A GEOGRAPHICAL ANALYSIS OF FOOD SECURITY STATUS IN BIHAR, INDIA

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Abstract

The present study attempts to highlight the status of food security and its components like food accessibility, availability and stability across the districts of Bihar, India. Based on secondary data, multidimensional index has been calculated through the indicators approach to assess the status of food security and its components. The results reveal that there are wide variations in terms of food security in the state depending upon the dissimilarities in availability, accessibility, and stability of food. Rohtas district has emerged as the most secure in terms of food security, followed by Kaimur, Katihar, Madhepura, and Nalanda districts. On the other hand, Madhubani district has been found as the most insecure, followed by Siwan, Purba Champaran, Gaya and Sitamarhi districts. The correlation matrix reveals that food availability and food stability are significantly associated with the food security index. Hence, study recommends that food accessibility in Bihar can be improved by removing the spatial disparity of food security.

Keywords: Food accessibility, Food availability, Food security, Food stability, Bihar.

Introduction

The word "food security" has been used in a variety of contexts around the world (Smith et al., 1993). However, the definition "Food security exists when all peoples, at all times, have access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" given by FAO (1996) is widely accepted and used. The four components of this definition are; food availability, food accessibility, food usage, and food stability (Gross et al., 2000). The first component food availability focuses on the supply side that is produced locally or imported from any area. In other words, it describes the region's accessible food stock and net trade in food items (Rajput and Arora, 2021). Bengal famine 1943, in which people remained without food and starved to death, because they could not afford it, has left a memorable mark on the public's consciousness of the crucial need for access to food (Sen, 1981). The ability to obtain food is measured by food accessibility which is influenced by social structure, political will, and factors such as household and individual's purchasing power, food prices, and legal entitlements (Singh and Singh 2019). The food utilization component evaluates whether people or families get adequate energy and nutrients from their food (Jatav et al., 2022). Food stability refers to food security of a population, home or individual that must always have access to enough food. Individuals shouldn't have to go without food because of sudden events, such as an economic downturn, a natural disaster, or

cyclical occurrences, such as the seasonal scarcity of food. The concept of stability includes both people's access to and availability of secure food supply (Anderson, 2019).

Food insecurity is a widespread issue that continues at varying levels of severity. It is connected to the irregularity or unpredictability about the availability of food, water and fuel and may be influenced by a number of factors. Undernutrition, overweight, and obesity are caused by food insecurity, and many nations have high rates of these types of malnutrition (FAO, 2018). Malnutrition not only denies people their right to health; but also has a serious economic implication (Sajjad, 2011). Therefore, UNO (2015) has set zero hunger, food security, improved nutrition and promotion of sustainable agriculture as one of the major goals for the world to be attained by 2030, especially in low-income countries. Food insecure households may have a higher risk for multiple chronic health conditions and obesity, which may be explained by the higher expense of nutrient-dense foods, the stress of dealing with food insecurity, and physiological adaptations to dietary restrictions. The total number of people over the globe who suffer from chronic food insecurity or undernourishment climbed up from about 600 million in 2016 to almost 620 million in 2019 (FAO, 2021). About 278 million people in Africa, 425 million people in Asia, and 56.5 million people in Latin America and the Caribbean have been affected by hunger (FAO, 2022). The state of food security in India is also not far better, as it has been ranked 68th out of 113 countries in the Global Food Security Index (GFSI, 2022). While, in Global Hunger Index (GHI, 2022), India has been placed at 107th position out of 121 countries and depicted worse conditions than its surrounding countries. CNNS (2019)

has reported that "among all the states, Bihar has the highest percentage of stunted (below-average height for age) children. One of India's worst states for malnutrition is Bihar. Its rate of stunted children under the age of five (48 per cent), is the highest in India. Bihar has the second-highest percentage of women (30 per cent) and children (43 per cent) who are overweight and also has been one of the five states in India with the highest percentage of women and children who are anemic (TCI, 2022). Among the households belonging to the richest consumption class, the probability of better food and nutrition security is high in rural Bihar. In contrast, the households with low social status especially of scheduled castes have reduced food security (Dutta and Mishra, 2021). Mohan and Thakur (2014) have pointed that no nation or region can hope to flourish in the environment of political, economic or social stability without securing ample and nutritious food for its population either through domestic production or imports. The above-mentioned studies are either based on a dietary approach or other dynamics of food security. None of the study has been found to be related to highlighting the status of food security at district level in Bihar. So, the present study bridges this research gap by highlighting the status of food security and its components in Bihar.

Objectives of the Study

Major objectives of the study are:
- to highlight inter-district variation in the status of food security and its components in Bihar and
- to assess the association among the components of food security.

Study Area

The state of Bihar is located in between

the latitudes of 24° 20' 10" N to 27° 31' 15" N and longitudes of 83° 19' 50" E to 88° 17' 40" E (Fig. 1). With about 104 million population, it is the third most populated state in India after Uttar Pradesh and Maharashtra. Geographically, it is situated in the lower and middle Ganga plain, which is drained by various rivers along with the river Ganga. Administratively, the state is divided into nine divisions, 38 districts and 534 blocks. With a population density of 1106 people per km^2, Bihar is one of the most densely populated state in India. It is also known as the "state of youth" since the majority of its population (58 per cent) is under the age of 25, and urban areas are home of 11.3 per cent of Bihar's total population (Census, 2011). Bihar is primarily an agricultural state, as about 70 per cent of its main workers have been engaged in agriculture and allied activities (Census, 2011). The high percentage of food grains (94.0 per cent) in the total gross cultivated area is an indication of subsistence farming (Singh et al., 2021). In Bihar, over 43 per cent of children under the age of five have stunted growth or are underweight for their age. At the same time, 42 per cent of women and 36 per cent of men are either too thin, overweight, or obese (IIPS, 2021).

Database and Methodology

Latest available secondary data have been extracted from the Census of India 2011, Bihar Economic Survey 2019-20, Livestock Census of India 2012 and Bihar Statistical Handbook 2018. Based on the availability of district-wise data, 14 variables have been selected under different components of food security (Table 1). Due to data constraints, food utilization component of food security has been left out of study. United Nations Development Program's (UNDP's) normalization technique has been used for data normalization:

$$XI = \frac{Xi - Min(Xi)}{Max(Xi) - Min(Xi)} \qquad (1)$$

$$XI = \frac{Max(Xi) - Xi}{Max(Xi) - Min(Xi)} \qquad (2)$$

where XI is the index value of variable i, Xi is the actual value of variable i, Min (Xi) is the minimum value of variable i, and Max (Xi) is the maximum value of variable i. Further, equation 1 has been used for the normalization of positively related variables, while equation 2 has been used for negatively related variables. The positive and negative association of selected variables to the food security index has been adopted from Jatav et al. (2022) as shown in Table 1. Normalized scores of all the selected variables have been presented in Table 2. After the normalization of raw data, food availability, accessibility, and stability indices have been calculated by using the arithmetic mean of the normalized scores of selected variables under the given components (Table 1). Finally, the district-wise Food Security Index has been assessed as the geometric mean of its componential indices, calculated as under:

$$FSIi = \sqrt[3]{FAIi \times FACIi \times FSTIi} \qquad (3)$$

where $FSIi$ is the Food security index of district i, $FAIi$ is the Food availability index of district i, $FACIi$ is the Food accessibility index of district i and $FSTIi$ is the Food stability index of district i. To prepare maps, the Arc-Map 10 Software has been used and quartile technique has been adopted for the categorization of districts into very high, high, medium, and low categories. Karl Pearson's correlation coefficient has been calculated to find out the interrelationship between food security and its components.

Fig. 1

Table 1
Bihar: Selected Variables for Measuring the Status of Food Security

Components	Variables
Food Availability	X_1. Number of livestock per 1000 population*
	X_2. Per capita availability of food grains (kg/year)*
	X_3. Per capita availability of fruits (kg/year)*
	X_4. Per capita availability of vegetables (kg/year)*
	X_5. Per capita availability of milk (liters)*
Food Accessibility	X_6. Literacy rate (per cent)*
	X_7. Per capita state domestic product (Rupees)*
	X_8. Road length per lakh population (kms)*
	X_9. Urbanization rate (per cent)#
	X_{10}. Population below poverty line (per cent)#
Food stability	X_{11}. Yield of food grains (kg/ha)*
	X_{12}. Consumption of fertilizers per unit of gross cropped area (kg/ha)*
	X_{13}. Gross irrigated area to gross sown area (per cent)*
	X_{14}. Cropping intensity (per cent)*

Source: Compiled by Authors. # Negatively; * Positively associated with Food Security Index.

Results and Discussion
Food Availability

The study reveals that Madhepura (0.58), Rohtas (0.52), Katihar (0.52), Nalanda (0.50), and Khagaria (0.48) have been the top-performing districts in availability of food, while Gaya (0.13), Sitamarhi (0.15), Saran (0.17), Nawada (0.18), and Siwan (0.19) have been found to be the least-performing districts (Table 3; Fig 2). The cross-variables analysis between Madhepura (top performing) and Gaya (bottom performing) districts reveals that the per capita availability of fruits, food grains, vegetables, milk, and the number of livestock per thousand population is considerably greater in the Madhepura district than in Gaya district. The Gaya and Madhepura districts respectively have recorded 79 kg and 297 kg per person availability of food grains; 339 and 788 livestock per thousand persons; 8 and 46 kg/person fruits; 10 and 117 kg/year vegetables per person and 79 and 111kg/year per capita availability of milk (Table 4). The study further

shows that out of the total 38 districts, 8 districts, namely Madhepura, Rohtas, Katihar, Nalanda, Khagaria, Supaul, Kaimur, and Saharsa have recorded very high levels of food availability. By registering food availability scores ranging between 0.34 and 0.40, ten districts like Banka, Bhagalpur, Araria, Sheohar, Samastipur, Arwal, Begusarai, Buxar, Vaishali, and Kishanganj have reported high levels of food availability. All these districts with very high or high levels of food availability have witnessed comparatively good agricultural conditions due to the combination of favourable cropping intensity, high gross irrigated area, and per unit consumption of chemical fertilizers. Therefore, these districts have witnessed high to very high levels of food availability. Further, Sheikhpura, Aurangabad, Bhojpur, Lakhisarai, Munger, Muzaffarpur, Jamui, Jahanabad, Pashchim Champaran and Purnia districts have registered moderate levels of food availability. The districts of Purba Champaran, Darbhanga, Patna, Gopalganj,

Table 2

Bihar: Normalized Scores of Selected Variables for Measuring the Status of Food Security

District	Normalized Scores of Variables													
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
Araria	0.87	0.30	0.05	0.15	0.59	0.11	0.03	0.63	0.94	0.39	0.68	0.37	0.25	0.96
Arwal	0.18	0.45	0.20	0.35	0.60	0.73	0.04	0.24	0.90	0.61	0.34	0.11	0.90	0.47
Aurangabad	0.27	0.66	0.00	0.15	0.46	0.86	0.07	0.93	0.85	0.50	0.18	0.11	0.85	0.37
Banka	0.62	0.17	0.35	0.21	0.66	0.32	0.04	0.79	1.00	0.82	0.25	0.11	0.69	0.24
Begusarai	0.15	0.27	0.32	0.34	0.65	0.57	0.19	0.00	0.60	0.72	0.43	0.72	0.64	0.45
Bhagalpur	0.44	0.16	0.47	0.30	0.62	0.54	0.18	0.21	0.59	0.57	0.46	0.55	0.53	0.16
Bhojpur	0.16	0.42	0.20	0.20	0.57	0.87	0.10	0.28	0.73	0.73	0.28	0.33	0.91	0.00
Buxar	0.19	0.56	0.26	0.18	0.56	0.86	0.08	0.50	0.85	0.82	0.28	0.24	0.91	0.38
Darbhanga	0.09	0.04	0.57	0.33	0.19	0.25	0.07	0.38	0.84	0.68	0.37	0.27	0.64	0.11
Gaya	0.31	0.05	0.03	0.00	0.29	0.57	0.09	0.59	0.76	0.61	0.29	0.18	0.87	0.11
Gopalganj	0.10	0.11	0.28	0.39	0.15	0.65	0.09	0.42	0.93	0.79	0.16	0.00	0.59	0.47
Jamui	0.60	0.04	0.09	0.14	0.50	0.84	0.06	1.00	0.88	0.54	0.08	0.19	0.28	0.81
Jahanabad	0.20	0.25	0.10	0.29	0.49	0.71	0.07	0.65	0.79	0.83	0.46	0.13	0.71	0.89
Kaimur	0.34	0.77	0.33	0.11	0.66	0.82	0.06	0.84	0.99	0.78	0.32	0.21	0.92	0.46
Katihar	0.44	0.48	1.00	0.34	0.32	0.05	0.08	0.31	0.86	0.68	0.72	0.58	0.61	0.49
Khagaria	0.30	0.44	0.39	0.27	1.00	0.31	0.08	0.14	0.96	0.50	0.41	1.00	0.56	0.40
Kishanganj	0.59	0.13	0.20	0.23	0.54	0.20	0.05	0.74	0.85	0.00	0.45	0.14	0.00	0.39
Lakhisarai	0.24	0.41	0.11	0.18	0.62	0.51	0.11	0.22	0.73	0.92	0.33	0.04	0.73	0.35
Madhepura	1.00	0.61	0.49	0.30	0.54	0.05	0.03	0.47	0.98	0.40	0.83	0.42	0.55	0.46
Madhubani	0.24	0.09	0.24	0.22	0.22	0.34	0.04	0.47	1.00	0.35	0.08	0.00	0.14	0.45
Munger	0.23	0.00	0.24	0.43	0.66	0.87	0.27	0.12	0.39	0.53	0.11	0.21	0.73	0.09
Muzaffarpur	0.16	0.17	0.68	0.18	0.29	0.55	0.15	0.41	0.84	0.44	0.20	0.29	0.44	0.46
Nalanda	0.15	0.33	0.37	1.00	0.68	0.60	0.10	0.48	0.69	0.57	0.35	0.37	0.89	0.43
Nawada	0.26	0.13	0.05	0.23	0.25	0.39	0.04	0.40	0.84	0.79	0.14	0.03	0.92	0.09
Pashchim Champaran	0.27	0.16	0.37	0.34	0.23	0.21	0.05	0.30	0.84	0.40	0.30	0.13	0.75	0.62
Patna	0.00	0.08	0.23	0.46	0.34	0.88	1.00	0.14	0.00	0.77	0.49	0.32	0.63	0.20
Purba Champaran	0.22	0.18	0.41	0.25	0.19	0.21	0.07	0.36	0.89	0.32	0.10	0.19	0.32	0.44
Purnia	0.33	0.36	0.21	0.17	0.28	0.00	0.05	0.53	0.82	0.51	1.00	0.95	0.73	0.05
Rohtas	0.35	1.00	0.40	0.37	0.49	1.00	0.12	0.48	0.72	0.83	0.29	0.24	1.00	0.41
Saharsa	0.45	0.37	0.44	0.30	0.53	0.10	0.09	0.34	0.88	0.52	0.43	0.27	0.45	1.00
Samastipur	0.18	0.24	0.52	0.28	0.57	0.48	0.07	0.33	1.00	0.79	0.38	0.20	0.65	0.77
Saran	0.06	0.10	0.21	0.24	0.27	0.67	0.06	0.43	0.86	0.81	0.12	0.37	0.44	0.18
Sheikhpura	0.23	0.19	0.17	0.51	0.54	0.57	0.05	0.66	0.66	0.80	0.00	0.26	0.88	0.25
Sheohar	0.22	0.18	0.72	0.52	0.30	0.12	0.00	0.35	0.98	0.41	0.37	0.12	0.39	1.00
Sitamarhi	0.10	0.24	0.25	0.16	0.00	0.04	0.04	0.15	0.95	0.41	0.48	0.12	0.81	0.86
Siwan	0.10	0.15	0.23	0.29	0.17	0.82	0.06	0.27	0.95	1.00	0.10	0.11	0.27	0.35
Supaul	0.66	0.35	0.20	0.19	0.99	0.30	0.03	0.59	0.97	0.33	0.61	0.17	0.55	0.69
Vaishali	0.08	0.03	0.79	0.50	0.33	0.70	0.10	0.41	0.92	0.44	0.14	0.50	0.54	0.45
State Average	**0.27**	**0.25**	**0.35**	**0.29**	**0.40**	**0.48**	**0.13**	**0.42**	**0.80**	**0.59**	**0.47**	**0.27**	**0.61**	**0.42**

Source: Compiled by Authors.

Table 3
Bihar: District-wise Food Availability Index

District	Index	District	Index	District	Index
Madhepura	0.59	Arwal	0.35	Pashchim Champaran	0.27
Katihar	0.52	Begusarai	0.35	Purnia	0.27
Rohtas	0.52	Buxar	0.35	Purba Champaran	0.25
Nalanda	0.50	Vaishali	0.35	Darbhanga	0.24
Khagaria	0.48	Kishanganj	0.34	Patna	0.22
Supaul	0.48	Sheikhpura	0.33	Gopalganj	0.20
Kaimur	0.44	Aurangabad	0.31	Madhubani	0.20
Saharsa	0.42	Bhojpur	0.31	Siwan	0.19
Banka	0.40	Lakhisarai	0.31	Nawada	0.18
Bhagalpur	0.40	Munger	0.31	Saran	0.17
Araria	0.39	Muzaffarpur	0.30	Sitamarhi	0.15
Sheohar	0.39	Jamui	0.27	Gaya	0.13
Samastipur	0.36	Jahanabad	0.27	**State Average**	**0.31**

Source: Compiled by Authors.

Madhubani, Siwan, Nawada, Saran, Sitamarhi, and Gaya have witnessed low levels of food availability (Fig. 2). Due to the low cropping intensity, gross irrigated area, and per unit consumption of chemical fertilizers, these districts are agriculturally backward. As a result, these districts have witnessed low per capita availability of food grain and milk, along with low availability of livestock per thousand persons.

Further, the study reveals wide inter-regional variations in the levels of food availability in Bihar. Most of the districts along the north-western border have low level of food availability, while the districts along the south-western border have a high level of food availability. Except for the Purnia district, all the districts along the eastern border of the state have shown a high level of food availability (Fig. 2). The study further reveals that per capita availability of milk (r = 0.68), food grains (r = 0.63), and per thousand livestock availability (r = 0.55) have a strong positive relationship with food availability index. It shows that the high availability of food grains, animal products, and milk is directly related to the high level of food availability. While, per capita availability of vegetables, has not been significantly related with the food availability index. Hence, inter-regional variations in the food availability have not been affected by per capita availability of vegetables. Thus, the study suggests that to enhance food availability, emphasis should be given to the development of agriculture and animal husbandry in the state.

Food Accessibility

In food accessibility index, Kaimur (0.70) has been the top performing district followed by Jamui (0.66), Aurangabad (0.64), Rohtas (0.63), Buxar (0.62) and Siwan (0.62) districts. On the other hand, Sitamarhi (0.32), Paschim Champaran (0.36), Seohar (0.37), Purba Champaran (0.37), and Kishanganj (0.37) have been the least-performing districts (Table 5). The cross-variable analysis of the top-performing district Kaimur and least-performing district Sitamarhi reveals strong

Table 4
Bihar: Data on Selected Variables

| District	Variables													
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
Araria	706	176	10	65	118	53	8776	121	6	65	3143	498	49	191
Arwal	260	232	22	135	120	67	9125	79	7	57	2345	267	90	149
Aurangabad	319	314	5	62	101	70	11012	152	9	61	1963	267	87	140
Banka	545	126	34	84	127	58	9269	138	3	49	2131	270	77	128
Begusarai	236	165	32	133	125	64	17587	54	19	53	2568	803	74	146
Bhagalpur	426	121	44	120	122	63	17324	76	20	58	2636	659	67	121
Bhojpur	248	222	22	84	115	70	12459	84	14	53	2212	460	91	107
Buxar	266	278	27	76	114	70	11289	107	10	50	2212	381	91	140
Darbhanga	202	76	53	129	67	56	10932	94	10	55	2410	407	74	116
Gaya	339	79	8	10	79	64	11897	117	13	57	2225	328	89	116
Gopalganj	203	100	28	150	62	65	12129	98	6	51	1912	170	71	149
Jamui	529	75	13	59	107	70	10166	160	8	60	1729	340	51	178
Jahanabad	270	156	14	116	105	67	11182	123	12	49	2643	283	78	185
Kaimur	364	359	32	49	127	69	10412	143	4	51	2311	358	92	147
Katihar	429	245	89	135	83	52	11278	87	9	55	3241	682	72	150
Khagaria	338	231	38	106	171	58	11515	69	5	61	2524	1056	69	142
Kishanganj	523	110	22	94	111	55	9928	132	9	79	2609	296	33	141
Lakhisarai	299	218	14	76	122	62	13073	77	14	46	2334	206	80	137
Madhepura	788	297	46	117	111	52	8609	104	4	65	3511	544	68	148
Madhubani	295	95	25	89	70	59	9241	104	4	67	1727	169	42	146
Munger	291	60	26	165	127	70	22051	67	28	60	1795	352	80	115
Muzaffarpur	249	125	62	76	79	63	15402	97	10	63	2029	424	61	148
Nalanda	237	187	36	373	129	64	12561	105	16	59	2372	501	90	145
Nawada	312	110	9	95	75	60	9560	96	10	51	1883	192	91	115
Pashchim Champaran	316	120	36	132	72	56	9971	86	10	65	2264	281	81	162
Patna	142	90	25	177	86	71	63063	69	43	51	2700	450	73	125
Purba Champaran	284	129	39	101	67	56	10735	92	8	67	1788	341	53	146
Purnia	358	197	22	72	79	51	10099	110	10	61	3912	1011	80	111
Rohtas	369	447	39	144	106	73	13909	105	14	49	2233	379	97	143
Saharsa	432	203	42	120	111	53	12197	90	8	60	2560	410	62	195
Samastipur	259	151	48	111	116	62	10762	89	3	51	2436	347	74	175
Saran	182	97	22	95	78	66	10615	100	9	50	1833	495	61	123
Sheikhpura	288	135	20	196	111	64	9687	124	17	50	1547	395	89	129
Sheohar	281	130	66	199	81	54	7092	91	4	64	2410	278	58	195
Sitamarhi	208	151	27	68	43	52	9538	70	6	64	2685	274	84	182
Siwan	209	116	24	115	65	69	10685	83	5	43	1789	269	50	137
Supaul	571	195	22	77	170	58	8492	117	5	67	2979	320	68	168
Vaishali	196	72	72	191	85	67	12490	97	7	63	1878	608	67	146
State Average	**316**	**156**	**35**	**114**	**94**	**62**	**14574**	**98**	**11**	**58**	**2666**	**407**	**72**	**143**

Source: Compiled by Authors.
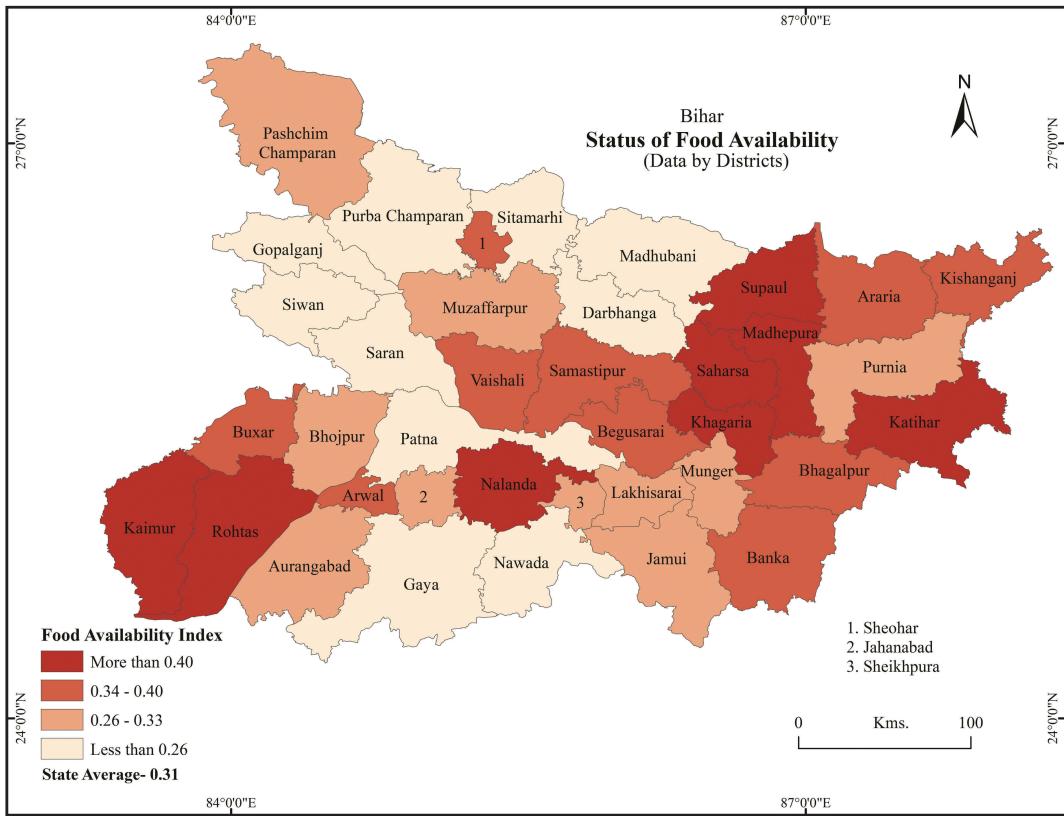
Fig. 2

variations in rate of literacy, road length, Gross Domestic Product (GDP), Below Poverty Line (BPL) population and rate of urbanization. Kaimur and Sitamarhi districts respectively has recorded 69 and 52 per cent rates of literacy; 143 and 70 kilometers road length per lakh of population, GDP of ₹ 10412 and ₹ 9538; 51 and 64 per cent BPL population and 4 and 6 per cent rate of urbanization (Table 4). These observations highlight strong variations in food accessibility between districts in Bihar on account of the variations in size of the urban and BPL populations, literacy rate, per capita income, and road length. The study further reveals that the districts such as Kaimur, Jamui, Aurangabad, Rohtas, Buxar, Siwan, Jahanabad, and Banka have recorded very high

levels of food accessibility by recording an index score of more than 0.57. Whereas, 10 districts namely Gopalganj, Saran, Patna, Sheikhpura, Bhojpur, Samastipur, Gaya, Vaishali, Arwal, and Lakhisarai have registered high levels of food accessibility by witnessing index score ranging between 0.50 to 0.57. These districts have registered high literacy rates, less BPL population and good road networks due to which these districts have recorded high scores in the food accessibility index (Table 4). The districts like Nalanda, Nawada, Muzaffarpur, Darbhanga, Madhubani, Munger, Supaul, Araria, Begusarai, and Bhagalpur fall in the category of moderate level of food accessibility. While, the districts of Katihar, Khagaria, Madhepura, Purnia,

Table 5
Bihar: District-wise Food Accessibility Index

District	Index	District	Index	District	Index
Kaimur	0.70	Samastipur	0.53	Begusarai	0.42
Jamui	0.66	Gaya	0.52	Bhagalpur	0.42
Aurangabad	0.64	Vaishali	0.51	Katihar	0.40
Rohtas	0.63	Arwal	0.50	Khagaria	0.40
Buxar	0.62	Lakhisarai	0.50	Madhepura	0.39
Siwan	0.62	Nalanda	0.49	Purnia	0.38
Jahanabad	0.61	Nawada	0.49	Saharsa	0.38
Banka	0.59	Muzaffarpur	0.48	Kishanganj	0.37
Gopalganj	0.57	Darbhanga	0.44	Purba Champaran	0.37
Saran	0.57	Madhubani	0.44	Sheohar	0.37
Patna	0.56	Munger	0.44	Pashchim Champaran	0.36
Sheikhpura	0.55	Supaul	0.44	Sitamarhi	0.32
Bhojpur	0.54	Araria	0.42	**State Average**	**0.48**

Source: Compiled by Authors.

Saharsa, Kishanganj, Purba Champaran, Sheohar, Pashchim Champaran, and Sitamarhi have registered low level of food accessibility in the state. High illiteracy, mass poverty and poor road network in these districts have been found to be the main factors for their poor performance in food accessibility.

There have been striking regional variations in the levels of food accessibility. The districts of south Bihar have a higher level of food accessibility than the districts of north Bihar. Seven districts namely Kaimur, Jamui, Aurangabad, Rohtas, Buxar, Jahanabad, and Banka located in south Bihar fall in areas of very high level of food accessibility as compared to only Siwan district of north Bihar. The districts along the north-western and north-eastern border areas have a low level of food accessibility. Thus, there have been well marked belts of high and low levels of food accessibility in Bihar (Fig. 3). The study further reveals that literacy rate has a very strong positive relationship (r = 0.81) with food accessibility, while BPL population (r = 0.66)

and road length per lakh population (r = 0.49) have moderate positive association with food accessibility. However, per capita GDP and rate of urbanization have not been found to be significantly related to food accessibility. Therefore, to combat low food accessibility in Bihar, there is a need to enhance the literacy rate, road connectivity, and poverty reduction as these variables control the regional variations in the food accessibility.

Food Stability

The highest level of food stability index has been witnessed by Purnia district (0.68) followed by Katihar (0.60), Khagaria (0.59), Madhepura (0.57), and Sitamarhi (0.57) districts. In this regard, Madhubani (0.16) district has recorded the lowest position in the state followed by Siwan (0.21), Kishanganj (0.25), Purba Champaran (0.26), and Saran (0.28) districts (Table 6). On account of the variables taken to assess the food stability, Purnia district has recorded relatively greater yields of food grains, consumption of fertiliz-
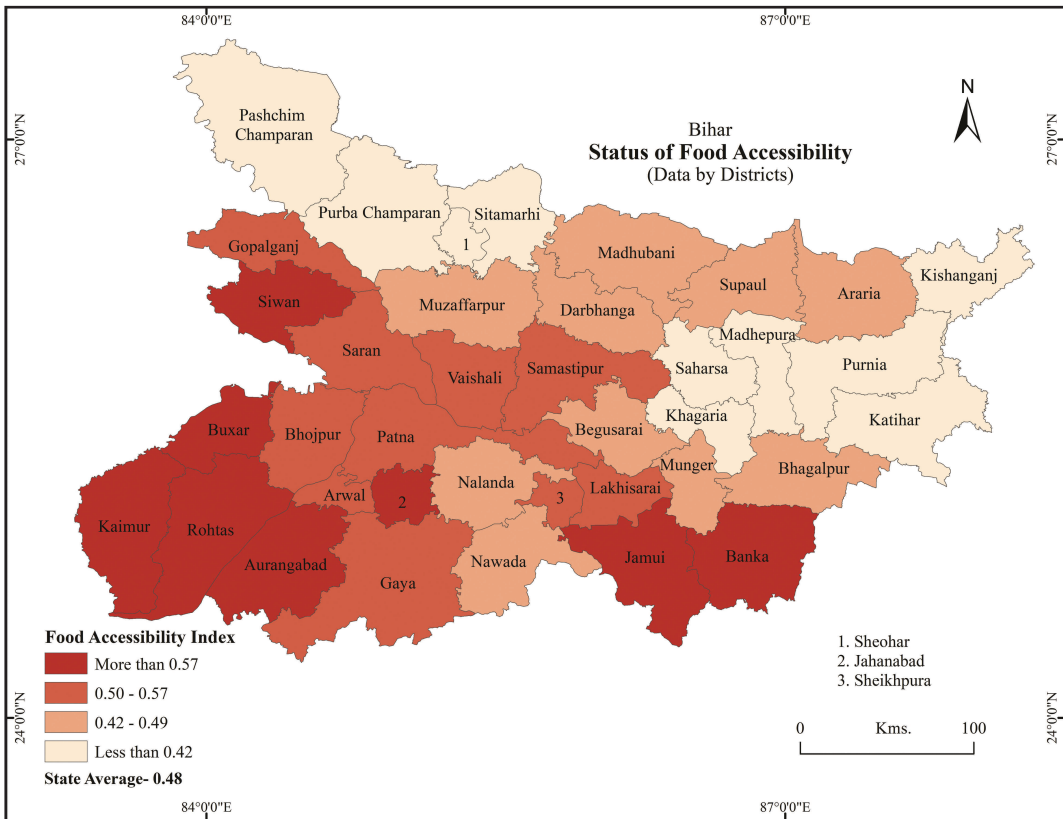
Fig. 3

ers per unit gross cropped area and gross irrigated area than the Madhubani district. Purnia and Madhubani districts respectively have registered 3912 and 1727 kg/ha yield of food grains; 1011 and 169 kg/ha consumption of fertilizers per unit gross cultivated area; 80 and 42 per cent of the gross cultivated area as gross irrigated area (Table 4). The study further reveals that districts like Purnia, Katihar, Khagaria, Madhepura, Sitamarhi, Araria, Begusarai, Jahanabad, and Saharsa have recorded very high levels of food stability by registering food stability index scores more than 0.51. While, Nalanda, Samastipur, Supaul, Kaimur, Rohtas, Sheohar, Arwal, Buxar, and Pashchim Champaran districts have

recorded high levels of food stability by registering index scores varying between 0.44 to 0.51. These districts have recorded high or very high degree of food stability by witnessing very high, high, or moderate scores across the selected variables used to measure the levels of food stability. The moderate level of food stability has been recorded by Bhagalpur, Patna, Vaishali, Aurangabad, Bhojpur, Gaya, Lakhisarai, Darbhanga, Muzaffarpur, and Sheikhpura districts by registering the index scores varying between 0.35 and 0.43. The districts namely Jamui, Banka, Gopalganj, Nawada, Munger, Saran, Purba Champaran, Kishanganj, Siwan, and Madhubani with food stability index scores less than 0.35 have

Table 6
Bihar: District-wise Food Stability Index

District	Index	District	Index	District	Index
Purnia	0.68	Rohtas	0.48	Muzaffarpur	0.35
Katihar	0.60	Sheohar	0.47	Sheikhpura	0.35
Khagaria	0.59	Arwal	0.46	Jamui	0.34
Madhepura	0.57	Buxar	0.45	Banka	0.32
Sitamarhi	0.57	Pashchim Champaran	0.45	Gopalganj	0.30
Araria	0.56	Bhagalpur	0.43	Nawada	0.29
Begusarai	0.56	Patna	0.41	Munger	0.28
Jahanabad	0.55	Vaishali	0.41	Saran	0.28
Saharsa	0.54	Aurangabad	0.38	Purba Champaran	0.26
Nalanda	0.51	Bhojpur	0.38	Kishanganj	0.25
Samastipur	0.50	Gaya	0.36	Siwan	0.21
Supaul	0.50	Lakhisarai	0.36	Madhubani	0.16
Kaimur	0.48	Darbhanga	0.35	**State Average**	**0.44**

Source: Compiled by Authors.

registered low levels of food stability. Low level of cropping intensity, gross irrigated area, per unit yield of food grains and per unit consumption of fertilizers has made these areas as poor performing districts in food stability.

Extensive inter-regional variations have been witnessed in the levels of food stability across the districts in Bihar. Leaving aside a few isolated patches, the areas of very high and high levels of food stability are concentrated in the north-eastern, north-western and south-western parts of the state. Similarly, leaving aside Kishanganj and Madhubani districts, there are well marked patches of low level of food stability in the north-western and south-eastern Bihar. The areas of moderate level of food stability are mostly confined to central and south-western areas of the state (Fig. 4). The study further reveals that the yield of food grains (r = 0.79) and per unit fertilizers consumption (r = 0.60) have strong positive association, while the moderate positive association has been marked by gross irrigated area (r = 0.38) with the food

stability. Whereas, cropping intensity has not been found to be significantly associated with the food stability index. Thus, there is a need for improvement in agricultural infrastructure and inputs like, per unit consumption of fertilizers and extension of irrigation which will improve cropping intensity which raises the yield of food grains.

Food Security

The study reveals that Rohtas district (0.54) has been the most food secure district followed by Kaimur (0.53), Katihar (0.50), Madhepura (0.50), and Nalanda (0.50) districts. While, Madhubani (0.24) has been the most food insecure district followed by Siwan (0.29), Purba Champaran (0.29), Gaya (0.29), and Sitamarhi (0.30) districts (Table 7). Inter-components analysis reveals that Rohtas district has attained 2nd, 4th and 13th position in the food availability, accessibility and stability indices, respectively. While, Madhubani district has secured 33rd, 24th, and 38th rank in the food availability, accessibility, and stability
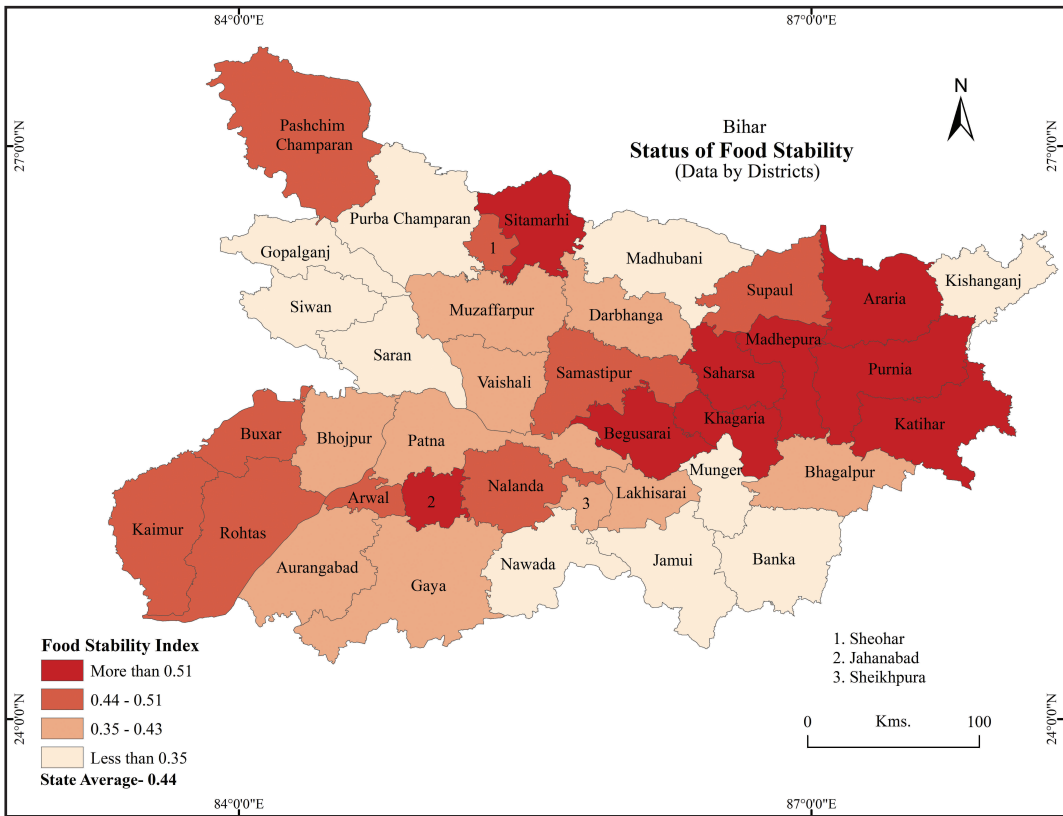
Fig. 4

indices respectively. Thus, the districts with the higher score in the componential indices have a higher level of food security and vice-versa. The study further reveals that Rohtas, Kaimur, Katihar, Madhepura, Nalanda, Khagaria, and Supaul districts have recorded very high levels of food security with an index score of more than 0.46. Whereas, the districts like Buxar, Samastipur, Araria, Jahanabad, Saharsa, Arwal, Banka, Begusarai, Aurangabad, and Vaishali have recorded high levels of food security by scoring indices ranging between 0.42 and 0.46. The above-mentioned districts have recorded very high or high scores for food stability and food availability, along with food accessibility levels varying from very high to

low. By recording food security index varying between 0.34 and 0.41, the moderate level of food security has been witnessed by the districts of Bhagalpur, Purnia, Sheohar, Bhojpur, Jamui, Sheikhpura, Lakhisarai, Muzaffarpur, Patna, Pashchim Champaran, and Munger. Whereas, Darbhanga, Gopalganj, Kishanganj, Nawada, Saran, Sitamarhi, Gaya, Purba Champaran, Siwan, and Madhubani districts have registered low levels of food security with index scores less than 0.34. The low levels of food security in the above-mentioned districts have been on account of low levels in the attainment of food security components, particularly of food availability and food stability.

Table 7
Bihar: District-wise Food Security Index

District	Index	District	Index	District	Index
Rohtas	0.54	Banka	0.43	Pashchim Champaran	0.35
Kaimur	0.53	Begusarai	0.43	Munger	0.34
Katihar	0.50	Aurangabad	0.42	Darbhanga	0.33
Madhepura	0.50	Vaishali	0.42	Gopalganj	0.33
Nalanda	0.50	Bhagalpur	0.41	Kishanganj	0.31
Khagaria	0.48	Purnia	0.41	Nawada	0.30
Supaul	0.47	Sheohar	0.41	Saran	0.30
Buxar	0.46	Bhojpur	0.40	Sitamarhi	0.30
Samastipur	0.46	Jamui	0.40	Gaya	0.29
Araria	0.45	Sheikhpura	0.40	Purba Champaran	0. 29
Jahanabad	0.45	Lakhisarai	0.38	Siwan	0.29
Saharsa	0.44	Muzaffarpur	0.37	Madhubani	0.24
Arwal	0.43	Patna	0.37	**State Average**	**0.41**

Source: Compiled by Authors.

Fig. 5 clearly shows that the high level of food insecurity prevails in north Bihar. Except for Paschim Champaran, all the districts along the north-western border area have witnessed a low level of food security. While, the areas along the south-western and north-eastern borders, except for Kishanganj and Purnia districts, have recorded very high or high levels of food security. Moderate levels of food security have been found mostly concentrated in south-eastern areas along with small patches throughout the state. The study further reveals that the food security index has a very strong positive association with the food availability index (r = 0.87) and food stability index (r = 0.73) at 0.01 level of significance. While the food accessibility index has no significant relation with the food security index in Bihar (Table 8). Thus, to combat food insecurity, special efforts should be made to raise food availability and food stability in the areas of low levels of food security in Bihar.

Conclusions

The study has highlighted the status of food security and its components, namely food availability, accessibility, and stability in the districts of Bihar. The findings reveal consider-

Table 8
Bihar: Correlation between Food Security Index and its Componential Indices

Components	FAVI	FACI	FSTI	FSI
FAVI	1	-0.10	0.54**	0.87**
FACI	-0.10	1	-0.28	0.18
FSTI	0.54**	-0.28	1	0.73**
FSI	0.87**	0.18	0.73**	1

Source: Compiled by Authors. **Significant at 0.01 level (2-tailed); FAVI= Food Availability Index, FACI= Food Accessibility Index, FSTI= Food Stability Index, FSI= Food Security Index
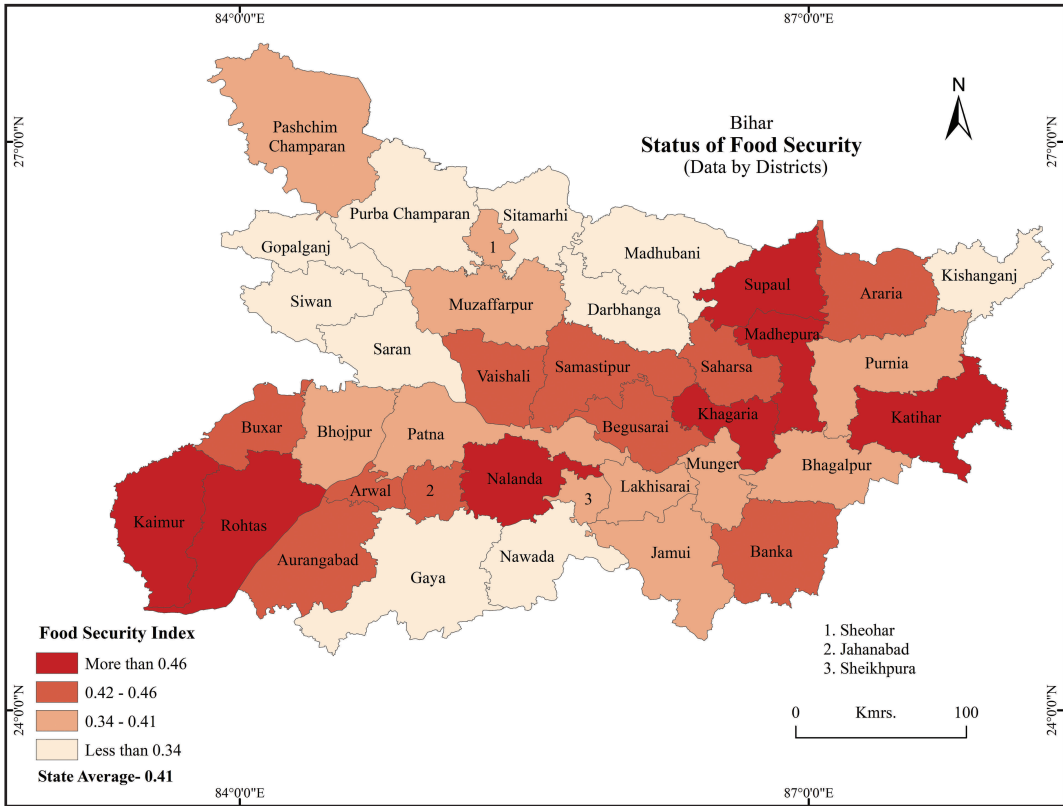
Fig. 5

able inter-district variations in the food availability, accessibility, and stability indices, resulting in wide regional inequality in the levels of food security. It has been found that Madhepura, Katihar, Rohtas, Nalanda, Khagaria, Supaul, Kaimur, and Saharsa districts have recorded very high levels of food availability, while Gaya, Sitamarhi, Saran, Nawada, Siwan, Madhubani, Gopalganj, Patna, and Darbhanga districts have witnessed low levels of food availability. Similarly, Kaimur, Jamui, Aurangabad, Rohtas, Buxar, Siwan, Jahanabad, and Banka districts have registered very high levels of food accessibil-ity, whereas low levels of food accessibility has been found in the districts of Sitamarhi, Pashchim Champaran, Sheohar, Purba

Champaran, Kishanganj, Saharsa, Purnia, Madhepura, Khagaria, and Katihar. Very high levels of food stability have been recorded by the districts of Purnia, Katihar, Khagaria, Madhepura, Sitamarhi, Araria, Begusarai, Jahanabad, and Saharsa; while low levels of food stability have been found in the districts of Madhubani, Siwan, Kishanganj, Purba Champaran, Saran, Munger, Nawada, Gopalganj, Banka, and Jamui. Consequently, by having very high or high levels of food availability and stability, Rohtas district has recorded the highest level of food security followed by Kaimur, Katihar, Madhepura, Nalanda, Khagaria, and Supaul districts. On the other hand, Siwan, Madhubani, Purba Champaran, Sitamarhi, Saran, Nawada,

Kishanganj, Gopalganj, and Darbhanga districts have witnessed low levels of food security. The correlation analysis of the food security index and its componential indices indicates that food stability and availability have considerable positive association with food security; however, food accessibility has shown a negligible relationship with the food security index. The study therefore, suggests that investment should be made in the development of agricultural infrastructure to uplift the productivity of food grains to improve the status of food availability in the state. The study further recommends that to improve food stability, the focus should be given to enhance the per unit yield of food grains by improving cropping intensity as well as gross irrigated area and per unit application of fertilizers. Low food accessibility can be combated by improving literacy rate, road length per lakh population, and by reducing the BPL population. Thus, low levels of food security in Bihar can be eliminated by simultaneously increasing the availability and stability of food.

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