Assessment of Spatio-Temporal Dynamics of Food Security Based on Food Security Index Analysis: A Case from Vaishali District, India

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Abstract. The paper has generated Food Security Index as a composite index of its three component indexes and analyzed spatio-temporal variation in food security at block level in Vaishali district of a backward state in India during 2000-03 and 2007-10. FSI identified not only the blocks requiring immediate attention but also the specific priority areas in which the efforts could be focused to attain long term sustainability of food security. The composite FSI using time series data could help in identifying the priority components and analyzing the progress of development interventions over a period of time aimed at sustainable food security.

Keywords: food security index; spatio-temporal; component indicators; food security; Vaishali

1. Introduction

The definition of food security has under gone many changes since 1970s.The World Food Summit (1974) defined food security as 'availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices' (UN 1975). The initial focus on food security as a global concern was on the volume and stability of food supplies (Anderson 2009). Later it became clear that availability and supply alone can't ensure food security and people need access to that food to gain their 'entitlement' (Sen 1981). Even if availability and access to food is satisfactory, the

biological absorption of food in the body will be determined by the consumption of safe drinking water, hygienic environmental conditions, primary health care and primary education. Finally even if physical and economic access to food is assured, ecological factors will determine the long term sustainability of food security system (Swaminathan 2001). The World Food Summit (1996) adopted the definition of food security as, "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO 1996). It is widely accepted and comprehensive definition which takes into consideration physical, economic, social and ecological access to determine productive and healthy life. Therefore, the concept of food security navigates across the physical supply and availability of food, the macro and micro social systems that determine entitlement to food and nutritional value and the capacity of the body to use food. A common way of combining all these areas is to consider food security from the point of view of availability, accessibility and utilization as important components (Weingärtner 2005).

Food availability is derived through interplay of the combination of domestic food stocks, commercial food imports, food aid programmes and domestic food production (Riely et al. 1999; Aidoo 2013; Yang 2009). The term availability is mostly used in the context of food supplies at a regional or national level (Riely et al. 1999). Food accessibility is determined by the availability of food supplies in the market and market price. Access to food is further determined by availability of food from household's own production, purchasing power of the households to buy food from the market and supply of food to the households from beneficiary schemes. These factors are in turn determined by the entitlements of the household and income generating activities for ensuring food security (Sajjad 2011). Food utilization, which is typically reflected in the nutritional status of an individual, is determined by the quantity and quality of dietary intake, safe drinking water, personal hygiene and primary education, along with health status and its determinants (Omonona et al. 2007; Staatz 2009).

The World Food Conference convened by FAO (1974) proposed resolution that "no person should go to bed hungry and no human being's physical and mental capabilities should be stunted by malnutrition" (FAO 1974). It did not make any dent towards solving the problem. According to FAO's annual hunger report (2009) nearly 850 million people all over the world were undernourished. About 96 per cent of such persons were living in developing countries (FAO 2006). In Asia and the Pacific region, an estimated 642 million people are suffering from chronic hunger. India is home to 42 per cent of the world underweight children and improvement in this indicator since 1990 has been far too slow to suggest that the Millennium Development Goal target of 26.8% by 2015 can be achieved (Millennium Development Goals 2007). State of Food Insecurity in the World currently estimated that 842 million people globally suffered from chronic hunger in 2011-13 (FAO 2013). All these testify to failure to achieve global food security. Currently food security has been greatly undermined globally resulting in food rationing in the developed countries and food riots in the developing countries of Asia and Africa.

Food security has been a major developmental objective in India since the beginning of planning. India achieved self-sufficiency in food grains in the 1970's and has sustained it since then. But the achievement of food grain security at the national level did not percolate down to households and the level of chronic food insecurity is still high. India at present finds itself in the midst of a paradoxical situation: endemic mass-hunger coexisting with the mounting food grain stocks. The food grain stocks available with the Food Corporation of India (FCI) stand at an all time high of 69 million tons against an annual requirement of around 60 million tons for ensuring food security. There may be and probably is sufficient food production in the country to fill all empty or half empty stomachs, but unless every person has a job, bringing him a steady income to buy his needs, how can a country gloat over higher food production and buffer stocks as a proud achievement because scarcity of access to food will remain and even grow with the soaring population. India ranks 63rd with global hunger index score of 21.3 and has been categorized as having alarming situation in hunger (IFPRI 2013). The M. S. Swaminathan Research

Foundation and World Food Program have recently brought out a food insecurity Atlas of rural India. According to the atlas, Bihar is the extremely food insecure state of the country (Swaminathan 2001). This is in line with the findings of the atlas of rural Bihar published by the Institute of Human Development in collaboration with the World Food Program (2009). It is therefore necessary that potential and existing situation of each part of the state should be evaluated with respect to socio economic indicators. In this backdrop, this paper makes an attempt to evaluate status of food security and its spatio-temporal variation using FSI approach in a district of one of the backward states of the country.

2. Materials & methods

Vaishali district is located between the latitudes of $25^0 29'$ N and $26^0 10'$ N and between $85°8'$ E and $85^0 33'$ E longitude with (Figure 1) the area of around 2036 sq. km. The district is bounded by river *Ganga* in the south and Gandak in the west and surrounded by Muzaffarpur district in the north and Samastipur in the East. There are three administrative divisions of the district viz. Hajipur, Mahnar Bazaar, Lalganj and 16 administrative subdivisions viz. Vaishali, Patepur, Belsar, Lalganj, Bhagwanpur, Goraul, Chehrakalan, Mahua, Jandaha, Rajapakar, Raghopur, Bidupur, Desri, Sahdai Buzrug and Mahnar. Earlier the district was divided into 11 community development blocks and five more blocks were created during the last decade.

The study area lies in the middle of Middle Gangetic Plain and north of the *Ganga* River. It has entisols and inceptisols soil orders. Vaishali district generally enjoys a bracing and healthy climate with three well marked seasons viz. winter, summer and rainy season. January is the coldest month when the mercury drops below 5^OC. The summer heat is intense and reaches above 40^0C in the month of May and continues until the rain comes. The average annual rainfall in this area ranges from 100 cm to 150 cm. The land being fertile, no area has been left for wild growth and the entire district is devoid of any forest. The district is famous for banana cultivation. The land being fertile, no area has been left for wild growth and the

entire district is devoid of any forest. The district is famous for banana cultivation. The district has a total population of 2.7 million with decadal growth rate of 26.67%. Population density is 1335 persons/sq.km. The proportion of scheduled caste to the total population is 21%. Sex ratio of total population is 920. Literacy rate is 50.49 % (Census of India, 2001). Economic classification of population shows that 31% are cultivators, 42% are agricultural labourers, 4.0 % are household industry workers and 23.0% are other workers (Census of India 2011).
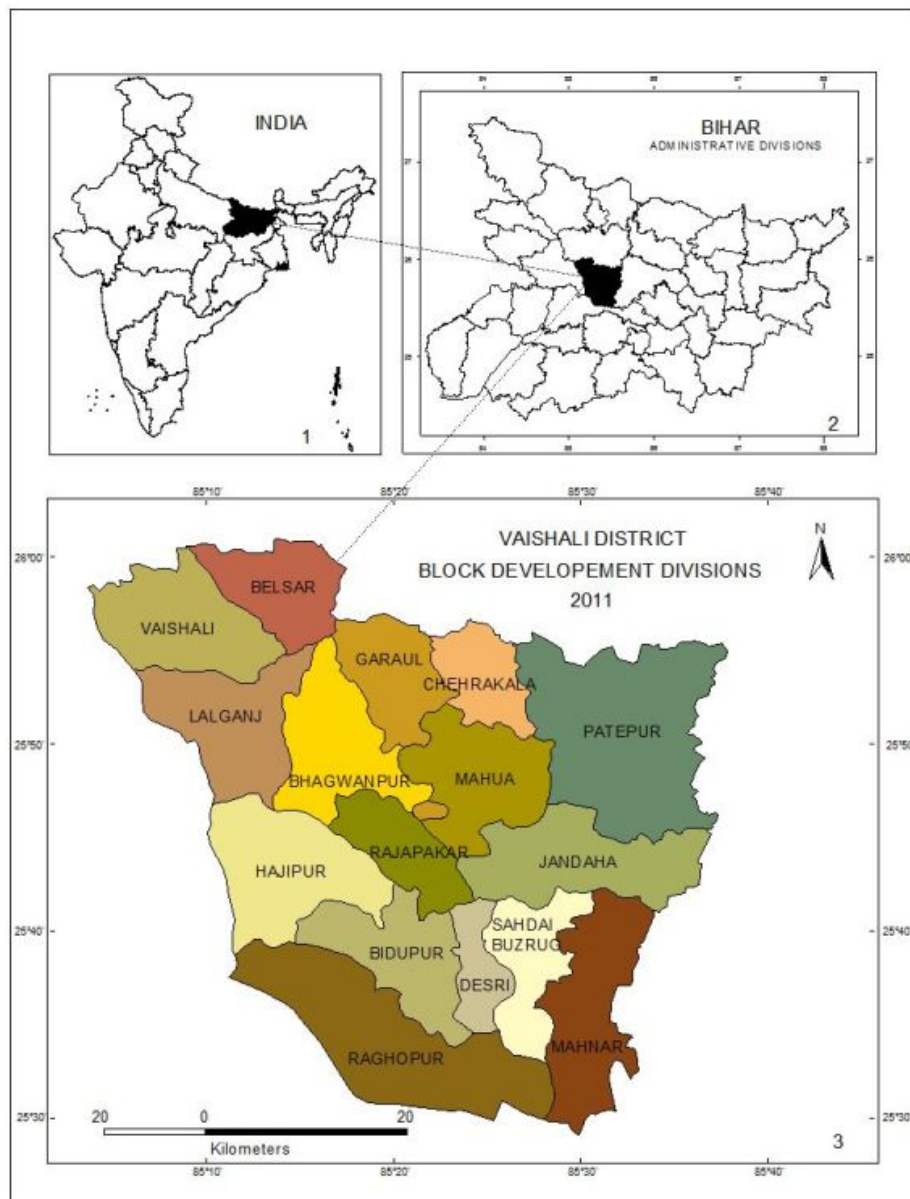

Figure1. Location of study area

2.1. Food Security Index: analytical framework and methodology

For the calculation of food security composite index, division by mean method has been used. Here the mean value for each indicator is calculated. Then the value of each block is divided by the corresponding mean value of independent indicators in case of positive indicator. The outcome is known as Scale Free Value (SFV).

Let SFV be the index for the ith component of SFV related to the jth entity (households in a village context, districts in a state context, regions in a national context, and nations in a global context) and let X_{ij} be the value of the variable representing the ith component of SFV related to the jth entity. Then the index for the ith component of SFV of the jth entity can be calculated as follows:

$$SFV = \frac{X_{ijk}}{\sum X_{ijk} \Big/ N} --------(1)$$

Where

I = Variables (1, 2, 3-------------------, I)

J= Components (1, 2, 3--------------, J)

K=Blocks (1, 2, 3---------------------, K)

In case of negative indicator the mean of an indicator is divided by the corresponding value of each block. The outcome is known as *Scale Free Value (SFV)*.

$$SFV = \frac{\sum X_{ijk} \Big/ N}{X_{ijk}} ----------(2)$$

$$FSCI = SFV_1 * \frac{1}{n} + SFV_2 * \frac{1}{n} + SFV_3 * \frac{1}{n} + ---- SFV_n * \frac{1}{n} -----(3)$$

Where,

 n=the number of indicators used in calculation of a component.

2.2. Rationale for variable selection

Based on availability of block level data, we have selected the following indicators for the construction of FSI:

Food availability indicators: per capita value of agricultural production, proportion of net irrigated area to the net sown area and rural connectivity;

Food accessibility: proportion of agricultural laboureres to the total workers, proportion of scheduled castes and scheduled tribes to the total population and female literacy rate;

Food utilization: percentage of the households having safe drinking water facilities, percentage of villages having primary health care and primary school enrolment per 1000 population.

Sources of the raw data used for the construction of FSI are shown in Table 1. The concern for food availability stems from production and related aspects that sustain a desired level of food production. Domestic production is the main source of food availability (Swaminathan 2001). Agricultural output is an indicator reflecting availability of food. Per capita food production has been chosen since it has great impact on food security. Food grains are considered to be of paramount significance for household food and nutritional security, the reason being that cereals and pulses are staple foods and there are no perfect substitutes for them (Chand 2007). Food grains are also the cheapest source of energy as compared to other foods and are indispensable for the food security of low-income classes (Chand and Kumar 2006). Irrigation has a key role in both stabilizing agricultural production and, through an increase in cropping intensity and an associated increase in productivity, improving a region's food security position. Rural connectivity to market places has important role to play in the agricultural and rural development (Fan et al. 1999; Jacoby 2000). Access to paved roads enables the farmers for bringing their produce to the market timely and saves them from the transition market and exploitation of the middle persons. Thus, it reduces transport costs and can reduce transaction costs, with possible positive results on the prices realized by farmers.

Table 1. Sources of data used for constructing FSI in Vaishali District, Bihar, India

S.N	Data type	Year	Source
1	Proportion of net irrigated area to net sown area (an average of three years)	2000-03 & 2007-10	Agriculture Department, Hajipur, Bihar
2	Per capita food grain output (triennium average)	2000-03 & 2007-10	Directorate of Economics & Statistics, Patna & Agriculture Department, Hajipur, Bihar
3	Proportion of agricultural labourers to total workers	2000-03 & 2007-10	Agriculture Department, Hajipur, Bihar
	Proportion of SC & ST population to total population	2001	Census of India, New Delhi
4	Female literacy	2001	Census of India, New Delhi
		2008*	Projected
5	Inhabited villages with paved road (%)	2001	Census of India, New Delhi
6	Households with safe drinking water	2001	Census of India, New Delhi
7	Inhabited villages with PHC (%)	2001	Census of India, New Delhi
8	Primary school enrolment per 1000 population	2001	Census of India, New Delhi

Access to food or food distribution has been regarded to be the most important factor determining food security. A household's access to food depends on its own production of food and the food it can acquire through sale of labour power or commodities produced by it. These are linked to what Amartya Sen calls endowment and exchange entitlements: 'A person starves *either* because he does not have the ability to command enough food, or because he does not use this ability to avoid starvation. The entitlement approach concentrates on the former, ignoring the latter possibility' (Sen 1981). Agricultural labourers are characterized by extremely

poor socio-economic conditions. They are landless labourers who work on other's farms. Since agriculture is seasonal activity so they do not get employment all the year round (NCEUS 2007). Thus, it is expected that the proportion of agricultural labourers will be negatively related to food security, i.e. the more the agricultural labourers in a district, the worse will be the food security situation. The Scheduled Tribe (ST) and Scheduled Caste (SC) households are known to be generally more food insecure, largely on account of their economic and social deprivation – the former on account of geographical marginalization and the latter due to historical deprivation and exclusion from the mainstream – all resulting in political marginalization. The proportion of ST and SC population in a region has been taken as an indicator of this marginalization. The assumption is that the greater the ST and SC population in a district, the less it will be associated with food security. It is well-known that there are gender-based inequalities in food consumption within a household. Rural female literacy rate has been chosen as the variable to represent gender-based inequality in household consumption. The argument is that a higher literacy rate for women is more likely to enable women to enhance their roles in family decision-making and increase their share of household consumption. At the same time, higher women's literacy is also likely to lead to better knowledge of nutritional systems and improved health practices in the household.

The ability of the body to translate food intake into nutritional status is mediated by a number of factors, some genetic and others related to access of safe drinking water, primary health care facility and primary education. Studies have shown that water and sanitation account for a substantial portion of the difference in infant and child mortality rates experienced by the rich and the poor (Leipziger et al. 2003). Clean and safe water supply is an essential element for achieving food security and good nutrition. Although India has taken huge strides in terms of provision of safe drinking water since Independence, the fact remains that more people in India lack this basic minimum necessity now than 50 years ago. This is besides the fact that more people are vulnerable to waterborne diseases (Gujja and Shaik 2005). Empirical studies have shown that water quality is a big problem in

rural areas (Krishnan et al. 2003). The health infrastructure prevents the local inhabitants from exposure to diseases, for instance, through assuring food safety, vector control and health education to improve personal health behavior (Gupta 2005). In rural areas, all the health services are pivoted around the physical health centers; hence we have taken access to them as an indicator of determining food absorption.

2.3. Procedure for calculating food security index

The indexes for all the representative variables were calculated by a straightforward application of Eq. (1) to the values of the selected indicators (Table 2 & 3). The indexes for the indicators are shown in Table 4 & 5. The three component index of FSI, i.e. the food availability index, the food accessibility index and the food utilization index are calculated by taking the equal weights of the index of the respective representative variables. In calculating these indexes, we have assumed equal weights. All the indexes were mapped using Arc GIS.

3. Results and discussion

Spatio-temporal variation and relative performance of FSI and its component index (availability, accessibility, and utilization) at the block (administrative subdivision) level are presented in Table 6 and Figure 2, 3, 4 and 5. During 2000-03 high food availability was recorded in seven blocks viz. Belsar, Garaul, Chehrakalan, Vaishali, Lalganj, Sahdai Buzrug and Bhagwanpur. Six blocks including Patepur, Hajipur, Rajapakar, Bidupur, Desri and Mahnar came under the medium category. Only three blocks of Raghopur, Mahua and Jandaha formed the low food availability regions (Figure 2).

During the next phase of the study (2007-10) the food availability has declined in Sahdai Buzrug and Desri mainly due to decrease in area under irrigation and per capita food grain output. Only Raghopur block has experienced in food availability due to better irrigation facilities and increase in production.

Table 2. Raw data used for the calculation of FSI in Vaishali district (2000-03)

Blocks	Availability indicators			Accessibility indicators			Utilization indicators		
	Proportion of net irrigated area to net sown area	Per capita food grain output (In kg/annum)	Percentage of Inhabited villages having paved roads	Percentage of Agricultural laboureres to total workers	Percentage of SC & ST population to total population	Rate of Female literacy	Percentage of household having safe drinking water	Percentage of inhabited villages having PHC	Primary school enrolment per 1000 population
Hajipur	34.0	83.9	61.7	30.2	22.9	43.0	86.6	2.9	156
Lalganj	57.0	117.3	58.3	44.6	23.0	35.5	89.3	1.1	164
Bhagwanpur	73.4	100.9	48.5	44.5	19.9	39.3	85.2	2.0	155
Vaishali	73.7	149.5	39.4	50.0	18.3	36.3	89.2	0.9	189
Belsar	68.1	196.3	37.7	46.0	23.5	34.5	50.0	4.2	224
Bidupur	94.7	59.8	35.6	38.1	19.0	39.4	72.0	0.9	124
Raghopur	46.3	75.3	24.3	40.1	17.0	19.6	80.2	3.4	67
Mahua	24.0	83.4	33.7	39.9	22.1	35.7	78.0	3.9	131
Rajapakar	60.2	111.0	32.9	36.4	29.2	37.4	86.5	0.0	190
Patepur	54.8	131.1	27.8	50.4	21.9	28.2	91.0	1.4	143
Garaul	57.0	161.9	48.4	39.7	20.6	35.3	71.2	1.2	183
Chehrakalan	69.4	154.4	42.6	39.2	21.5	31.2	84.8	2.0	185
Jandaha	17.9	101.3	38.3	43.7	21.6	36.0	40.7	0.0	119
Mahnar	24.6	151.5	44.3	44.9	21.9	37.9	65.6	2.0	167
Sahdai Buzrug	85.7	126.1	32.8	41.4	20.3	37.5	88.9	3.3	158
Desri	39.1	122.0	32.2	41.2	21.8	36.6	53.8	2.4	161

Table 3. Raw data used for the calculation of FSI in Vaishali district (2007-10)

Blocks	Availability indicators			Accessibility indicators			Utilization indicators		
	Proportion of net irrigated area to net sown area	Per capita food grain output (In kg/ annum)	Percentage of Inhabited villages having paved roads	Percentage of Agricultural laboureres to total workers	Percentage of SC & ST population to total population	Rate of Female literacy	Percentage of household having safe drinking water	Percentage of inhabited villages having PHC	Primary school enrolment per 1000 population
Hajipur	37.3	64.8	61.7	28.5	25.9	65.7	86.6	2.9	195
Lalganj	67.3	94.1	58.3	47.6	25.3	50.9	89.3	1.1	217
Bhagwanpur	74.3	69.8	48.5	42.9	20.7	59.1	85.2	2.0	218
Vaishali	90.7	115.8	39.4	51.5	16.7	56.4	89.2	0.9	234
Belsar	61.5	127.8	37.7	47.4	21.5	53.5	50.0	4.2	210
Bidupur	57.8	45.6	35.6	35.1	19.3	56.3	72.0	0.9	191
Raghopur	52.1	89.1	24.3	36.0	15.9	32.6	80.2	3.4	103
Mahua	1.2	72.8	33.7	42.1	26.8	53.7	78.0	3.9	210
Rajapakar	64.3	95.7	32.9	35.2	32.0	57.9	86.5	0.0	219
Patepur	51.4	112.4	27.8	51.5	21.8	38.0	91.0	1.4	205
Garaul	41.1	151.7	48.4	34.2	20.1	55.5	71.2	1.2	215
Chehrakalan	74.6	95.6	42.6	33.7	20.9	49.1	84.8	2.0	213
Jandaha	15.7	94.3	38.3	43.0	23.8	56.5	40.7	0.0	124
Mahnar	19.1	97.4	44.3	44.8	24.9	51.8	65.6	2.0	221
Sahdai Buzrug	65.8	81.0	32.8	38.1	20.9	54.8	88.9	3.3	212
Desri	35.2	75.2	32.2	37.9	22.4	53.5	53.8	2.4	214

Table 4. Component indexes of food security in Vaishali district, Bihar (2000-2003)

Blocks	Availability indices			Accessibility indices			Utilization indices		
	Proportion of net irrigated area to net sown area	Per capita food grain out put	Inhabited villages having paved roads	Percentage of Agricultural laboureres to total workers	Percentage of SC & ST population to total population	Rate of Female literacy	Percentage of household having safe drinking water	Percentage of inhabited villages having PHC	Primary school enrolment per 1000 population
	Index	Index	Index	Index	Index	Index	Index	Index	Index
Hajipur	0.21	0.23	0.51	0.46	0.31	0.41	0.38	0.49	0.33
Lalganj	0.35	0.32	0.49	0.31	0.31	0.34	0.39	0.18	0.35
Bhagwanpur	0.45	0.28	0.41	0.31	0.36	0.37	0.37	0.34	0.33
Vaishali	0.45	0.41	0.33	0.28	0.39	0.34	0.39	0.16	0.40
Belsar	0.41	0.54	0.31	0.30	0.31	0.33	0.22	0.70	0.47
Bidupur	0.57	0.17	0.30	0.37	0.38	0.37	0.32	0.15	0.26
Raghopur	0.28	0.21	0.20	0.35	0.42	0.19	0.35	0.57	0.14
Mahua	0.15	0.23	0.28	0.35	0.32	0.34	0.34	0.66	0.28
Rajapakar	0.36	0.31	0.28	0.38	0.25	0.35	0.38	0.00	0.40
Patepur	0.33	0.36	0.23	0.28	0.33	0.27	0.40	0.24	0.30
Garaul	0.35	0.45	0.40	0.35	0.35	0.33	0.31	0.20	0.39
Chehrakalan	0.42	0.43	0.36	0.36	0.33	0.30	0.37	0.34	0.39
Jandaha	0.11	0.28	0.32	0.32	0.33	0.34	0.18	0.00	0.25
Mahnar	0.15	0.42	0.37	0.31	0.33	0.36	0.29	0.34	0.35
Sahdai Buzrug	0.52	0.35	0.27	0.34	0.35	0.35	0.39	0.55	0.33
Desri	0.24	0.34	0.27	0.34	0.33	0.35	0.24	0.41	0.34

Table 5. Component indexes of food security in Vaishali district, Bihar (2007-2010)

Blocks	Availability indices			Accessibility indices			Utilization indices		
	Proportion of net irrigated area to net sown area	Per capita food grain out put	Inhabited villages having paved roads	Percentage of Agricultural laboureres to total workers	Percentage of SC & ST population to total population	Rate of Female literacy	Percentage of household having safe drinking water	Percentage of inhabited villages having PHC	Primary school enrolment per 1000 population
	Index	Index	Index	Index	Index	Index	Index	Index	Index
Bhagwanpur	0.49	0.25	0.41	0.32	0.36	0.37	0.37	0.34	0.36
Vaishali	0.60	0.42	0.33	0.26	0.45	0.36	0.39	0.16	0.39
Belsar	0.41	0.46	0.31	0.29	0.35	0.34	0.22	0.70	0.35
Bidupur	0.38	0.16	0.30	0.39	0.39	0.36	0.32	0.15	0.32
Raghopur	0.34	0.32	0.20	0.38	0.47	0.21	0.35	0.57	0.17
Mahua	0.01	0.26	0.28	0.32	0.28	0.34	0.34	0.66	0.35
Rajapakar	0.42	0.34	0.28	0.38	0.23	0.37	0.38	0.00	0.36
Patepur	0.34	0.40	0.23	0.26	0.34	0.24	0.40	0.24	0.34
Garaul	0.27	0.55	0.40	0.40	0.37	0.35	0.31	0.20	0.36
Chehrakalan	0.49	0.34	0.36	0.40	0.36	0.31	0.37	0.34	0.35
Jandaha	0.10	0.34	0.32	0.31	0.31	0.36	0.18	0.00	0.21
Mahnar	0.13	0.35	0.37	0.30	0.30	0.33	0.29	0.34	0.37
Sahdai Buzrug	0.43	0.29	0.27	0.36	0.36	0.35	0.39	0.55	0.35
Desri	0.23	0.27	0.27	0.36	0.33	0.34	0.24	0.41	0.36

Vaishali, Belsar, Lalganj, Bhagwanpur, Garaul and Chehrakalan have remained high food availability regions during 2007-10. However, Belsar and Chehrakalan have shown declining trend in their food availability index. Hajipur, Rajapakar, Bidupur, Mahnar and Patepur have remained moderate food availability regions but Bidupur and Mahnar have experienced decline in their respective index while Mahua and Jandaha have remained low food availability blocks during this phase. Thus in the light of analysis, Mahua, Jandaha, Bidupur, Mahnar, Belsar and Chehrakalan and Sahdai Buzrug need immediate attention for improving their food availability status. Food availability is decreasing in the district mainly due to climatic factors and commercialization of agriculture. The production of rice is decreasing due to less irrigation facilities while production of sugarcane and tobacco is increasing. The cultivation of cash crops is hampering the food grain production and subsequently food grain availability is declining (Table 7).

Remarkable regional variation was found in food accessibility among blocks of the district from 2000-03 to 2007-10 (Figure 3). High concentration of food accessibility during 2000-03 has been observed only in two blocks of Hajipur and Bidupur. Vaishali, Bhagwanpur, Garaul, Chehrakalan, Mahua, Rajapakar, Jandaha, Desri, Sahdai Buzrug and Mahnar were found to have medium food accessibility status. Four blocks experienced low food accessibility status viz. Belsar, Lalganj, Patepur and Raghopur. During 2007-10, Vaishali, Garaul and Chehrakalan blocks experienced increase in food accessibility as these have become high food accessibility blocks. Jandaha and Mahnar came under low concentration of food accessibility regions as their index slipped from medium to low category. It is attributed to the increase in the proportion of scheduled caste population. Raghopur and Belsar have experienced increase in food accessibility as they have attained medium status in 2007-10. Hajipur and Bidupur have remained high in food accessibility. Bhagwanpur, Rajapakar, and Desri have remained in the

concentration of medium food accessibility. Hence, Jandaha, Mahnar, Lalganj and Patepur are priority areas for improving food accessibility.

Food utilization depends on many social factors. Access to safe drinking water, personal hygiene, primary health care and literacy are the prime factors which determine proper utilization of food consumed. High social food utilization pattern was observed in Belsar, Chehrakalan, Mahua, Hajipur and Sahdai Buzrug during first phase of the study (2000-03). Vaishali, Lalganj, Bhagwanpur, Garaul, Patepur, Rajapakar, Raghopur, Desri and Mahnar were found to have medium concentration of food utilization. Two blocks were found to have low food utilization viz. Bidupur and Jandaha. During the next phase of the period i.e. 2007-10, only Bhagwanpur and Raghopur have attained their status having high concentration of food utilization. Bidupur improved in food utilization from low to medium concentration during this period. Belsar, Chehrakalan, Mahua, Hajipur and Sahdai Buzrug have remained high food utilization regions but Hajipur and Belsar have shown decline in food utilization during the study period. Vaishali, Lalganj, Garaul, Patepur, Rajapakar, Desri and Mahua blocks have maintained their status as medium food utilization regions. However, Vaishali, Garaul and Rajapakar have observed decline in their respective food utilization index while Jandaha has remained as low food utilization block (Figure 4). The analysis shows Belsar, Hajipur, Vaishali, Garaul, Rajapakar and Jandaha are the blocks which need prioritization in food utilization component of food security. Safe drinking water facilities, primary health care and education among the masses need to be encouraged in these blocks of the study area.

During 2000-03, eight blocks namely Vaishali, Belsar, Garaul, Chehrakalan, Lalganj, Bhagwanpur, Hajipur and Sahdai Buzrug were found to have high food security index. Seven blocks viz. Mahua, Patepur, Rajapakar, Bidupur, Raghopur, Desri and Mahnar were having medium food security index while only one block i.e. Jandaha was found to have low food security index.

Table 6. Block-wise ranking of the availability, accessibility, utilization and food security composite indexes in Vaishali district, Bihar (2000-03 and 2007-10)

| Blocks	Food availability index				Food accessibility index				Food utilization index				Food security composite index			
	2000-03		2007-10		2000-03		2007-10		2000-03		2007-10		2000-03		2007-10	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Hajipur	0.95	9	0.99	9	1.18	1	1.18	1	1.21	4	1.20	4	1.11	3	1.12	3
Lalganj	1.16	5	1.27	2	0.96	14	0.90	15	0.92	12	0.94	11	1.01	8	1.04	8
Bhagwanpur	1.13	7	1.15	6	1.05	4	1.05	8	1.04	7	1.07	7	1.07	5	1.09	6
Vaishali	1.19	4	1.34	1	1.02	7	1.07	5	0.95	11	0.94	12	1.05	6	1.12	2
Belsar	1.27	1	1.18	5	0.94	15	0.97	12	1.40	1	1.27	3	1.20	1	1.14	1
Bidupur	1.04	8	0.84	13	1.12	2	1.13	2	0.73	15	0.78	14	0.96	11	0.92	13
Raghopur	0.69	15	0.87	11	0.96	13	1.05	7	1.06	6	1.09	5	0.90	15	1.00	9
Mahua	0.66	16	0.55	16	1.01	8	0.94	13	1.28	3	1.35	1	0.98	9	0.95	10
Rajapakar	0.95	10	1.04	7	0.98	12	0.98	11	0.78	14	0.75	15	0.90	14	0.92	14
Patepur	0.93	12	0.98	10	0.87	16	0.85	16	0.95	10	0.99	10	0.92	13	0.94	11
Garaul	1.20	2	1.22	3	1.03	5	1.12	3	0.90	13	0.87	13	1.04	7	1.07	7
Chehrakalan	1.20	3	1.19	4	0.99	11	1.07	4	1.11	5	1.07	6	1.10	4	1.11	5
Jandaha	0.71	14	0.76	15	0.99	10	0.98	10	0.43	16	0.39	16	0.71	16	0.71	16
Mahnar	0.94	11	0.85	12	1.00	9	0.93	14	0.98	9	0.99	9	0.97	10	0.92	15
Sahdai Buzrug	1.14	6	1.00	8	1.05	3	1.06	6	1.28	2	1.30	2	1.16	2	1.12	4
Desri	0.84	13	0.77	14	1.02	6	1.03	9	0.99	8	1.00	8	0.95	12	0.93	12
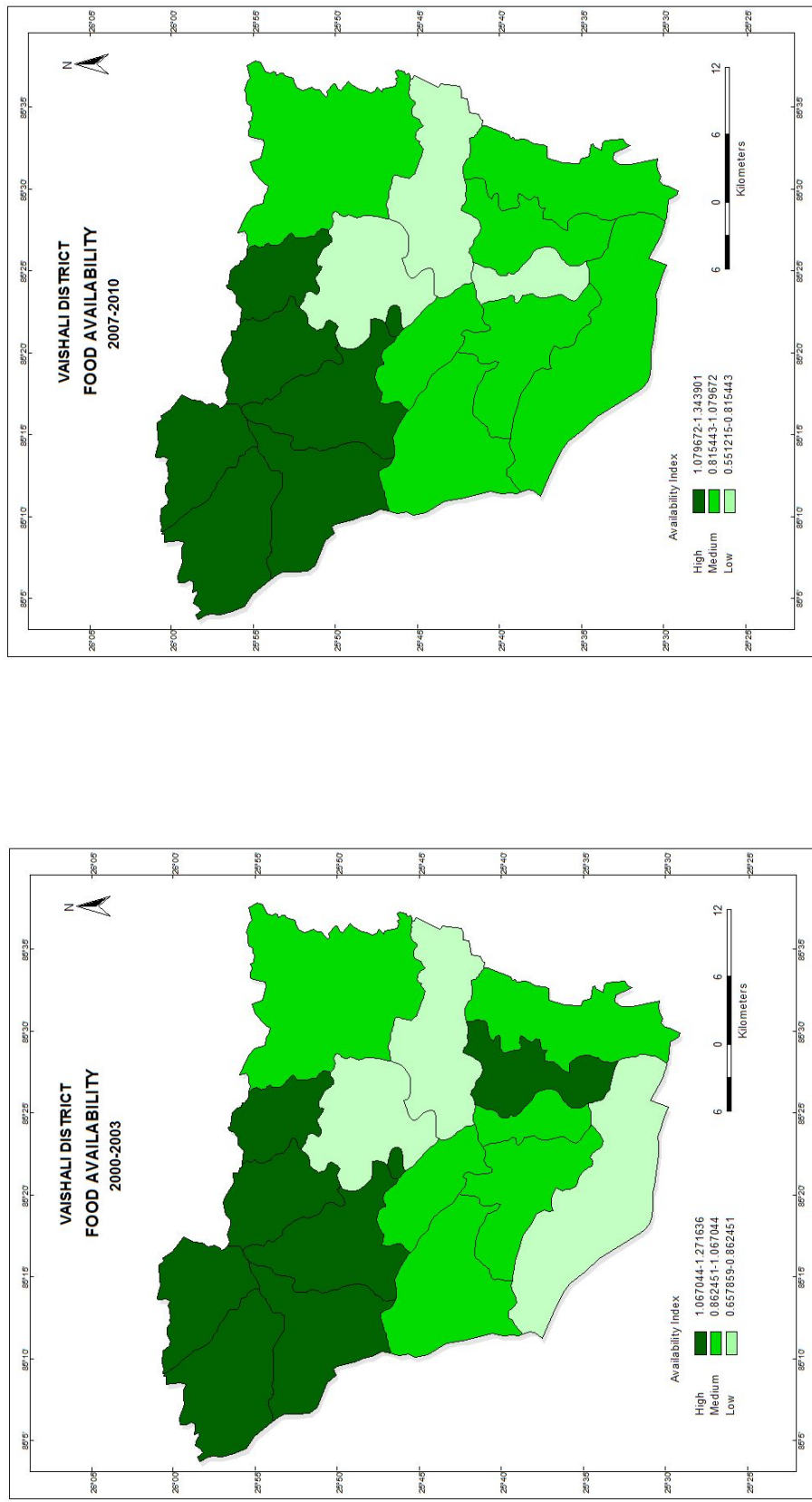
Figure 2. Spatio-temporal variation in food availability in Vaishali district (2000-03 and 2007-10)

Table 7. Production of crops in Vaishali district (2000-03 & 2007-10)

| Blocks	Rice		Wheat		Maize		Oil Seeds		Pulses		Sugarcane		Tobacco	
	2000-03	2007-10	2000-03	2007-10	2000-03	2007-10	2000-03	2007-10	2000-03	2007-10	2000-03	2007-10	2000-03	2007-10
Hajipur	5012	4100	6980	8816	6313	2986	144	150	1013	400	625	950	590	665
Lalganj	6582	4374	6295	9787	6487	3552	156	168	1029	384	948	1134	811	885
Bhagwanpur	4729	3148	6209	6895	4662	1961	127	140	771	301	730	1198	686	883
Vaishali	7320	4851	6529	9396	6968	3633	155	176	1056	384	994	1599	813	1001
Belsar	5559	2882	4208	6001	4234	1987	120	118	617	293	682	882	528	684
Bidupur	3812	3015	4176	5059	3784	1952	100	123	628	301	698	734	488	421
Raghopur	1511	828	8735	13615	3057	2595	133	170	840	1308	-	-	332	313
Mahua	5665	4198	8069	10164	4014	2521	125	116	466	466	505	582	395	565
Rajapakar	4216	2829	5081	7368	3516	2183	89	103	531	368	478	688	446	647
Patepur	12703	8951	15436	20606	7798	4543	179	182	1143	956	1323	1919	1055	1259
Garaul	7663	5518	6701	13131	7043	3523	110	151	536	459	1340	1866	797	1160
Chehrakalan	5544	3183	3795	4879	5509	2257	94	148	721	368	1275	1820	969	1137
Jandaha	5160	3721	10250	14914	5011	2445	107	122	628	392	1063	1635	901	1056
Mahnar	5626	2939	4188	5247	5594	2588	126	155	752	384	927	1388	877	1084
Sahdai Buzrug	4700	2540	3195	3602	3979	2125	97	142	660	384	876	1350	812	1069
Desri	2575	1744	2901	2700	3646	1585	94	113	362	302	749	945	678	907
Vaishali District	88382	58827	102754	142183	81621	42442	1961	2282	11759	7450	13220	18694	11184	13739
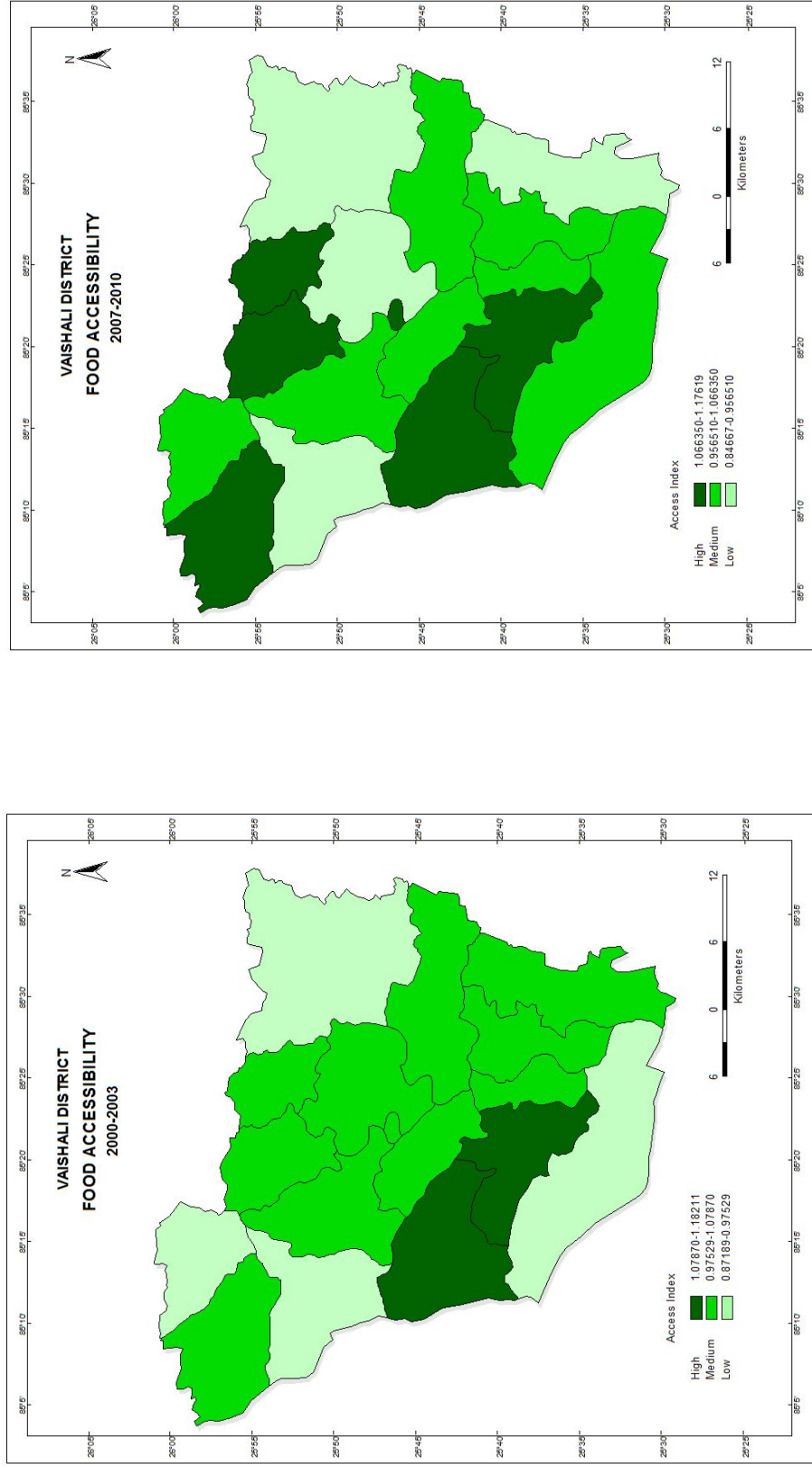
Figure 3. Spatio-temporal variation in food accessibility in Vaishali district (2000-03 and 2007-10)

During next phase of the study (2007-10), only Raghopur has improved its position from medium to high food security block. Vaishali, Belsar, Lalganj, Bhagwanpur, Garaul, Chehrakalan, Hajipur and Sahdai Buzrug have remained high food security blocks but it was observed that Belsar, Bhagwanpur and Sahdai Buzrug showed decline in their ranks. Patepur, Mahua, Rajapakar, Bidupur, Desri and Mahnar have remained medium food security regions. Temporal analysis shows that among these blocks, Mahua, Bidupur, Desri and Mahnar experienced decline in food security index. Jandaha has remained low food security block (Fig. 5). Belsar, Bhagwanpur, Sahdai Buzrug, Mahua, Bidupur, Desri, Mahnar and Jandaha blocks of the district must be taken as priority areas for improving food security.

Jandaha was at 16th rank in food security 2000-03 and remained at the same position during 2007-10. It has the lowest FSI rank because of its very low food availability, food accessibility and food utilization index. Hence agricultural, economic and social developments require immediate attention in Jandaha. Rajapakar ranked 14th in food security the first phase of the study and remained in the same rank in the second phase of the study. However it has improved its food availability and accessibility but it has experienced decline in food utilization index. Therefore it requires improvement in drinking water and health care facilities together with awareness of personal hygiene. Similarly Desri remained at 12th rank in food security during the study period. Its status in terms of food availability and food accessibility has declined and food utilization remained the same. This block requires policy intervention for agricultural, economic and social development. Mahnar, Bidupur, Sahdai Buzrug, Mahua, Bhagwanpur and Chehrakalan also experienced decline in food security status. In all these blocks food availability has declined mainly due to decrease in irrigation area and consequent decrease in per capita food grain production. These blocks have also experienced increase in the proportion of scheduled caste population and therefore engulfed in low accessibility of food.
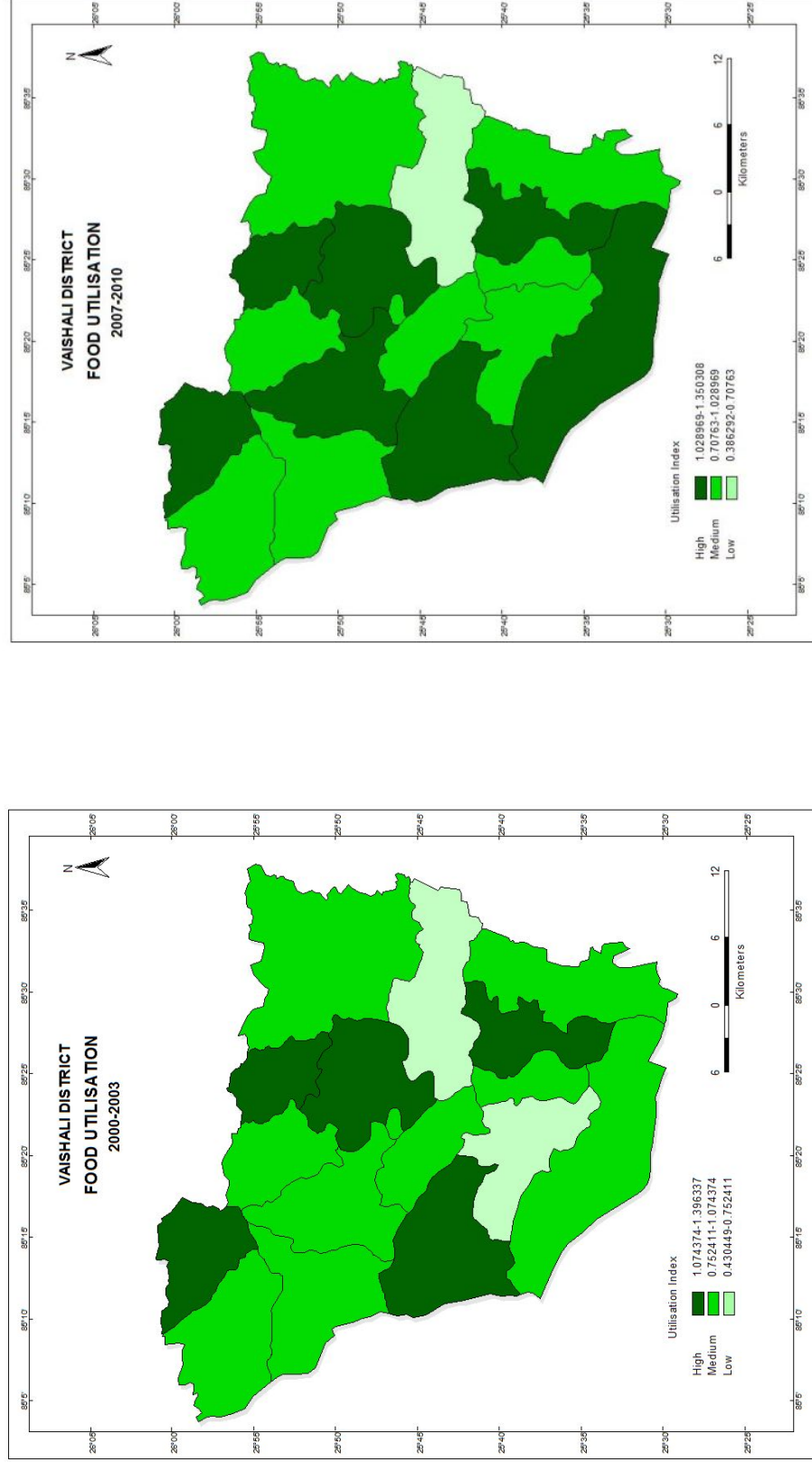
Figure 4. Spatio-temporal variation in food utilization in Vaishali district (2000-03 and 2007-10)
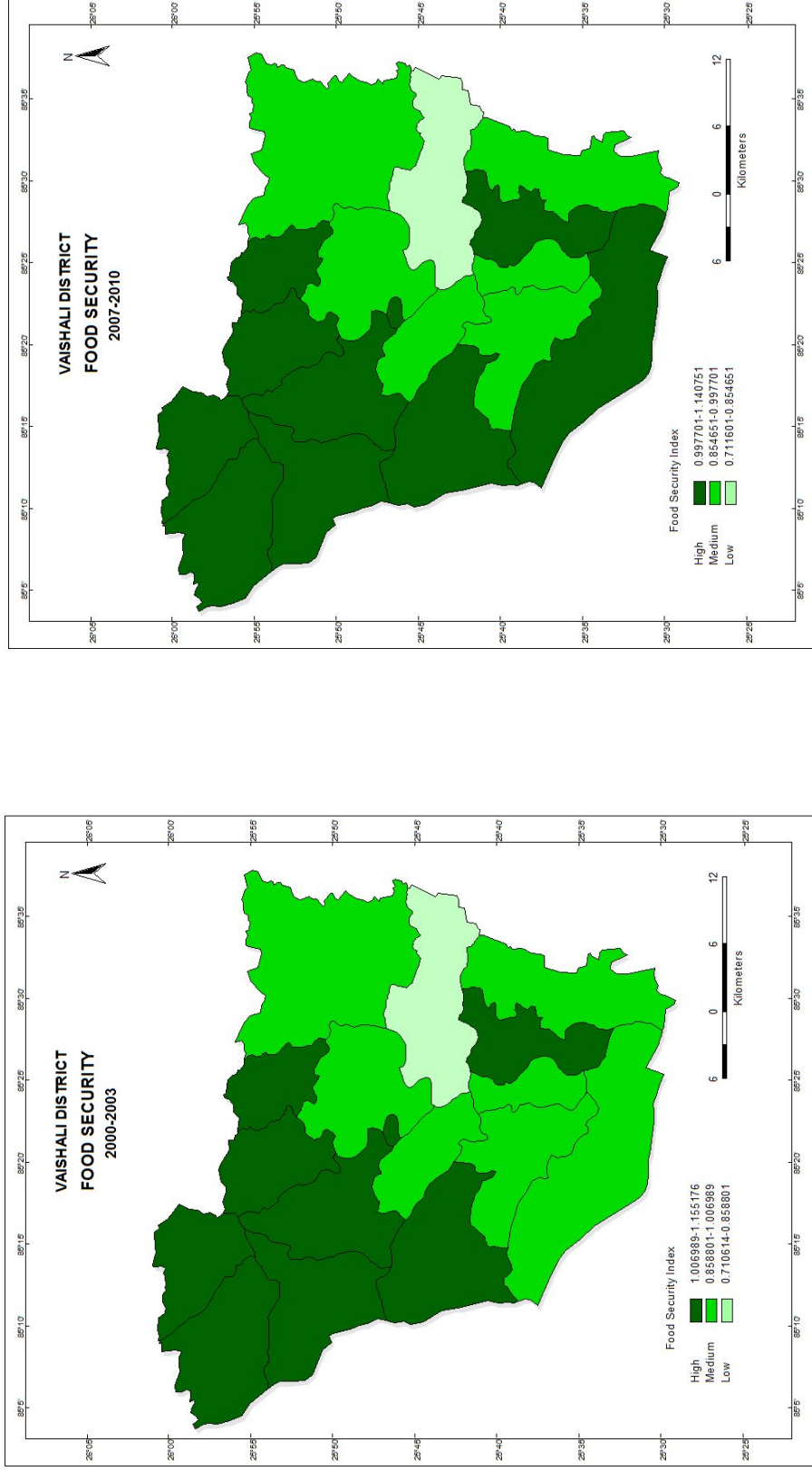
Figure 5. Spatio-temporal variation in food security in Vaishali district (2000-03 and 2007-10)

Thus, unless proper management of irrigation and economic development programmes are initiated, food security of these blocks will not be sustained in the long run.

4. Policy implications

FSI identifies not only the regions requiring immediate attention but also the specific thematic areas in which the efforts could be focused to attain food. It also helps in establishing inter-regions priorities for the allocation of agricultural resources and prioritizes the activities and programmes relevant to each region for sustainable food security.

FSI ranking implied that Belsar, Vaishali, Hajipur, Sahdai Buzrug, Chehrakalan, Bhagwanpur, Garaul, Lalganj and Raghopur had shown better performance in food security. All these blocks were having FSI more than 1.0 and were identified as advanced blocks having better conditions for food security. Similarly the blocks with FSI lower than 1.0 identified as backward blocks possessing poor conditions for sustainable development of food security during the reference period. The study revealed that Mahua, Patepur, Desri, Bidupur, Rajapakar, Mahnar and Jandaha having their FSI lower than 1.0 are the priority blocks of the district which require immediate attention for improvement in food security. Mahua and Mahnar should be given priority for improving food availability and food accessibility components. These blocks require urgent attention on irrigation facilities and welfare schemes for agricultural labourers. Patepur and Bidupur should be considered for prioritizing food availability. These blocks have poor rural connectivity to market. Therefore, efforts should be made on government part to provide them paved roads to encourage agricultural development. Jandaha and Desri should be accorded for improving food availability, food accessibility and food utilization components of the food security while Rajapakar block need emphasis on foot utilization component. Jandaha block requires attention to increase irrigation facilities and rural connectivity for improvement in food

availability. It also need emphasis on socio-economic conditions of agricultural labourers and scheduled caste population. This block has no facility for primary health centres so the same should be established and provision should be made to provide safe drinking water in the block to safeguard the social security of the people. Heath care facilities must be extended in Rajapakar block. Advanced blocks of the district also require policy interventions for long term food security. In Belsar food availability and food utilization should be accorded higher priority over food accessibility. Rural connectivity, safe drinking water and health care facilities should be given priority for increasing food security in Belsar block. In Sahdai Buzrug food availability and food accessibility should be accorded higher priority over food utilization. Development of paved roads and regular employment for scheduled caste population are thrust areas for improvement in Sahdai Buzrug. Food utilization should be given priority in Chehrakalan while food availability should be improved in Bhagwanpur. Increasing health care facilities and Chehrakalan and rural connectivity should be given priorities for long term sustainability of food security.

Assessment of gap between potential and actual yield, improvement in irrigation facilities, extension in institutional support, new gains through diversification of farming systems, minimum support price should be accorded for improving food availability. There is urgent need for a planned and vigorous promotion of low cost, low risk, high nutrition, holistic and sustainable farming systems to stem the rising tide of farmer's indebtedness, distress and food insecurity. Attempts should be made to diversify crops and to provide subsidy for agricultural inputs like irrigation, high yielding variety of seeds, fertilizer, insecticides and pesticides for increasing food availability. Efforts like increase in employment opportunities through rural industries and rural work programmes and credit facilities for micro enterprises should be initiated to improve food accessibility. Social equity programmes like better education, safe drinking water and health facilities, hygienic living

environment and awareness of personal hygiene should be accorded priority to increase the food utilization in the study area.

5. Conclusion

FSI as a composite index of its three components of food availability index, food accessibility index and food utilization index worked as a powerful policy tool for identifying the necessary conditions for sustainable food security in Vaishali district. FSI based spatio-temporal analysis revealed that there have been wide variation in food security and its three components within blocks during the reference period. Construction of FSI using time series data has helped to assess the progress of different development interventions during 2000-03 and 2007-10. FSI approach has also proved to be effective planning instrument for analyzing the performance and changing status of its three components in different blocks of the district. FSI identified blocks which require immediate attention for improving food security and helped to focus the priorities on its three components. Mahua, Patepur, Desri, Bidupur, Rajapakar, Mahnar and Jandaha were found to have poor conditions for food security during the reference period. These blocks thus call for timely policy interventions in their respective priority areas. The study also identified the priority areas for the blocks which have performed better in sustainable food security. These blocks should be given priority in their respective low ranking components of food security. Thus, FSI approach can best be utilized for analyzing food security situation and for identifying priority areas for sustainable food security of the region.

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