964	0.63
17	Maternal mortality rate	number of maternal deaths per 100,000 live births	55.15	31.25	1.41	30.385	20.077	0.95
18	No. of beds in allopathic hospitals/ dispensaries	per lakh population	140.78	39.82	3.06	21.538	8.54	2.81
19	No. of MCH Centres/sub centres	per lakh population	3.41	1.21	3.4	4.366	1.104	4.64
20	No. of PHC centres	per lakh population	4.37	0.93	3.92	3.37	0.927	2.85

Source: Investigator compiled.2011 & 2021 data

III. RESULTS AND DISCUSSION

I. Food Availability

- Production of Food Grains (kg per head per annum): The study area shows an increasing trend in food grain production. In 2021, the average food production per capita was 471.42 kg, compared to 335.15 kg in 2011, indicating a 40.65 per cent increase. Several districts, including Ballari, Belagavi, Haveri, Koppal, Raichur, and Yadgiri, surpassed the average food grain production in both 2021 and 2011. However, some districts like Bidar, Dharwad, and Gadag showed a decrease in food grain production. Overall, the trend is positive, with more districts showing above-average production in 2021 compared to 2011. Providing more irrigation facilities in the region might increase food grain production, thereby enhancing food security.
- Population per Livestock: The availability of livestock per capita has increased by 75.75per cent over the last decade. In 2021, half of the region recorded below-average availability of livestock per capita at 0.58. Districts in the northern part of the study region (Bagalkot, Ballari, Koppal, Raichur, and Yadgiri) witnessed above-average availability in 2011, while others, including Ballari, Gadag, Koppal, Raichur, Vijayapura, and Yadgiri, showed below-average availability. Coastal districts such as Uttara Kannada recorded a steep growth in livestock per person in 2011. Livestock population is directly related to agriculture; more land under farming means higher livestock population and food grain production. It's akin to icing on the cake
- Production of Meat (kg per head per annum): Meat and poultry, essential sources of protein and nutrients, have experienced a decadal growth of 257.83 per cent. Districts like Bagalkot, Ballari, Haveri, Koppal, Raichur, and Uttara Kannada had higher meat per head than the study region average in 2011. By 2021, only four districts namely Bagalkot, Dharwad, Haveri, and Koppal remained above the study area average. The study shows that while some districts were well above average previously, by 2021 more than half of the study area fell below the average range.
- Production of Milk (kg per head per annum): Milk, a significant source of nutrients, witnessed a positive decadal growth of 79.61 per cent from 2011 to 2021. The average production in 2011 was 25.61 kg per capita per annum, increasing to 46 kg in 2021. District-wise analysis revealed progressive growth across every district. Belagavi, Bidar, and Raichur showed above-average production in 2011, and Belagavi, Bidar, Koppal, and Yadgiri maintained their positions even in 2021. These districts, such as Yadgiri and Belagavi, consistently surpassing the regional average, indicate thriving allied activities and a stable income source.
- Percentage of Net Irrigated Area to Net Cropped Area: The total area under irrigation increased to 71.65 per cent from 2011 to 2021. In 2011, the average area under irrigation to net cropped area was 16.61 per cent, which increased to 28.19 per cent in 2021. Some districts, including Bagalkot, Ballari, Belagavi, Raichur, Vijayapura, and Uttara Kannada, had a higher percentage of net irrigated area than the study area average in 2011. In 2021, Bagalkot, Belagavi, Raichur, and Vijayapura maintained their status of a high percentage of net irrigated area (Table 2&3).

These findings highlight positive trends in food availability, supported by improvements in food grain production, livestock availability, meat and milk production, and increased irrigation, contributing to enhanced food security in the North Karnataka region

Table .2: Food Availability- 2011

Food availability 2011					
District	Production of food grains (kg per head per annum)	Population per livestock	Production of meat (kg per head per annum)	Production of milk (kg per head per annum)	Percentage of net irrigated area to net cropped area
Bagalkot	222.48	0.59	0.96	31.46	17.89

Ballari	524.98	0.37	1.83	20.61	25.92
Belagavi	152.85	0.32	0.47	44.7	22.28
Bidar	135.21	0.17	0.63	27.26	9.71
Dharwad	253.97	0.07	0.08	19.36	15.83
Gadag	331.45	0.41	0.61	22.61	8.35
Haveri	451.4	0.26	1.64	27.62	6.37
Kalaburagi	381.39	0.21	0.24	22.36	14.21
Koppal	540.71	0.36	1.11	24.39	6.71
Raichur	715.66	0.49	1.45	27.11	34.56
Vijayapura	242.09	0.37	0.18	19.13	25.05
Yadgiri	165.34	0.71	0.60	21.22	11.32
Uttara Kannada	239.4	0.01	0.86	25.14	17.73
MEAN	335.15	0.33	301.31	25.61	16.61
SD	177.46	0.20	203.77	6.80	8.51

Source: Karnataka at Glance. Karnataka Government

Table: 3 Food Availability 2021

Food availability 2021					
District	Production of food grains (kg per head per annum)	Population per livestock	Production of meat (kg per head per annum)	Production of milk (kg per head per annum)	Percentage of net irrigated area to net cropped area
Bagalkot	417.25	0.75	6.8	38.19	44.17
Ballari	593.01	0.64	1.69	33.39	38.07
Belagavi	472.44	0.58	1.6	79.87	42.65
Bidar	84.36	0.37	0.8	49.92	12.62
Dharwad	215.78	0.23	4.85	33.79	10.54
Gadag	273.39	0.55	0.28	32.57	15.46
Haveri	682.61	0.5	12.61	43.86	23.45
Kalaburagi	416.99	0.42	1.16	23.32	9.15
Koppal	779.52	0.77	3.59	52.78	27.82
Raichur	1052.5	0.76	1.7	33.87	37.26
Vijayapura	368.42	0.53	0.55	43.58	29.17
Yadgiri	481	1.13	0.9205	89.5	41.84
Uttara Kannada	291.19	0.34	2.06	43.42	34.23
MEAN	471.42	0.58	2.97	46	28.19
SD	247.36	0.23	3.31	18.25	12.31

Source: Karnataka at Glance. Karnataka Government

Application of standardized score and spatial pattern of food Stability:

To assess food availability in the thirteen districts of North Karnataka, a standardized score (Z score) was computed for per capita availability of food, production of food grains, livestock population, production of meat, production of milk, and net irrigated area to net cropped area, and calculated for all the districts with the help of Z score. The spatial distribution of food availability was categorized into three groups: food severity, food deficiency, and food self-sufficiency regions.

The data revealed that most districts experienced food deficiency, except for two districts classified under the food self-sufficiency region (self-sufficiency > 2.70 in 2011 and > 2.57 in 2021). In

2021, Yadgiri (3.09) showed an increase in every component of food availability over the past decade, achieving self-sufficiency. Similarly, Raichur (3.21) also saw increases in every component over the past decade, supported by good irrigation sources through canals, maintaining food self-sufficiency since 2011.

In contrast, districts such as Bagalkot, Ballari, Belagavi, Haveri, and Koppal were classified under the food deficiency category in 2011. By 2021, Raichur had joined this list while the others remained in the same category. Bidar, Dharwad, Gadag, Kalaburagi, Vijayapura, and Uttara Kannada districts showed food severity in both 2011 and 2021 (Fig. 2)

Upon analysing the data, it became evident that the region faced significant challenges in achieving food security. Remarkably, only Yadgiri transitioned from the food severity category in 2011 to the high food security category in 2021. This highlights the persistent challenge of improving food security across the region, as most districts did not progress from lower to higher categories during the study period.

Table: 4 Composite Z score of Food availability 2021

Food availability 2021						
District	Production of food grains (kg per head per annum)	Population per livestock	Production of meat (kg per head per annum)	Production of milk (kg per head per annum)	Percentage of net irrigated area to net cropped area	Composite Z.score
Bagalkot	1.69	3.26	2.05	2.09	3.59	2.54
Ballari	2.40	2.78	0.51	1.83	3.09	2.12
Belagavi	1.91	2.52	0.48	4.38	3.46	2.55
Bidar	0.34	1.61	0.24	2.74	1.03	1.19
Dharwad	0.87	1.00	1.47	1.85	0.86	1.21
Gadag	1.11	2.39	0.08	1.78	1.26	1.32
Haveri	2.76	2.17	3.81	2.40	1.90	2.61
Kalaburagi	1.69	1.83	0.35	1.28	0.74	1.18
Koppal	3.15	3.35	1.08	2.89	2.26	2.55
Raichur	4.25	3.30	0.51	1.86	3.03	2.59
Vijayapura	1.49	2.30	0.17	2.39	2.37	1.74
Yadgiri	1.94	4.91	0.28	4.90	3.40	3.09
Uttar Kannada	1.18	1.48	0.62	2.38	2.78	1.69

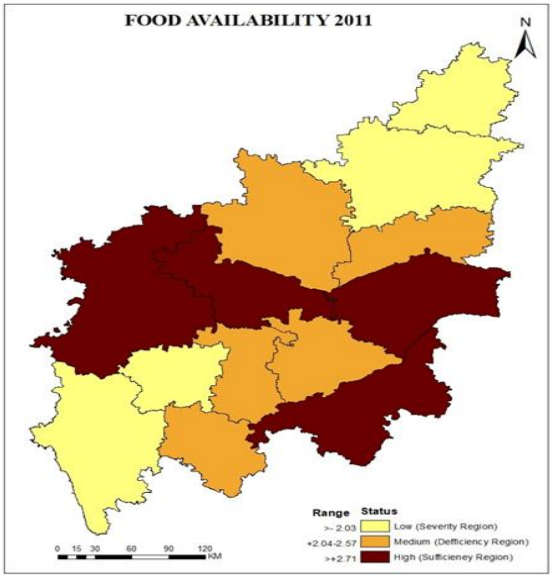
Source: Investigator computed based on table 3

Table 5: Composite Z score Of Food Availability 2011

Food availability 2011						
District	Production of food grains (kg per head per annum)	Population per livestock	Production of meat (kg per head per annum)	Production of milk (kg per head per annum)	Percentage of net irrigated area to net cropped area	Composite Zscore
Bagalkot	1.25	3.00	1.73	4.63	2.10	2.54
Ballari	2.96	1.88	3.28	3.03	3.05	2.84
Belagavi	0.86	1.63	0.85	6.58	2.62	2.51
Bidar	0.76	0.87	1.13	4.01	1.14	1.58
Dharwad	1.43	0.36	0.15	2.85	1.86	1.33

Gadag	1.87	2.09	1.10	3.33	0.98	1.87
Haveri	2.54	1.32	2.95	4.06	0.75	2.33
Kalaburagi	2.15	1.07	0.45	3.29	1.67	1.72
Koppal	3.05	1.83	2.00	3.59	0.79	2.25
Raichur	4.03	2.49	2.61	3.99	4.06	3.44
Vijayapura	1.36	1.88	0.33	2.81	2.95	1.87
Yadgiri	0.93	3.61	1.09	3.12	1.33	2.02
Uttara Kannada	1.35	0.05	1.55	3.70	2.08	1.75

Source: Investigator computed based on table 2



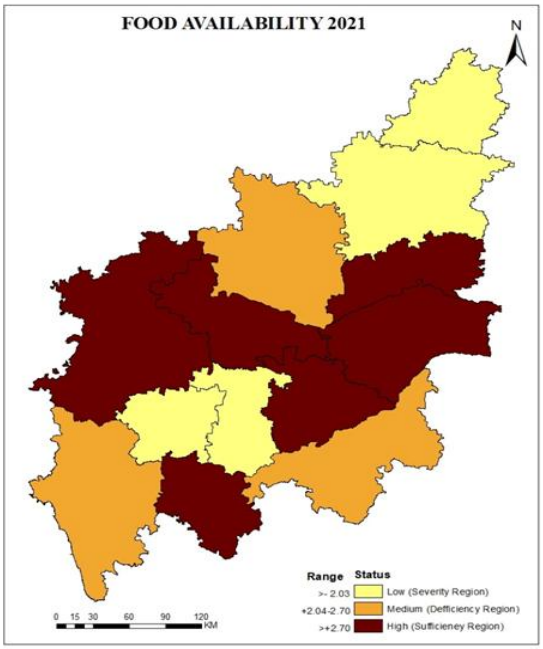


Fig: 2

II. Food Stability

Food stability encompasses components like production, price, marketing, and distribution systems, all contributing to the overall stability in the food supply. Several components were considered to evaluate food stability in the region, including the area under food grains, fertilizer consumption, and the yield of food grains.

Trends in Food Stability

- Area under Food Grains: The area under food grains is directly proportional to production, signifying greater stability with increased cultivation. In 2011, the average area under food grains was 1,869,000 hectares, contrasting with 451,000 hectares in 2021. This significant decrease (-75.84%) was attributed to the 2019 floods in Karnataka. Four districts—Ballari (3,649.3), Haveri (3,021.3), Raichur (2,923.5), and Uttara Kannada (3,954.5)—surpassed the study area average in 2011. In 2021, however, Belagavi (584.63), Kalaburagi (930.99), Raichur (589.61), and Vijayapura (1,047.54) registered more area under food grain cultivation (Table. 6)
- Fertilizer Consumption: Fertilizer consumption is a crucial component historically linked to increased agricultural yield. In 2011, the average fertilizer consumption was 199.04 kg/ha, which decreased to 157.51 kg/ha in 2021. High consumption was noted in four districts: Bagalkot (232.65), Ballari (465.32), Haveri (288.77), and Raichur (405.05) in 2011. In 2021, Ballari (386.7), Belagavi (244.35), Raichur (243.4), Yadgiri (293.71), and Uttara Kannada (200.71) districts exhibited higher utilization. Some districts showed a decrease in fertilizer consumption in 2021, but Belagavi, Kalaburagi, Yadgiri, and Uttara Kannada districts experienced high utilization during the study period

- Yield of Food Grain: The yield of food grain per hectare indicates the agricultural status of a region. The study area witnessed substantial growth in yield, increasing from 693.78 kg/ha in 2011 to 1,949 kg/ha in 2021. This growth was consistent across all districts. However, in 2021, five districts—Bagalkot (2,219), Ballari (3,341), Belagavi (2,039), Yadgiri (6,210), and Uttara Kannada (3,193)—registered yields of food grain above the study region average. In 2011, notable progress in food grain yield was observed in four districts: Dharwad (653.03), Haveri (1,102.80), Raichur (1,067.10), and Uttara Kannada

The trends in these indicators collectively contribute to assessing food stability in a region, reflecting both challenges and positive developments in the agricultural sector

Spatial pattern of food Stability

To evaluate food stability in the region, three indicators were considered, and district-wise Z-scores were separately calculated. The composite Z-score was then derived and organized into three groups: High (food self-sufficiency region), Medium (food deficiency region), and Low (food severity region). In 2011, nine districts fell under the low stability category, while in 2021, eight districts faced food severity. Additionally, three districts in 2021 and one district in 2011 were classified as medium stability (food deficiency). Two districts in 2021 and three in 2011 were noted to have high food stability, indicating food sufficiency

In 2011, Raichur (2.81), Uttara Kannada (2.86), and Ballari (3.4) districts were categorized as having high food stability. By 2021, Ballari (2.42) and Yadgiri (2.46) districts maintained high food stability with Z-scores greater than 2.03. Notably, Yadgiri district, which faced food severity in 2011, showed significant improvement by 2021, achieving high stability. This positive trend indicates considerable growth in high stability from 2011 to 2021 (Table 7 and Fig. 3).

In 2011, Belagavi (1.87), Raichur (1.83), and Vijayapura (1.53) districts were classified in the low stability category. However, by 2021, these districts had moved to the medium stability category. Uttara Kannada (1.36) enjoyed high stability in 2011 but regressed to low stability by 2021. Similarly, Haveri (1.2) was categorized as medium stability in 2011 but declined to low stability in 2021.

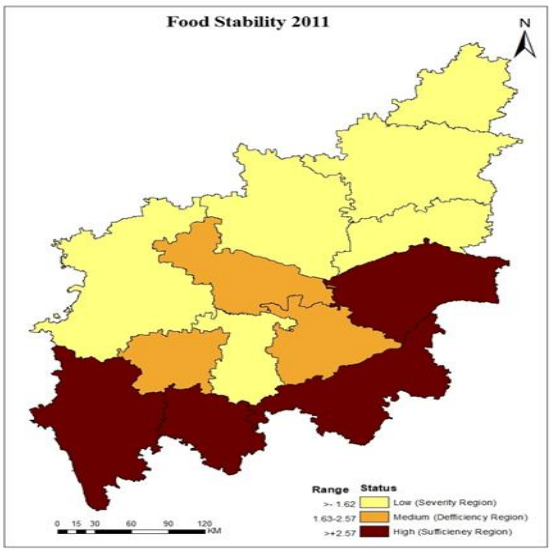
To elevate the study area to a high stability region, attention must be directed towards the districts currently in the low stability category, which are relatively numerous and require immediate intervention and improvement efforts.

Table: 6 Food Stability: 2011 and 2021

Food Stability- 2011				Food Stability -2021		
District	Area under food grains (in 1000 ha)	Fertilizer consumption (in kg/ ha)	Yield of food grains (kg/ha)	Area under food grains (in 1000 ha)	Fertilizer consumption (in kg/ ha)	Yield of food grains (kg/ha)
Bagalkot	1107.2	232.65	404.11	403.37	114.91	2219
Ballari	3649.3	465.32	1332	445.96	386.7	3341
Belagavi	1181.6	34.49	431.29	584.63	244.35	2039
Bidar	770.31	119.73	281.16	216.69	78.52	517
Dharwad	1789.1	189.97	653.03	287.06	70.89	782
Gadag	1149.2	140.78	419.44	398.06	49.33	418
Haveri	3021.3	288.77	1102.8	295.40	149.12	1859
Kalaburagi	1216.3	119.87	443.95	930.99	38.45	953
Koppal	1338	195.9	488.37	384.69	121.65	1452
Raichur	2923.5	405.05	1067.1	589.61	243.4	1832
Vijayapura	1385.9	95.62	258.78	1047.54	56.65	522
Yadgiri	816.3	102.73	306,65	220.81	293	6210

Uttara Kannada	3954.5	196.67	1443.4	65.61	200.71	3193
MEAN	1869.42	199.04	693.78	451.57	157.51	1949.00
SD	1110.28	124.37	423.15	279.927	108.257	1601.46

Source: Karnataka at Glance. Karnataka Government



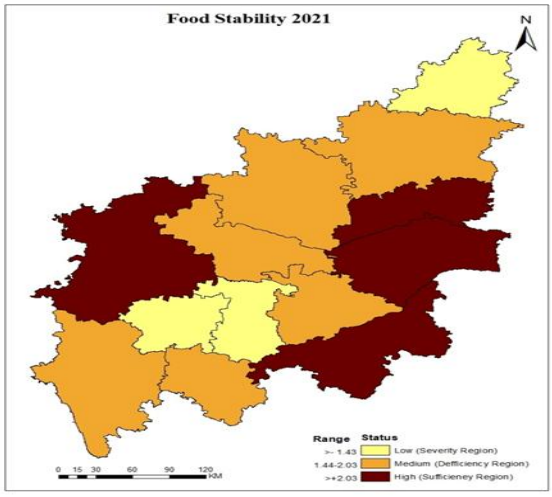


Fig: 3

Table 7: Composite Z score of Food Stability 2021

Food Stability 2011					Food Stability 2021			
District	Area under food grains (in 1000 ha)	Fertilizer consumption (in kg/ ha)	Yield of food grains (kg/ha)	Composite Z score	Area under food grains (in 1000 ha)	Fertilizer consumption (in kg/ ha)	Yield of food grains (kg/ha)	Composite Z score
Bagalkot	1.00	1.87	0.96	1.28	1.44	1.06	1.39	1.30
Ballari	3.29	3.74	3.18	3.40	1.59	3.57	2.09	2.42
Belagavi	1.06	0.28	1.03	0.79	2.09	2.26	1.27	1.87
Bidar	0.69	0.96	0.67	0.78	0.77	0.73	0.32	0.61
Dharwad	1.61	1.53	1.56	1.57	1.03	0.65	0.49	0.72
Gadag	1.04	1.13	1.00	1.06	1.42	0.46	0.26	0.71
Haveri	2.72	2.32	2.63	2.56	1.06	1.38	1.16	1.20
Kalaburgi	1.10	0.96	1.06	1.04	3.33	0.36	0.60	1.43
Koppal	1.21	1.58	1.17	1.32	1.37	1.12	0.91	1.13
Raichur	2.63	3.26	2.55	2.81	2.11	2.25	1.14	1.83
Vijaypur	1.25	0.77	0.62	0.88	3.74	0.52	0.33	1.53

Yadgiri	0.74	0.83	0.73	0.76	0.79	2.71	3.88	2.46
Uttar kannada	3.56	1.58	3.44	2.86	0.23	1.85	1.99	1.36

Source: Investigator calculated based on table 6.

III. Food Accessibility

Food availability, food stability, and food accessibility are important components determining the food security of an area (Prof. M.S. Swaminathan, 2010). Most of the malnourished population cannot produce or afford enough food, facing inadequate access to natural resources, jobs, income, or social scores (Chaturvedi, 1997). Indicators such as the number of fair price shops, main workers, and length of roads, literacy rate, and urbanization are considered to examine food accessibility.

Trends in Food Accessibility:

- Percentage of Main Workers to Total Population: The percentage of total workers is significant as it indicates total employability, contributing to food security. The average percentage of main workers to the total population was 30.01per cent in 2011 and increased to 36.1 per cent in 2021. While there is an overall growth trend in the percentage of workers, some districts experienced a decline in main workers. For instance, Haveri decreased to 27.1 Per cent in 2021 from 33.23 per cent in 2011, and Koppal decreased to 26.3 per cent in 2021 from 30.34 per cent in 2011. Gadag recorded the highest percentage of main workers in 2011, while Kalaburagi recorded the lowest percentage of workers (Table 8 & 9)

Table.8: Food Accessibility 2011

Food Accessibility 2011						
District	Percentage of main workers to total population	No. of person per fair price shop	Literacy rate (2011)	Per capita income	Length of the roads per lakh population (Kms)	Urbanization (%)
Bagalkot	29.69	2891	69.39	30166	247.87	31.63
Ballari	31.64	4263	67.85	52881	340.95	37.52
Belagavi	32.17	2789	73.48	31551	357.12	25.34
Bidar	24.99	2288	71.01	3292	412.81	23.68
Dharwad	31.78	3586	80.3	53600	332.96	56.82
Gadag	36.49	2942	75.18	30510	202.41	35.63
Haveri	33.23	3666	77.6	26812	198.62	16.16
Kalaburagi	26.62	3777	65.65	26647	264.86	32.55
Koppal	30.34	3091	67.28	27160	281.13	12.09
Raichur	28.28	2834	60.46	27475	295.88	25.42
Vijayapura	25.37	2732	67.2	26471	211.74	23.05
Yadgiri	27.91	2992	52.36	37154	275.47	18.79
Uttara Kannada	31.68	3221	84.3	32753	126.17	26.26
MEAN	30.01	3159.38	70.16	31267.08	272.92	28.07

SD	3.31	530.63	8.41	12525.64	77.44	11.37

Karnataka at Glance. Karnataka Government.

- Number of Persons per Fair Price Shop: A crucial component of food accessibility is the fair price shop, as it stores and distributes food. The availability of fair price shops is essential for ensuring food accessibility. In 2011, there were 3,159.38 persons per fair price shop, and 3,066.69 persons per shop in 2021. This indicates little dip in the number of shops over time, indicating that the people have uplifted economically since main worker and per capita have increased over the period.
- Literacy Rate: Literacy plays a crucial role in food security, influencing the availability and stability of food and overall area development. The study region exhibited an increasing trend in literacy, rising from 70.16 Per cent to an estimated 75.69 Per cent in 2021. Dharwad topped the table in both decades with literacy rates of 80.30 Per cent in 2011 and 90.34 Per cent in 2021. Conversely, Yadgiri consistently showed the lowest literacy rates in the study region during these periods.
- Per Capita Income: Income significantly influences the overall food security of the region. The study region experienced an increase in per capita income, rising from 31,267.08 in 2011 to 109,398.15 in 2021. This positive trend indicates income growth and the ability to purchase items not locally grown, ensuring a diversified diet.
- Length of Roads per Lakh Population: The length of roads serves as a key indicator of regional development, providing a safe and efficient means to transport food crops and goods. The region experienced a growing trend in road length, increasing from 272.92 km in 2011 to 327.11 km in 2021. This growth contributes to economic development and overall regional progress.

Table .9: Food Accessibility 2021

Food Accessibility 2021						
District	Percentage of main workers to total population	No. of person per fair price shop	literacy rate (2011)	per capita income	length of the roads per lakh population (Kms)	Urbanization (%)
Bagalkot	35.8	3099	74.39	151030	263.27	31.63
Ballari	44.6	3952	72.85	133982	322.51	37.52
Belagavi	36.3	2778	78.48	105133	262.55	25.34
Bidar	46.5	2355	76.01	98578	263.07	23.68
Dharwad	37.4	3635	84.3	149469	295.05	56.82
Gadag	39.8	3050	80.18	115808	551.63	35.63
Haveri	27.1	3503	82.6	111426	290.85	16.16
Kalaburagi	32.9	2610	71.65	91970	332.49	32.55
Koppal	26.3	3130	72.28	96380	119.15	12.09
Raichur	31.6	2697	67.46	96492	315.48	25.42
Vijayapura	42.6	2607	73.2	93908	146.68	23.05
Yadgiri	37.2	2928	61.36	38097	352.04	18.79
Uttara	31.2	3523	89.3	139903	737.62	26.26

Kannada						
MEAN	36.1	3066.69	75.69	109398.15	327.11	28.07
SD	6.266	453.73	8.41	29112.3	154.48	10.92

Source: Karnataka at Glance. Karnataka Government

- Urbanization: Urban populations generally have better access to food, making urbanization a key indicator of food security. The proportion of urbanization in the study area increased from 28.07 per cent in 2011 to an estimated 33.97 per cent in 2021. The degree of urbanization varied across districts, with Dharwad being the most urbanized district.

Spatial pattern of food Accessibility

To assess food accessibility in the years 2011 and 2021, district-wise Z-scores of six indicators were separately calculated, and composite Z-scores were determined. Ballari and Dharwad consistently exhibited high food accessibility during both study periods, while Uttara Kannada transitioned from medium food accessibility in 2011 to high food accessibility in 2021. However, across the entire study region, more than half of the districts faced low to medium food accessibility. Dharwad had the highest food accessibility score in the region (6.58), while Bidar had the lowest (4.66). By 2021, only three districts—Gadag (5.61), Belagavi (5.51), and Haveri (5.38)—remained in the medium category. This indicates that since 2011, no district has consistently maintained its position in the medium category except Gadag. Concerning, most districts were classified in the low category for food accessibility, with none progressing to a higher category. Moreover, Belagavi and Haveri, which were in the medium category in 2011, have slipped to the low category by 2021. Districts like Bagalkot, Bidar, Kalaburagi, Koppal, Raichur, Vijayapura, and Yadgiri consistently remained in the low accessibility category in both periods. It is evident that the study area continues to experience challenges with low food accessibility (Table 8, 9 & Fig. 4)

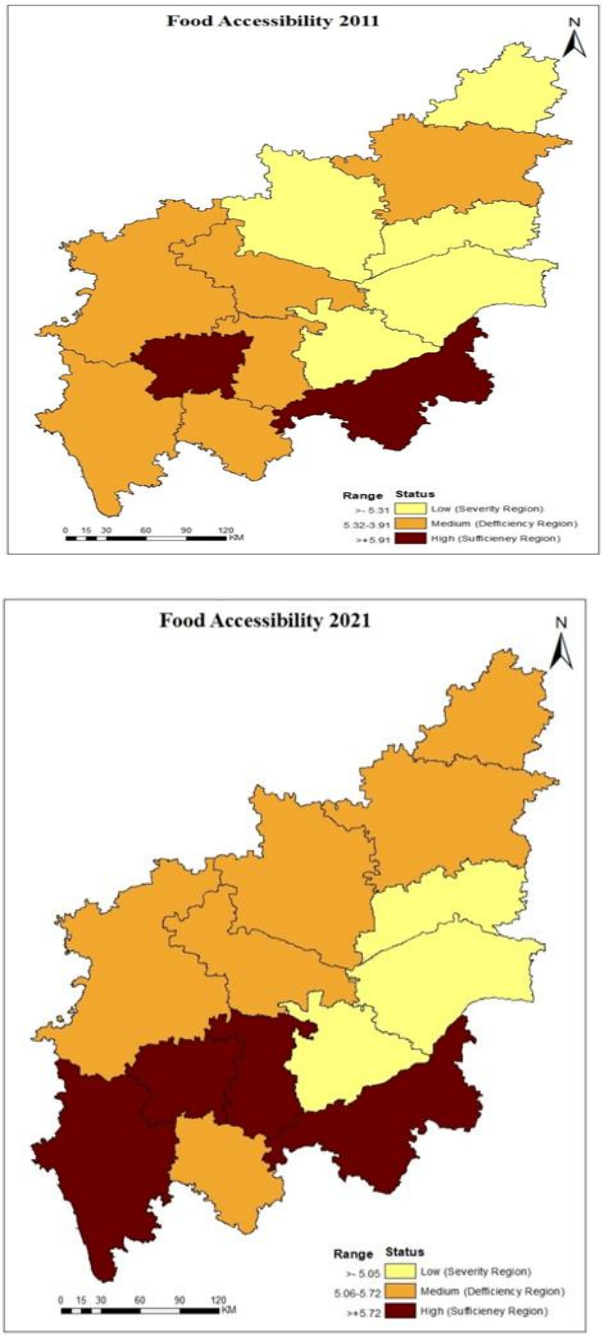


Fig.4

Table 8: Food Accessibility – Composite Z. Score: 2011
Table 9: Food Accessibility -Composite Z. Score: 2021

District	Percentage of main workers to total population	No. of person per fair price shop	Literacy rate (2011)	Per capita income	Length of the roads per lakh population (Kms)	Urbanization (%)	Composite Zscore
Bagalkot	8.97	5.44	8.24	2.40	3.20	2.78	5.18
Ballari	9.56	8.03	8.07	4.22	4.40	3.30	6.26
Belagavi	9.72	5.26	8.73	2.52	4.61	2.23	5.51
Bidar	7.55	4.31	8.44	0.26	5.33	2.08	4.66
Dharwad	9.60	6.76	9.54	4.28	4.30	5.00	6.58
Gadag	11.03	5.54	8.94	2.44	2.61	3.13	5.61
Haveri	10.04	6.91	9.22	2.14	2.56	1.42	5.38
Kalaburgi	8.04	7.12	7.80	2.13	3.42	2.86	5.23
Koppal	9.17	5.83	8.00	2.17	3.63	1.06	4.98
Raichur	8.54	5.34	7.19	2.19	3.82	2.24	4.89
Vijaypur	7.67	5.15	7.99	2.11	2.73	2.03	4.61
Yadgiri	8.43	5.64	6.22	2.97	3.56	1.65	4.75
Uttarkannada	9.57	6.07	10.02	2.61	1.63	2.31	5.37

IV. FOOD UTILIZATION

Utilization encompasses how effectively people in the region are using available resources, such as drinking water, managing infant and maternal mortality rates, ensuring the availability of hospital beds, and providing access to maternal and child health centres for mothers and newborns. Furthermore, the number of Primary Health Care (PHC) centres in the region is crucial in relation to the population size. These factors collectively impact

Food Accessibility 2021							
District	Percentage of main workers to total population	No. of person per fair price shop	literacy rate (2011)	per capita income	length of the roads per lakh population (Kms)	Urbanization (%)	Composite Z score
Bagalkot	5.71	6.83	8.51	5.19	1.70	2.90	5.14
Ballari	7.12	8.71	8.34	4.60	2.09	3.44	5.72
Belagavi	5.79	6.12	9.08	3.61	1.70	2.32	4.77
Bidar	7.42	5.19	8.72	3.39	1.70	2.17	4.76
Dharwad	5.97	8.01	9.89	5.13	1.91	5.20	6.02
Gadag	6.35	6.72	9.29	3.98	3.57	3.26	5.53
Haveri	4.33	7.72	9.52	3.83	1.88	1.48	4.79
Kalaburagi	5.25	5.75	8.02	3.16	2.15	2.98	4.55
Koppal	4.20	6.90	8.42	3.31	0.77	1.11	4.12
Raichur	5.04	5.94	7.36	3.31	2.04	2.33	4.34
Vijayapura	6.80	5.75	8.30	3.23	0.95	2.11	4.52
Yadgiri	5.94	6.45	6.47	1.31	2.28	1.72	4.03
Uttar Kannada	4.98	7.76	10.39	4.81	4.77	2.40	5.85

After considering all three afore mentioned components, the judicious utilization of food resources is crucial for food security. Some individuals face challenges in accessing food, while others may not use available resources effectively. Therefore, food utilization is equally significant as the other components in ensuring food security.

Trends in Food Accessibility

the overall utilization of resources and contribute to enhancing food security.

- Drinking Water: Access to safe and clean drinking water is a fundamental human need for survival and a basic right. Since the beginning of 2011, the region has seen an improvement in drinking water accessibility. In 2011, the average percentage of the population with access to drinking water was 59.21per cent, which increased to 67.97 per cent by 2021. However, despite these gains, rural areas of the region continue to encounter challenges in accessing water, highlighting an urban bias in drinking water distribution
- Infant Mortality Rate: Infant mortality rates, which are calculated as the number of deaths in the first year of life per 1000 live births, depend significantly on the health of both the baby and the mother. Fortunately, the region has seen positive development in this regard, with the infant mortality rate decreasing from 8.54 per 1000 births in 2011 to 5.59 per 1000 births in 2021
- Maternal Mortality: Ensuring the safety of women and children is crucial for food security. The maternal mortality ratio, calculated as the number of maternal deaths per 100,000 live births, has shown a decline in the region. In 2011, the ratio was 55.15, and by 2021, it decreased to 30.38. All districts in the study area have reported lower mortality rates in 2021 compared to 2011. This improvement signifies positive progress in maternal health outcomes across the region
- Number of Beds in Allopathic Hospitals/Dispensaries per Lakh Population: The number of hospital beds per capita is a critical indicator of healthcare infrastructure in the region. However, there has been a concerning trend with a decrease in the average beds per lakh population from 140.78 in 2011 to 21.53 in 2021. This decline in hospital bed numbers is alarming, especially considering the increase in population over the same period
- Number of MCH Centres/Sub Centres per Lakh of Population: Maternal and Child Health (MCH) centres are crucial for promoting healthy and safe delivery practices. While there has been a slight increase, with MCH centres rising from 3.41 per lakh population in 2011 to 4.36 in 2021, the region still needs more of these centres to adequately support safe deliveries and maternal health care.

Number of PHC Centres/Sub Centres per Lakh of Population: Health is indeed considered wealth, and the availability of health centres is vital for the well-being of the population. Unfortunately, the study area has experienced a decline in Primary Health Care (PHC) centres, decreasing from 4.13 per lakh population in 2011 to 3.37 in 2021. This downward trend is concerning, especially considering the significance of healthcare, particularly in rural areas where access to information may be limited and diseases could be overlooked. Increasing the number of PHC centres is crucial for addressing the healthcare needs of the population effectively.

Table. 10: Food Accessibility 2011

Food Utilization 2011						
District	Drinking water (%)	Infant mortality rate	Maternal mortality rate	No. of beds in allopathic hospitals/ dispensaries per lakh population (including PHC)	No. of MCH Centres/sub centres per lakh of population	No. of PHC centres per lakh population
Bagalkot	60.79	3.73	19	24	5.12	2.64
Ballari	69.8	5.55	45	25	4	2.96
Belagavi	78.16	4.17	52	29	2.29	3.22
Bidar	65.28	8.88	20	9	4.53	3.11
Dharwad	76.49	22.13	69	40	3.16	1.73

Gadag	62.15	11.85	7	22	6.48	3.47
Haveri	71.01	3.08	15	25	5.56	4.5
Kalaburagi	67.03	4.59	52	20	3.45	3.46
Koppal	64.43	0.42	18	9	4.73	3.37
Raichur	65.68	0.12	46	12	3.44	2.75
Vijayapura	70.57	6.84	19	22	4.35	3.12
Yadgiri	66.42	0.13	28	17	4.83	3.92
Uttara Kannada	65.88	3.85	5	26	4.82	5.56
MEAN	67.976	5.795	30.385	21.538	4.366	3.370
SD	5.114	5.964	20.077	8.540	1.104	0.927

Source: Karnataka at Glance. Karnataka Government

Table. 11: Food Utilization -2021

Food Utilization -2021						
District	Drinking water (%)	Infant mortality rate	Maternal mortality rate	No. of beds in allopathic hospitals/ dispensaries per lakh population (including PHC)	No. of MCH Centres/sub centres per lakh of population	No. of PHC centres per lakh population
Bagalkot	55.79	6.02	44	121.85	4.12	3.64
Ballari	60.8	8.08	89	150.05	3	3.96
Belagavi	70.16	7.4	125	98.14	1.29	4.22
Bidar	58.28	6.05	26	149.58	3.53	4.11
Dharwad	66.49	30.07	46	147.91	2.16	2.73
Gadag	54.15	10.05	44	167.09	6.1	4.47
Haveri	61.01	3.48	31	153.26	4.56	5.5
Kalaburagi	60.03	8.93	63	136.1	2.45	4.46
Koppal	54.43	3.12	93	106.08	3.73	4.37
Raichur	55.68	13.38	66	138.25	2.44	3.75
Vijayapura	60.57	7.99	31	117.05	3.35	4.12
Yadgiri	56.42	1.65	44	94.97	3.83	4.92
Uttara Kannada	55.88	4.8	15	249.85	3.82	6.56
MEAN	59.21	8.54	55.15	140.78	3.41	4.37
SD	4.77	7.19	31.25	39.82	1.21	0.93

Source: Karnataka at Glance. Karnataka Government

Spatial Pattern of Food Utilization

To assess food utilization across the study area for 2011 and 2021, six indicators were analyzed, and district-wise Z-scores were calculated. Composite Z-scores categorized inter-district variations into High, Medium, and Low groups. Overall, the study area predominantly exhibits low to medium food utilization, with a decline noted in high food utilization regions.

In 2011, Gadag (Z-score 4.7) and Uttara Kannada (Z-score 4.89) were classified in the high food utilization category. By 2021, only Dharwad (Z-score 5.25) remained notably in the high utilization region.

Medium utilization districts in 2011 included Ballari (Z-score 4.54), Belagavi (Z-score 4.63), Dharwad (Z-score 4.67), and Haveri (Z-score 4.63). In 2021, Ballari (Z-score 4.43) retained its medium

categorization, while Haveri (Z-score 4.66), Belagavi (Z-score 4.59), Gadag (Z-score 4.45), and Uttara Kannada (Z-score 4.53) shifted from high to medium food utilization.

Several districts such as Bagalkot, Bidar, Kalaburagi, Koppal, Raichur, Vijayapura, and Yadgiri were categorized under low food utilization in both 2011 and 2021, indicating a consistent status.

In conclusion, the study area generally shows a low to medium level of food utilization, with no districts demonstrating a shift from low or medium to high utilization, except for Dharwad (Table 10 & 11 and Fig. 5).

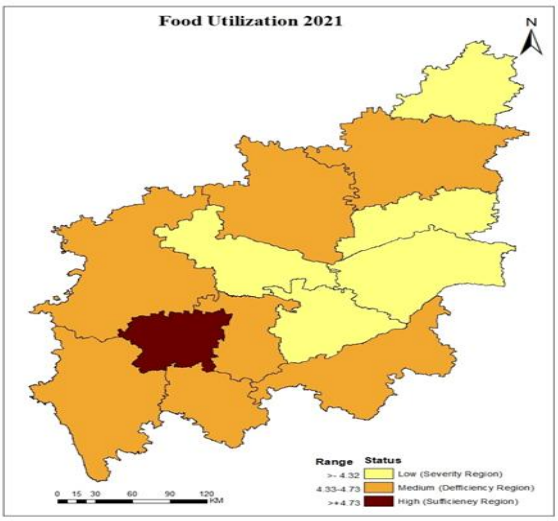


Fig.5

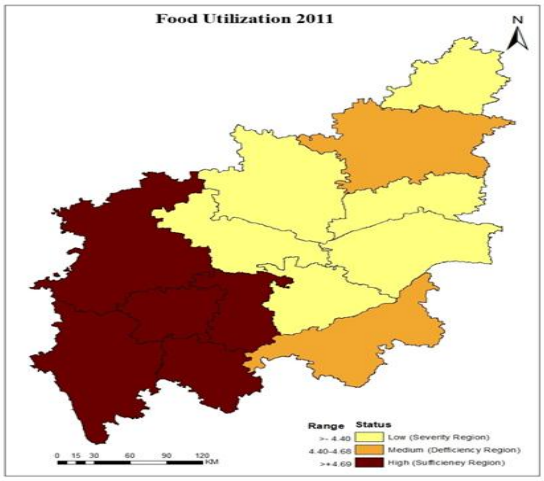


Table 12: Food Utilization- Composite Zscore: 2011

Food Utilization 2011							
District	Drinking water (%)	Infant mortality rate	Maternal mortality rate	No. of beds in allopathic hospitals/ dispensaries per lakh population (including PHC)	No. of MCH Centres/sub centres per lakh of population	No. of PHC centres per lakh population	Composite Zscore
Bagalkot	11.89	0.63	0.95	2.81	4.64	2.85	3.96
Ballari	13.65	0.93	2.24	2.93	3.62	3.19	4.43
Belagavi	15.28	0.70	2.59	3.40	2.07	3.47	4.59
Bidar	12.76	1.49	1.00	1.05	4.10	3.35	3.96
Dharwad	14.96	3.71	3.44	4.68	2.86	1.87	5.25
Gadag	12.15	1.99	0.35	2.58	5.87	3.74	4.45
Haveri	13.88	0.52	0.75	2.93	5.03	4.85	4.66
Kalburgi	13.11	0.77	2.59	2.34	3.12	3.73	4.28
Koppal	12.60	0.07	0.90	1.05	4.28	3.63	3.76
Raichur	12.84	0.02	2.29	1.41	3.11	2.97	3.77

Vijayapura	13.80	1.15	0.95	2.58	3.94	3.36	4.30
Yadgiri	12.99	0.02	1.39	1.99	4.37	4.23	4.17
Uttar Kannada	12.88	0.65	0.25	3.04	4.36	6.00	4.53

Source: Computed based on table 10

Table 13: Food Utilization 2021

Food Utilization 2021							
District	Drinking water (%)	Infant mortality rate	Maternal mortality rate	No. of beds in allopathic hospitals/ dispensaries per lakh population (including PHC)	No. of MCH Centres/sub centres per lakh of population	No. of PHC centres per lakh population	Composite Z. score
Bagalkot	11.69	0.84	1.41	3.06	3.40	3.92	4.05
Ballari	12.73	1.12	2.85	3.77	2.48	4.27	4.54
Belagavi	14.70	1.03	4.00	2.46	1.06	4.55	4.63
Bidar	12.21	0.84	0.83	3.76	2.91	4.43	4.16
Dharwad	13.93	4.18	1.47	3.71	1.78	2.94	4.67
Gadag	11.34	1.40	1.41	4.20	5.03	4.82	4.70
Haveri	12.78	0.48	0.99	3.85	3.76	5.93	4.63
Kalaburagi	12.57	1.24	2.02	3.42	2.02	4.81	4.35
Koppal	11.40	0.43	2.98	2.66	3.08	4.71	4.21
Raichur	11.66	1.86	2.11	3.47	2.01	4.04	4.19
Vijayapura	12.69	1.11	0.99	2.94	2.77	4.44	4.16
Yadgiri	11.82	0.23	1.41	2.38	3.16	5.31	4.05
Uttar Kannada	11.70	0.67	0.48	6.27	3.15	7.07	4.89

Source: Computed based on table 11

V. OVERALL FOOD SECURITY REGIONS

To evaluate the overall spatial pattern of food security regions, district-wise Z-scores of 20 indicators were calculated. These indicators were aggregated and averaged to determine the composite Z-score for each district, reflecting its food security status. The standard deviation method was then used to classify the study region into three categories:

1. High food security region (Food Sufficiency): Districts with Z-scores indicating high food security.
2. Medium food security region (Deficiency): Districts with Z-scores indicating moderate food security challenges.
3. Low food security region (Severity): Districts with Z-scores indicating significant food security challenges.

Table 14 and Figure 6 illustrate the wide variation in composite Z-scores among the districts of the study region, providing a comprehensive view of the spatial distribution and disparities in food security levels

1.High Food Security Regions - Sufficiency:

During the study period from 2011 to 2021, the study region experienced a slight decline in food security. In 2011, two districts, Ballari (Z-score 4.19) and Raichur (Z-score 3.78), demonstrated sufficiency in food security. By 2021, only Ballari (Z-score 3.69) maintained sufficiency in the region. Additionally, the threshold for sufficiency also showed a slight negative change. In 2011, the sufficiency threshold was set at Z-score > 3.76, whereas by 2021, it had

decreased to > 3.50.The decline in food security in 2021 was attributed to the impact of the 2019-2020 Karnataka floods. These events disrupted agricultural activities and food production, contributing to the observed decrease in food security levels in the region.

2. Medium Food Security Regions - Deficiency:

This segment has shown growth from 2011 to 2021. In 2011, three districts (Dharwad with a Z-score of 3.34, Haveri with 3.66, and Uttar Kannada with 3.69) fell within the Z-score range of 3.35 to 3.76. By 2021, three additional districts from the low (severity) range were included in this category: Bagalkot (Z-score 3.27), Belagavi (Z-score 3.47), and Yadgiri (Z-score 3.46).

A positive aspect is that all the newly added districts to this category in 2021 were originally classified under the low (severity) category. This suggests that fewer districts were categorized under 'severity' in 2021 compared to 2011.

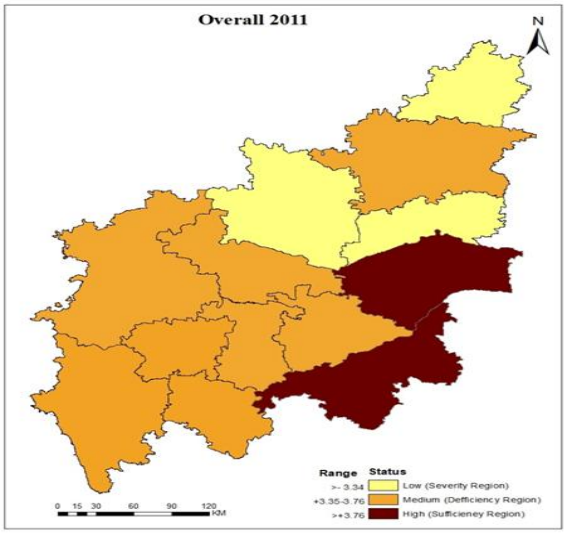
The positive decadal growth observed from 2011 to 2021 can be attributed to increases in per capita income and literacy rates. These factors likely contributed to improved overall food security indicators in the region, leading to the upgrading of certain districts to a more favorable food security category.

3. Low Food Security Region - Severity:

There has been positive development in the severity range of food security indicators. In 2011, there were 8 districts categorized in the severity range with a Z-score range of <3.34. By 2021, the number of districts in this category decreased to 6, and the Z-score range dropped to <3.21.

All districts falling into the low category are characterized as low-income districts, except Gadag. These districts generally have below-average income levels compared to the northern part of Karnataka. Many of these districts have geological compositions that are not well-suited for food crops. For instance, Bidar primarily uses its land for sugarcane cultivation and lacks sufficient irrigation options.

This scenario underscores the challenges faced by these districts in achieving higher food security, despite some improvement in their severity categorization over the decade. Economic factors, coupled with geographic constraints, continue to influence their food security status negatively.



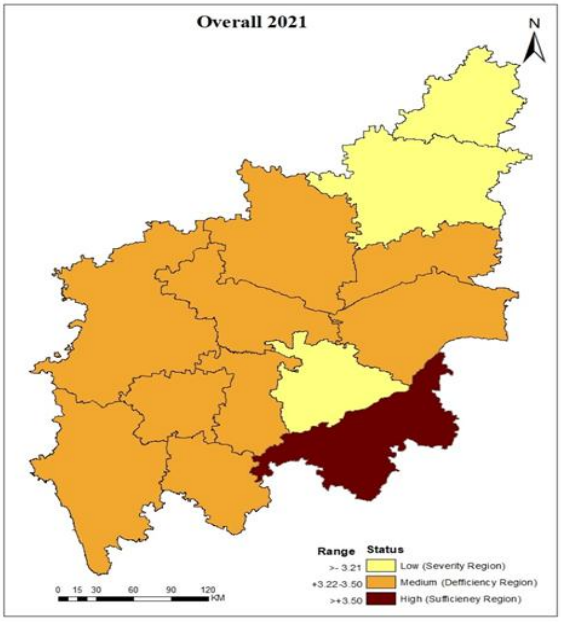


Fig.6

Table 14: District wise Z score (composite standard score) for Food availability, Food, Stability, Food Accessibility Food Utilization, and overall Food Security- 2011-2021 in North Karnataka

Sl. No	Name of the Districts	Food Availability	Food Stability	Food Accessibility	Food Utilization	Overall

		2011	2021	2011	2021	2011	2021	2011	2021	2011	2021
1	Bagalkot	2.39	2.54	1.28	1.3	5.18	5.28	4.05	3.96	3.23	3.27
2	Ballari	2.55	2.12	3.4	2.42	6.26	5.79	4.54	4.43	4.19	3.69
3	Belagavi	2.43	2.55	0.79	1.87	5.51	4.88	4.63	4.59	3.34	3.47
4	Bidar	1.48	1.19	0.78	0.61	4.66	4.89	4.16	3.96	2.77	2.66
5	Dharwad	1.32	1.21	1.57	0.72	6.58	6.12	4.67	5.25	3.54	3.33
6	Gadag	1.77	1.32	1.06	0.71	5.61	5.64	4.7	4.45	3.29	3.03
7	Haveri	2.06	2.61	2.56	1.2	5.38	4.92	4.63	4.66	3.66	3.35
8	Kalaburagi	1.68	1.18	1.04	1.43	5.23	4.69	4.35	4.28	3.08	2.90
9	Koppal	2.07	2.55	1.32	1.13	4.98	4.27	4.21	3.76	3.15	2.93
10	Raichur	3.21	2.59	2.81	1.83	4.89	4.44	4.19	3.77	3.78	3.16
11	Vijayapura	1.84	1.74	0.88	1.53	4.61	4.64	4.16	4.3	2.87	3.05
12	Yadgiri	1.92	3.09	0.76	2.46	4.75	4.11	4.05	4.17	2.87	3.46
13	Uttara Kannada	1.63	1.69	2.86	1.36	5.37	5.99	4.89	4.53	3.69	3.39

Sources: Computed based on Tables 2- 13

After analysing all segments, it is evident that Food Availability has shown growth across various components. This growth includes an increase in food grain production, livestock farming, and meat production, supported by expanded irrigation facilities. Government initiatives such as Ganga Kalyan and Pradhan Mantri Krishi Sinchayee Yojanas have played a crucial role in extending irrigation facilities, thereby contributing to the increase in food grain production. When farmers have access to irrigation facilities, they are more inclined to diversify into allied agricultural activities such as livestock farming, including sheep rearing and goat farming. This diversification leads to an increase in meat production alongside traditional crop farming.

Overall, the expansion of irrigation facilities has not only bolstered food grain production but has also facilitated diversification in agriculture, enhancing food availability and contributing to improved food security in the region

When considering food stability, there has been a nuanced growth pattern. While the area under food grain cultivation and fertilizer consumption have decreased, there has been an increase in the yield of food grains. This trend suggests a shift among farmers from conventional farming practices to more modern and scientific approaches aimed at maximizing returns with fewer resources. Farmers are increasingly focusing on locally available crops and adopting agricultural practices that enhance productivity and efficiency. Government policies, such as subsidies, incentives for scientific farming techniques, and support for locally suitable crops, have played a vital role in this transformation.

Overall, this shift towards modern scientific farming practices reflects a strategic adaptation to optimize agricultural output amidst changing environmental and economic conditions. It underscores a pathway towards en

Accessibility, as above mentioned that the food is available, to avail that food all year where accessibility comes in. In this regard this segment has shown growth, because employment rate has increased, MNREGA is also playing important part in it. but fair price shops have gone down, still it considers as good sign cause government have lifted many people from BPL. Literacy is one of the most important aspects of, not only farming but life; literacy gives you rightful information and knowledge about farming filed. Per capita is one of main component of food security more income means assured food security? Good roads connect to market to access the food all year. In past decade roads have shown tremendous growth in region. Urbanization means more people are moving to city, in hope to get

employment and better life and comparatively cities have more job option and access to food.

Utilization, access to clean and safe drinking water is basic human right, and it has shown growth in region through policies like *Jal Jeevan Mission* and *Har Ghar Jal*. Infant and Maternal mortality rate decreased due to awareness, like ensuring delivery at hospitals by doctors. Though maternal and infant mortality rate decreased but numbers of beds in hospitals have become less

VI. MAJOR FINDINGS

Food Availability:

1. Food Grain Production: The average production of food grains increased from 335.15 units in 2011 to 471.42 units in 2021. This substantial increase indicates improved agricultural productivity and a step towards better food security in the region.
2. Livestock Farming: Livestock farming also saw an increase, with the average rising from 0.33 units in 2011 to 0.58 units in 2021. This not only provides additional income sources for the local population but also diversifies livelihood options.
3. Meat Production: The production of meat showed remarkable growth, increasing from 0.83 units in 2011 to 2.97 units in 2021. This reflects changing dietary patterns and increased demand for meat products in the region.
4. Milk Production**:** Milk production, which is a crucial source of nutrients, increased from 25.61 kg per unit to 46 kg per unit from 2011 to 2021. This growth in milk production contributes significantly to nutritional security.
5. Net Irrigated Area: The net irrigated area showed a notable growth of 71.65% during this period. This expansion in irrigated land is essential as it supports increased agricultural productivity by ensuring consistent water supply, thereby contributing to the overall increase in food production.

Food Stability:

1. Area under Food Grains: The area under food grains decreased significantly, with the average area declining from 1,869.42 hectares in 2011 to 451.57 hectares in 2021. This decline could be attributed to various factors, including natural disasters like the 2019 floods, which may have affected agricultural land and productivity.
2. Fertilizer Consumption: Fertilizer consumption also decreased over the decade, from an average of 199.04 kg per hectare in 2011 to 157.51 kg per hectare in 2021. This reduction is likely linked to the decrease in the area under food grains, as farmers may have adjusted their fertilizer use based on reduced cultivation areas.
3. Yield of Food Grains: Despite the decrease in both the area under food grains and fertilizer usage, the yield of food grains saw a significant increase. It rose from 693.78 kg per hectare in 2011 to 1,949.00 kg per hectare in 2021. This substantial increase in yield indicates improved agricultural practices, possibly including better irrigation methods, enhanced seed varieties, and improved farming techniques.

Overall, these trends suggest a shift towards more efficient and productive agricultural practices despite challenges such as reduced land under cultivation and lower fertilizer consumption. The increase in food grain yield highlights the resilience and adaptability of farmers in the region to improve productivity per unit area, contributing positively to food security and agricultural sustainability.

Food Accessibility:

1. Employment Growth: Employment in the region grew by 6% over the decade, indicating increased economic activity and opportunities for livelihoods.
2. Fair Price Shops**:** The number of fair price shops declined, likely due to government initiatives that lifted people out of below poverty line (BPL) status. This reflects improved socio-economic conditions and reduced dependency on subsidized food distribution.
3. Literacy Rate**:** The region witnessed an increasing trend in literacy, rising from 70.16 per cent in 2011 to an estimated 75.69 per cent in 2021. This improvement in literacy enhances access to knowledge and opportunities, including better agricultural practices and overall development.
4. Per Capita Income: Per capita income in the region increased significantly, from 31,267.08 to 109,398.15 units. This substantial growth

indicates improved economic well-being and purchasing power, potentially reducing reliance on subsidized food through fair price shops.

5. Road Infrastructure: The length of roads increased from 272.92 km per lakh population to 327.11 km per lakh population. Improved road infrastructure enhances connectivity, facilitates transportation of agricultural produce to markets, and supports economic growth.
6. Urbanization: Urbanization in the study area increased from 28.07% to 33.97%. This shift towards urban living reflects migration trends and aspirations for better employment opportunities and living standards in urban centres.

Overall, these developments signify positive socio-economic progress in the region, including improved literacy, income levels, infrastructure, and urbanization. These factors collectively contribute to enhancing living standards, economic opportunities, and potentially improving food security by increasing accessibility to diverse food sources.

Food Utilization:

1. Access to Drinking Water: Access to drinking water facilities increased from 59.21% in 2011 to 67.97% in 2021. This improvement signifies progress in providing a basic necessity essential for health and well-being.
2. Infant and Maternal Mortality: Both infant and maternal mortality rates showed a declining trend over the decade. This positive development indicates improvements in healthcare services, prenatal care, and overall maternal and child health outcomes in the region.
3. Hospital Beds**:** The number of hospital beds per lakh population decreased significantly from 140.78 in 2011 to 21.53 in 2021. This decline in hospital beds raises concerns about healthcare capacity and access to in-patient care facilities, despite advancements in other health indicators.
4. Maternal and Child Health (MCH) Centres**:** MCH Centres increased from 3.41 to 4.36 per lakh population. This increase suggests efforts to improve maternal and child healthcare services, likely contributing to the decline in maternal mortality rates observed.
5. Primary Health Care (PHC) Centres: PHC centres saw a slight decline from 4.37 to 3.37 per lakh population. While there has been a decrease in the number of PHC Centres, these facilities remain crucial for providing primary healthcare services, especially in rural areas where access to healthcare may be limited.

Overall, while there are improvements in access to drinking water and declines in mortality rates, the decrease in hospital beds and PHC centres highlights challenges in healthcare infrastructure and accessibility that need attention for sustained improvements in public health outcomes.

REFERENCES

[1] Srivastava, A., Kaur, S., Srivastava, A., & Singh, N. (2010). Assessment on vulnerability of sorghum to climate change in India. Indian Journal of Agricultural Sciences, 138 (2010) 160–169.

[2] Singh, A. K. (2015). Carbon emission and global food security: A cross-country analysis. Journal of Environmental Economics and Management, 2(1):7-24

[3] Martins, B. O. (2020). The impact of climate change on food security: A case study of Karnataka, India. International Journal of Climate Change Strategies and Management, 10.13140/RG.2.2.24853.35042.

[4] Konda, C. (2018). Climate Change and Food Security in India: Some Issues and Challenges. Journal of Agricultural Development and Policy, ISSN: 2320-2882

[5] Rosenzweig, C. (1994). Potential impact of climate change on world food supply. Nature, 133–138

[6] Tacoli, E., Bukhari, B., & Fisher, S. (2013). Urban poverty, food security and climate change. Human Settlements Working Paper, ISBN: 978-1-84369-914-9

[7] Kanamaru, H. (2009). Food security under a changing climate. International Journal of Climate Change Strategies and Management, 127503338

[8] Sirba, H. Y., & Begna, T. (2022). Review of Impact of Climate Change on Food Security in Africa. African Journal of Agricultural Research Volume 8, Issue 3,

[9] Semenov, M. A. (1995). Climatic variability and the modelling of crop yields. Agricultural and Forest Meteorology, 73(3-4), 265-283.
[10] Chakrabarty, M. (2016). Climate change and food security in India. Journal of Food Security, ISSUE NO. 157.
[11] Farooq, M. S., Hussain, A., & Rehman, A. (2022). Uncovering the Research Gaps to Alleviate the Negative Impacts of Climate Change on Food Security: A Review. International Journal of Environmental Research and Public Health, Volume 13
[12] Maisonet-Guzman, O. E. (2021). Food Security and Population Growth in the 21st Century. Journal of Population and Development,
[13] Lloyd, S. J., Kovats, R. S., & Chalabi, Z. (2011). Climate Change, Crop Yields, and Undernutrition: Development of a Model to Quantify the Impact of Climate Scenarios on Child Undernutrition. Environmental Health Perspectives, 21844000
[14] Raj, S., & Kumar, R. (2022). Food Security and Climate Change: Differences in Impacts and Adaptation Strategies for Rural Communities in the Global South and North. Global Environmental Change, Volume 5.
[15] Downing, T. E., & Patwardhan, A. (2002). Climate Change and Food Insecurity: Toward a Sociology and Geography of Vulnerability. Global Environmental Change, 10.1007/978-3-642-61086-8_7
[16] Bano, W. (2020). Food Security Programmes in Karnataka: A brief snapshot. Journal of Food Security and Nutrition, Volume 8, Issue 4