

Development of Agriculture Sustainability Index for Bihar, India: A District-level Analysis

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Received: 28.6.2022

• Accepted: 18.7.2022

Abstract: Sustainable development goals (SDGs) are key milestones for socio-economic and agricultural development across the world. The impending threats to agricultural sustainability and its broad dimensions have been well documented by different scholars at the micro and macro level. The empirical analysis of sustainable agriculture faces many practical difficulties and the available studies are very limited in terms of indicators and quantification of sustainability. The present study tries to assess the agricultural sustainability of districts associated with Bihar, India. By employing an indicator approach, heterogeneity of districts in terms of resource accessibility was also examined. To estimate the agricultural sustainability index, district-level secondary data on 28 agroecological indicators were used. To capture region-specific heterogeneity, indicators are divided into six dimensions, i.e. physical resources, financial resources, human resources, social resources, livelihood diversity, and information accessibility. The data has been collected from Census, NSSO, MoSPI, and NABARD. We found that agriculture is moderately sustainable in Bihar and also emphasis on the district-wise socio-economic and environmental dimension deteriorates. Thus, there is a need for special focus on efficient use of physical resources as well as human resources and better management practices. The proposed framework for the measurement of sustainability has a potential tool for application in other parts of the country.

Keywords: Sustainability, Indicator, SDGs, Sustainability Index

1. Introduction

The World Commission on Environment and Development (1987) defined sustainable agriculture as the management and utilization of the agricultural ecosystem in a way that maintains its biological diversity, productivity, regeneration capacity, vitality, and ability to function, so that it can fulfill today and in future-significant ecological, economic and social functions at the local, national and global levels and does not harm other ecosystems (Sanatan and Singh, 2020). Sustainable agriculture has multiple and diverse goals. Society depends on agricultural systems to produce enough human energy from food, a variety of nutrients necessary in the human diet, and economic returns for farmers, companies, and others who make a living from the food system (Singh, 2020c). Simultaneously, sustainable agricultural systems seek to adapt to climate change and unpredictability,

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minimize greenhouse gas emissions and the environmental consequences of agrochemicals, and make better use of land and water (Singh, 2020a).

These numerous, nuanced, and often contradictory aims have resulted in a healthy proliferation of definitions and conceptualizations of sustainable agriculture. Low-income, subsistence-based farming households who rely primarily on cereals for nourishment are disproportionately harmed by cereal nutritional content degradation and the scarcity of nutrient-dense foods such as animal source food, fruits, and vegetables. In 2011-12, for example, the percentage of energy intake given by grains for rural Indians ranged from nearly 70% for the bottom 5% of the population to 42% for the top 5%. (NSSO, 2014b).

Aside from nutritional sufficiency, a sustainable agricultural system must be adaptable to variable and expected changes in precipitation, temperature, and severe events caused by both anthropogenic and natural sources. Models evaluating the influence of future climate change on agricultural productivity concur that, in the absence of appropriate adaptation strategies, agricultural systems in low latitudes (particularly India) are projected to suffer greater yield losses than those in higher latitudes as temperatures rise (Singh, 2020 & 2021). Millions of small-scale and low-income farmers in low latitudes are especially vulnerable to climate change and fluctuation because they have few options for adapting to change (Jatav et al., 2021). Furthermore, decreasing field sizes for smallholder farmers, agricultural labor restrictions as individuals acquire jobs in cities, and rising dependence ratios (the ratio of non-working to working members of a household) in rural regions all demand efficiency in agricultural land use (Singh, 2019a & b).

With these evidences, the present study tries to assess the agricultural sustainability of districts associated with Bihar, India. By employing an indicator approach, heterogeneity of districts in terms of resource accessibility was also examined. Results from this study reveal that there is wide variation in terms of resource accessibility. Hence, district-specific interventions are a prerequisite to arresting heterogeneity and achieving equitable agriculture sustainability.

The paper is organized into four sections. Section 1 briefly discussed the agriculture sustainability issue; Section 2 provides the method and materials encompassing data and analytical tools used; Section 3 presented the results of the study while Section 4 presents the conclusion and policy implications.

2. Methods and Materials

2.1. Study Area

Bihar is located in the eastern region of India with highly fertile soil. Bihar shares its border with Uttar Pradesh, Jharkhand, and West Bengal state, while its international boundary touches Nepal. Bihar is segregated over four different agro-climatic zones Alluvial Plain, Northeast Alluvial Plain, Southeast Alluvial Plain, and Southwest Alluvial Plain. As per administrative division, Bihar consists of 38 districts divided into 534 Development Blocks and 45, 103 revenue villages. Bihar has a total geographical area of about 93.60 lakh hectares, out of which only 56.03 lakh hectares are the net cultivated area, and the gross cultivated area is 79.46 lakh hectares. About 33.51 lakh hectare net area and 43.86 lakh hectare gross area receive irrigation from different sources. Principal food crops are paddy, wheat, maize, and pulses. Bihar has notified forest area of 6, 764 square kilometers, which is 7.1% of its geographical area. Further, agriculture is a vital source of wealth in Bihar. 76% of its population is engaged in agriculture pursuits (Census, 2011). Ganga is the main river that is joined

by tributaries with their sources in the Himalayas. The state has a tropical monsoon climate with distinct seasons-winters, summer, and rainy. The normal rainfall is 1205 millimeters with an average number of rainy days is 52.5 in a year. With the wide fluctuation in Southwest Monsoon rainfall distribution every year, the state has been experiencing flood and drought and affecting the agriculture and water resources sectors.

2.2. Data and Descriptive Statistics

The present study uses district-wise secondary data on 28 agroecological indicators to assess the agriculture sustainability status of districts of Bihar. To capture regional-specific heterogeneity, indicators are divided into six dimensions, i.e. physical resources, financial resources, human resources, social resources, livelihood diversity, and information accessibility. Further, data on identified indicators were compiled from multiple sources such as Census (2011), NSSO 76th round (2019), MOSPI (2021), NABARD (2019), and agriculture census (2015-16).

Table 1 presents descriptive statistics which provide insightful information on associate indicators of agriculture sustainability. The physical resources index covers seven indicators namely average farm size, area under marginal farm, irrigation & cropping intensity, accessibility of all seasonal roads, forest area, and livestock ownership. Table 1 depicts that the average land size of Bihar is 0.26 hectares with 90.41% of the cropped area falling into the hand of marginal farmers. Irrigation and cropping intensities were reported at 168.71 & 144.39%, while only 40.59% had access to all seasonal roads (Census, 2011). Further, marginal forest coverage (5.31%) was reported, and more than 70% of farmers owned livestock.

As far as accessibility of financial resources is concerned, it is reported in table 1 that only 22.24% of farmers have membership in the agricultural credit society, while only 1.80% of farmers have taken crop insurance to protect crops from natural calamities. As Bihar is a land-lock state, inter-state migration is a reality. The majority of the young population has migrated from Bihar to states like Maharashtra and Delhi in search of employment and livelihood security. Further, they have sent remittances to their dependents living in rural areas of Bihar. Hence, it is reported that about 12.59% of farmers have received remittances. Institutional credit is also a vital component of agriculture sustainability. It is reported in table 1 that about 33.73% of farmers have taken credit from institutional sources to meet their agricultural needs, while only 1.79% of farmers have owned tractors.

Human resources are equally vital for agriculture sustainability, results from table 1 reveal that only 0.82% of farmers have taken agricultural training to grow and manage crops. Further, a literate farmer is more capable of dealing with disaster. It is reported that 59.96% of farmers are literate and are young as in the majority (mean age, i.e. 26.54 years) with 46.42% working population. Likewise, the social resource index covers four indicators namely female-headed households, joint family, knowledge sharing, and household members' stay away from home for employment. Results from table 1 reveal that about 9.16% of farm households are headed by female-headed households, while 53.14% of the rural population is living under a joint family structure. Only 20.67% of farmers reported their indigenous knowledge to fellow farmers. Moreover, only 1.54% of household members stay away from home for employment <15 days a month.

As far as the livelihood diversity index is concerned, four indicators namely working in MGNREGA, crop diversification, area not available for cultivation, and dependency on agriculture were used. It is a consensus among the researchers that the majority of farmers are unskilled for

industrial work, hence, MGNREGA which employs an unskilled working population is vital for not only livelihood security but also agriculture sustainability because work done under MGNREGA is closely linked with agriculture development. The results from table 1 reveal that 18.12% of the population is working in MGNREGA, while only 28.54% of farmers have diversified their cropping pattern in favor of sustainable agriculture. It is also reported in table 1 that 37.45% of the population is solely dependent on agriculture for income. Moreover, 22.93% of the geographical area of Bihar is not available for cultivation.

As far as the information accessibility index is concerned, four indicators namely farmers having access to Telephone, awareness of MSP, perception of calamities, and information collected from TV and Radio. The results from table 1 reveal that only 60.81% of farmers have access to a Telephone, while only 29.35% of farmers are aware of the minimum support price, and only 18.41% of farmers have collected from TV and Radio. More than half of the farmers perceived that natural calamities damage crops.

Table 1. Component and Indicators of Agriculture Sustainability

Components	Indicators	Description	Source	Mean	Functional Relationship
Physical Resources Index	Average Farm Size (Hac.)	It is expected that large farmers are relatively less susceptible to any change. Hence, higher land size leads to higher agricultural sustainability	Agriculture Census, 2015-16	0.26	+
	Area under Marginal Farmers (%)	It is reported from grass-root studies that marginal farmers are highly vulnerable and less environmentally sustainable	NSSO, 2019	90.41	-
	Irrigation Intensity (%)	Water is a key factor for agriculture growth and higher production. Hence, higher irrigation intensity leads to higher agricultural sustainability	NSSO, 2019	168.71	+
	Cropping Intensity (%)	Higher cropping intensity means higher crop production that leads to higher agricultural sustainability	NSSO, 2019	144.39	+
	Accessibility of All Seasonal Roads (%)	Lower agricultural marketing has a key constraint for low farm income. Hence, accessibility of all seasonal roads provides better connectivity with agricultural markets which will reduce wastages of farm produced that ultimately enhance farm income.	Census, 2011	40.59	+
	Forest Area (%)	Higher forest cover provides wood, medicines, and vegetation that lead to agricultural sustainability	NSSO, 2019	5.31	+
	Households owned any livestock (%)	Income diversification by owning livestock added a layer of sustainability to the system	NSSO, 2019	72.05	+
Financial Resources Index	Membership of Agricultural Credit Society (%)	Membership in the agricultural credit society ensures access to financial resources whenever requires at a minimum interest rate. Hence, it leads to higher agricultural sustainability	Census, 2011	22.24	+
	Crop Insurance (C+D) (%)	Crop insurance provides a safety net to any natural calamity and reduces crop loss. Hence, higher crop insurance coverage leads to higher agricultural sustainability	NSSO, 2019	1.80	+
	Remittances Received (%)	Remittance for rural farmers has a vital component of sustainable livelihoods. Migrant workers are sent money to their relatives that ultimately invested in agriculture.	NSSO, 2019	12.59	+
	Institutional Credit (%)	Timely availability of credit is vital for distressed occupations, i.e. agriculture. Hence, higher access to institutional credit leads to higher agricultural sustainability	NABARD, 2020	33.73	+

	Tractor ownership	Mechanization in agriculture not only reduces input costs but also made tasks easier and more sophisticated manner. Hence, higher access to machine such as tractors lead to higher agriculture sustainability	NSSO, 2019	1.79	+
Human Resources Index	Agriculture Training (%)	Knowledge about modern techniques provides an advantage to deal with distress as Indian farmers are facing such variability in rainfall and temperature and fluctuations in market price. Hence, agriculture training would be vital for making agriculture resource efficient and sustainable	Census, 2011	0.82	+
	Literacy Rate (%)	It is expected that an educated farmer is more aware of the agriculture system and would be more capable to deal with any constraints. Hence, a higher literacy rate leads to higher agriculture sustainability	Census, 2011	59.96	+
	Mean Age (Years)	It is expected that experienced farmers are more likely able to deal with any distress and come up with sustainable solutions in agriculture	Census, 2011	26.54	+
	Working Population (15-45 years)	Likewise, young farmers with compact modern technology are more likely able to make agriculture resources efficient and sustainable	NSSO, 2019	46.42	+
Social Resources Index	Female-headed households (%)	It is expected that female-headed households are more likely vulnerable and face several social and economic constraints in the male dominant society as Bihar	NSSO, 2019	9.16	-
	Joint Family (%)	Farmers living in a joint family system are more capable to deal with any distress and positively contribute to agriculture sustainability	NSSO, 2019	53.14	+
	Knowledge Sharing (%)	In agriculture, traditional knowledge is vital and expected key tool for dealing with future disasters such as drought and floods. Hence, knowledge sharing between farmers is expected to increase the degree of sustainability in agriculture	Agriculture Census, 2015-16	20.67	+
	Household members stay away from home for employment <15 days in a month (%)	It is expected that if the head of household stay away from home then their social relation will be weakened and hence, a decline in agriculture sustainability	NSSO, 2019	1.54	-
Livelihood Diversity Index	Households working in MGNREGA	Diversification is vital for equality and sustainable development. In this direction, MGNREGA is playing a vital role by providing assured employment to the unskilled population	NSSO, 2019	18.12	+
	Crop Diversification Index	Crop diversification is the most accepted and less resource-required strategy for dealing with disasters. It also helps in income enhancement	NSSO, 2019	28.54	+
	Area not available for cultivation (%)	Cropped area is a key determinant for agriculture production and sustainability. Hence, lower area leads to lower agriculture sustainability	NSSO, 2019	22.93	-

	Households solely dependent on farm income (%)	On the contrary, lower employment and income diversification lead to lower agriculture sustainability	NSSO, 2019	37.45	-
Information Accessibility Index	Households having access to Telephone (%)	Access to information is vital, hence, households having access to a Telephone will surely help in agriculture sustainability	Census, 2021	60.81	+
	Aware of MSP (%)	Awareness of Minimum Support Price provides a suitable price for the farm produce and motivates farmers to grow market-oriented crops in the field ultimately leads sustainability	NSSO, 2019	29.35	+
	Information from TV and Radio (%)	There are several modes of information available for agriculture development. Among these modes, TV and radio are two vital and acceptable tools adopted by farmers to get information about weather conditions, new technology, and market prices (Singh, 2020)	Census, 2011	18.41	+
	Perceived that Natural Calamities damages crops	Perception of climate change is vital in dealing with changing climate, hence, a higher perceived rate motivates farmers to develop a sustainable solution in resource constraint occupations, i.e. agriculture	NSSO, 2019	57.54	+

Source: Author's estimation, 2021

2.3. Analytical Method

The present study uses the indicator method to calculate agriculture sustainability. The indicator method can use any data at any scale. The beauty of this method is that if exact data is not available then the researcher can use proxy data for the development of the food security index at any scale i.e., individual, household, village, district, state, and country. Further, the indicator approach has several characteristics that have facilitated its widespread utilization in the planning process and policy communication over the years, which includes the ability (Singh and Alka, 2019) to consolidate a large volume of information into a manageable format, which is easy to comprehend to determine the current state of performance for complex and elusive fields that are not directly measurable; to identify, prioritize, and rank the food insecure regions to delineate the plausible barriers in the developmental process of a region; and to monitor and evaluate the progress of an intervention, for better decision-making (Singh and Sanatan, 2020).

2.4. Normalization

The normalization method should take into account the data properties, as well as the objectives of the composite indicator. Hence, the present study has adopted the min-max method (Iyengar and Sudarshan's method, 1982) to standardize indicators into a common range (0, 1) depending on their functional relationship with the dimension. Min-max can help simplify a complex array of information concerning food availability, food accessibility, and food stability nexus (Singh and Alka, 2019). In this respect, the method is important for informing the public and decision-makers about key food insecurity and livelihood vulnerability problems (Singh, 2020), and the actions required for their management (Jatav, 2021; Singh and Nayak, 2020; Nayak and Singh, 2020). The major advantage of this method is that it is capable to capture food security at any scale i.e., village, district, state, and country. Therefore, equations 1 & 2 were adopted for larger-better-and smaller-the better-type indicators, respectively.

$$Z_{ij} = \frac{X_{ij} - \text{Min}(X_{ij})}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})} \quad (1)$$

$$Z_{ij} = \frac{\text{Max}(X_{ij}) - X_{ij}}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})} \quad (2)$$

$$i = 1, 2, \dots, I \text{ and } j = 1, 2, \dots$$

Where, Z_{ij} is the variable index value, X_{ij} is the actual value, $\text{Max}(X_{ij})$ and $\text{Min}(X_{ij})$ is the maximum and minimum value of i^{th} indicator for the j^{th} district.

2.5. Assigning Weight

The assignment of appropriate weight for different components is an important issue in the construction of an index. Three methods are widely cited in the literature; equal weight, judgemental weight, and statistical weight (Jatav et al., 2021; Singh and Sanatan, 2020). The equal weight method assigns equal weight to all the indicators and components. But it is ethically not appropriate to give equal weight to each indicator because each indicator has differential and relative contribution to the targeted indicators i.e., the food security index. Judgmental weight purely depends on the researcher's

understanding and hence, is only suitable for field survey data, while statistical weight is appropriate for the secondary data (as the present study used). It assigns weight to each indicator by capturing the relative contribution of the indicator with the targeted index. Hence, the present study uses the statistical weight method using equations (3) and (4),

$$\left[W_i = \frac{k}{\sqrt{\text{Var}(Z_{ij})}} \right] \quad (3)$$

$$\text{Where, } \left[K = \frac{1}{\left\{ \sum_{i=1}^I \frac{1}{\sqrt{\text{Var}(Z_{ij})}} \right\}} \right] \quad (4)$$

The calculated weights were used to construct a component index P_j for j^{th} district using equation (5) where $0 < W_i < 1$ and $\sum_{i=1}^I w_i = 1$

$$P_j = \frac{\sum_{i=1}^I Z_{ij} * W_i}{\sum_{i=1}^I w_i} \quad (5)$$

Finally, the food security index for each district is calculated as an unweighted average of three components. Based on the index scores, districts were ranked in descending order where districts with higher scores indicate greater food security. Further, homogenous districts under each component indices were categorized into four groups; low (0-25th percentile), medium (26th to 50th), high (51st to 75th percentile), and very high (76th to 100th percentile) based on quartile estimation.

3. Results and Discussion

3.1. Physical Resource Sustainability Index (PRSI)

Table 2 depicts the status of physical resource sustainability in Bihar. It is reported from table 1 that Siwan district has the highest physical resource sustainability, while Sitamarhi district has the lowest physical resource sustainability among the districts belonging to Bihar. Further, the cross-indicators analysis revealed that relative advantage in irrigation and cropping intensity along with better transportation coverage were key factors contributing to higher physical resource sustainability in the Siwan district. Furthermore, the Siwan district has reported the highest irrigation and cropping intensities, i.e. 292.88 & 228.75, and more than 60% of the population has accessibility to all seasonal roads. On the contrary, the Sitamarhi district has only 121.63 & 155.43 irrigation and cropping intensities and only 34.87% of the population has accessibility to all seasonal roads (Table 2).

Table 2. District-wise Physical Resource Sustainability Index

Districts	Average Land size (Hac)	Area under marginal farmers (Hac)	Irrigation Intensity (%)	Cropping Intensity (%)	Access of All Seasonal Roads	Percentage of Forest Area	Percentage of Livestock	Physical Resources Index	Rank
Siwan	0.012	0.336	0.070	0.074	0.078	0.000	0.043	0.613	1
Lakhisarai	0.061	0.329	0.023	0.031	0.072	0.000	0.074	0.589	2
Katihar	0.051	0.316	0.052	0.018	0.085	0.000	0.065	0.587	3
Gopalganj	0.016	0.333	0.040	0.030	0.021	0.046	0.091	0.576	4
Nawada	0.033	0.321	0.040	0.029	0.035	0.028	0.089	0.576	5
Jehanabad	0.043	0.317	0.030	0.015	0.044	0.050	0.073	0.571	6
Samastipur	0.020	0.335	0.025	0.048	0.064	0.000	0.079	0.571	7
Saran	0.029	0.336	0.019	0.028	0.064	0.000	0.091	0.567	8
Muzaffarpur	0.036	0.326	0.031	0.038	0.044	0.003	0.082	0.560	9
Nalanda	0.050	0.305	0.028	0.014	0.039	0.038	0.078	0.552	10
Banka	0.054	0.325	0.025	0.015	0.033	0.023	0.076	0.552	11
Bhojpur	0.044	0.315	0.027	0.013	0.061	0.000	0.087	0.547	12
Madhubani	0.029	0.318	0.029	0.014	0.051	0.031	0.074	0.545	13
Purnea	0.058	0.291	0.048	0.029	0.044	0.000	0.067	0.539	14
Munger	0.019	0.329	0.028	0.020	0.059	0.000	0.082	0.537	15
Gaya	0.041	0.312	0.021	0.029	0.038	0.000	0.091	0.531	16
Rohtas	0.037	0.316	0.015	0.019	0.045	0.000	0.099	0.530	17
Saharsa	0.045	0.300	0.007	0.018	0.051	0.026	0.082	0.529	18
Madhepura	0.031	0.321	0.026	0.016	0.047	0.000	0.087	0.528	19
Aurangabad	0.053	0.289	0.011	0.032	0.049	0.009	0.084	0.528	20
East Champaran	0.027	0.324	0.022	0.005	0.036	0.024	0.087	0.525	21
Araria	0.050	0.298	0.007	0.032	0.056	0.000	0.079	0.522	22
Kishanganj	0.047	0.321	0.016	0.023	0.044	0.016	0.054	0.521	23
Begusarai	0.023	0.329	0.033	0.026	0.046	0.000	0.061	0.518	24
Sheikhpura	0.038	0.331	0.022	0.013	0.052	0.000	0.062	0.518	25
Darbhanga	0.020	0.328	0.008	0.002	0.069	0.000	0.089	0.516	26
Vaishali	0.039	0.314	0.021	0.018	0.040	0.000	0.084	0.515	27
Supaul	0.025	0.327	0.021	0.029	0.055	0.000	0.053	0.511	28
West Champaran	0.000	0.338	0.006	0.028	0.046	0.000	0.091	0.508	29
Jamui	0.033	0.302	0.005	0.058	0.047	0.001	0.060	0.506	30
Patna	0.027	0.319	0.031	0.013	0.046	0.000	0.065	0.501	31
Buxur	0.066	0.278	0.003	0.018	0.044	0.000	0.078	0.487	32
Bhagalpur	0.026	0.331	0.015	0.009	0.034	0.000	0.065	0.481	33
Kaimur	0.039	0.302	0.010	0.024	0.020	0.001	0.082	0.477	34

Arwal	0.038	0.318	0.007	0.000	0.049	0.000	0.060	0.473	35
Khagaria	0.033	0.306	0.027	0.022	0.023	0.000	0.059	0.471	36
Sitamarhi	0.025	0.323	0.005	0.030	0.041	0.000	0.039	0.463	37
Weight	10	35	11	8	11	15	10		

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.2. Financial Resource Sustainability Index (FRSI)

Table 3 describes the status of financial resource sustainability of districts associated with Bihar. The results from table 3 revealed that the Katihar district (index score, i.e. 0.090) has the highest financial resource sustainability, while the West Champaran district (index score, i.e., 0.028) has the lowest sustainability. The cross-indicator analysis shows that the highest membership of agricultural credit societies and the highest percentage of households receiving remittances are the main contributing factors to the highest financial resource sustainability. About 56% of farmers belonging to the Katihar district have taken membership in the agricultural credit society to cope with financial constraints. Further, about 38% of farmers have received remittances from urban areas. On the contrary, only 19% of farmers belonging to the West Champaran have membership in the agricultural credit society, while only 3% of farmers have received remittances from urban areas.

Table 3. District-wise Financial Resource Sustainability Index

Districts	Agricultural Credit societies (%)	Proportion of farmers took insurance (C+D %)	Percentage of HHs receiving Remittances	Percentage of HHs taken loan from institutional sources	Percentage of HHs access to Tractors	Financial Resources Index	Rank
Katihar	0.033	0.009	0.032	0.007	0.009	0.090	1
Purnea	0.030	0.000	0.005	0.036	0.009	0.080	2
Lakhisarai	0.019	0.013	0.021	0.018	0.008	0.079	3
Madhepura	0.017	0.039	0.004	0.009	0.009	0.077	4
Saran	0.020	0.000	0.012	0.020	0.021	0.073	5
Nawada	0.018	0.000	0.011	0.027	0.013	0.068	6
Khagaria	0.012	0.000	0.030	0.014	0.012	0.067	7
Jehanabad	0.004	0.004	0.028	0.015	0.014	0.066	8
Gaya	0.008	0.000	0.014	0.016	0.026	0.064	9
Patna	0.002	0.000	0.009	0.024	0.029	0.064	10
Araria	0.019	0.016	0.013	0.002	0.014	0.063	11
Rohtas	0.015	0.000	0.016	0.018	0.012	0.060	12
Siwan	0.028	0.014	0.004	0.003	0.011	0.059	13
Vaishali	0.013	0.000	0.009	0.013	0.022	0.057	14
Darbhanga	0.023	0.000	0.017	0.005	0.011	0.057	15
Bhagalpur	0.008	0.000	0.017	0.021	0.008	0.054	16
Madhubani	0.008	0.016	0.007	0.020	0.004	0.054	17
Aurangabad	0.005	0.000	0.009	0.006	0.027	0.047	18

Bhojpur	0.010	0.003	0.013	0.016	0.004	0.047	19
Saharsa	0.006	0.007	0.008	0.017	0.007	0.046	20
Jamui	0.006	0.006	0.011	0.009	0.013	0.046	21
Gopalganj	0.002	0.000	0.006	0.019	0.018	0.046	22
Samastipur	0.016	0.000	0.003	0.019	0.005	0.043	23
Muzaffarpur	0.020	0.000	0.008	0.006	0.009	0.042	24
Begusarai	0.017	0.005	0.004	0.011	0.006	0.042	25
Kaimur	0.011	0.000	0.017	0.003	0.010	0.041	26
Banka	0.005	0.000	0.008	0.007	0.019	0.040	27
East Champan	0.006	0.000	0.011	0.011	0.012	0.039	28
Munger	0.010	0.000	0.005	0.023	0.000	0.038	29
Buxur	0.012	0.007	0.008	0.011	0.000	0.038	30
Supaul	0.020	0.003	0.009	0.005	0.000	0.036	31
Kishanganj	0.010	0.003	0.006	0.014	0.002	0.036	32
Sitamarhi	0.015	0.000	0.004	0.012	0.005	0.035	33
Nalanda	0.012	0.000	0.006	0.008	0.009	0.035	34
Sheikhpura	0.010	0.004	0.000	0.018	0.000	0.033	35
Arwal	0.005	0.003	0.005	0.009	0.006	0.029	36
West Champan	0.011	0.005	0.003	0.007	0.003	0.028	37
Weight	16	23	19	21	21		

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.3. Human Resource Sustainability Index (HRSI)

Table 4 shows the status of human resource sustainability in Bihar. The results from table 4 revealed that the Saharsa district (index score, i.e. 0.127) has the highest sustainability, while the Supaul district (index score, i.e. 0.108) has the lowest sustainability. To construct the human resource sustainability index, four indicators namely households have taken formal agricultural training, literacy rate, mean age, and adult population. The cross-indicator analysis shows that farmers belonging to the Saharsa district are relatively more literate and young than those farmers belonging to the Supaul district. The literacy rate in Saharsa was more than 70%, while the mean age was 29 years (Table 4).

Table 4. District-wise Human Resource Sustainability Index

District	Percentage of HH taken formal Training in Agriculture	Literacy Rate (%)	Mean Age (Years)	Percentage of adult population in households	Human Resources Index	Rank
Saharsa	0.009	0.049	0.016	0.053	0.127	1
Begusarai	0.011	0.042	0.011	0.063	0.127	2

Banka	0.007	0.039	0.013	0.066	0.126	3
Bhojpur	0.010	0.047	0.003	0.066	0.125	4
Madhepura	0.016	0.040	0.011	0.058	0.125	5
Patna	0.015	0.042	0.000	0.066	0.124	6
Aurangabad	0.000	0.047	0.011	0.066	0.124	7
East Champaran	0.011	0.042	0.008	0.063	0.123	8
Kishanganj	0.007	0.041	0.013	0.061	0.122	9
Sheikhpura	0.006	0.044	0.013	0.058	0.121	10
Buxur	0.000	0.047	0.005	0.069	0.121	11
Khagaria	0.010	0.037	0.011	0.064	0.121	12
Muzaffarpur	0.008	0.043	0.011	0.059	0.121	13
Purnea	0.009	0.037	0.008	0.066	0.120	14
Vaishali	0.002	0.047	0.003	0.068	0.120	15
Nalanda	0.009	0.040	0.016	0.056	0.120	16
Samastipur	0.011	0.035	0.008	0.066	0.120	17
Gaya	0.006	0.044	0.000	0.070	0.119	18
Munger	0.007	0.042	0.008	0.062	0.119	19
Jehanabad	0.003	0.047	0.011	0.058	0.119	20
Jamui	0.004	0.045	0.016	0.054	0.118	21
Kaimur	0.013	0.034	0.013	0.058	0.118	22
Arwal	0.005	0.045	0.005	0.062	0.118	23
Siwan	0.009	0.036	0.011	0.061	0.117	24
Darbhanga	0.007	0.037	0.011	0.062	0.116	25
Katihar	0.002	0.039	0.018	0.057	0.116	26
Lakhisarai	0.007	0.035	0.013	0.060	0.114	27
Araria	0.009	0.036	0.005	0.064	0.114	28
Bhagalpur	0.007	0.041	0.008	0.059	0.114	29
Madhubani	0.000	0.045	0.011	0.057	0.113	30
West Champaran	0.005	0.039	0.005	0.063	0.112	31
Saran	0.000	0.042	0.011	0.060	0.112	32
Gopalganj	0.000	0.040	0.008	0.063	0.111	33
Sitamarhi	0.000	0.042	0.013	0.055	0.111	34
Nawada	0.000	0.037	0.003	0.071	0.110	35
Rohtas	0.005	0.033	0.011	0.061	0.110	36
Supaul	0.007	0.035	0.008	0.059	0.108	37
Weight	40	26	21	13		

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.4. Social Resource Sustainability Index (SRSI)

Table 5 illustrates the status of social resource sustainability of the district associated with Bihar. The results from table 5 that the Madhepura district has the highest social resource sustainability index score (i.e., 0.313), while the Nalanda district has the lowest sustainability index score (i.e., 0.229). The cross-indicator analysis revealed that farmers belonging to the Madhepura district highest (index score i.e., 0.035) have taken information from the progressive farmers to boost their agriculture

production and adopt sustainable measures in agriculture. Further, statistical data show that more than 60% of farmers have followed expert advice to cope with natural as well as man-made disasters, while, it is reported that none of the farmers belonging to the Nalanda district has followed the advice given by progressive farmers (Table 5).

Table 5. District-wise Social Resources Index

District	Percentage of Female Head Household	Percentage of Joint Family	Percentage of Households taken information to Progressive farmers	Percentage of HH member stayed away from usual place of residence for 15 day or more for employment purpose	Social Resources Index	Rank
Madhepura	0.206	0.044	0.035	0.028	0.313	1
Kaimur	0.210	0.062	0.003	0.028	0.303	2
Samastipur	0.213	0.083	0.000	0.006	0.302	3
Aurangabad	0.183	0.053	0.018	0.048	0.302	4
Purnea	0.210	0.057	0.019	0.013	0.300	5
Supaul	0.215	0.059	0.017	0.004	0.294	6
Gopalganj	0.205	0.052	0.020	0.009	0.287	7
Saran	0.204	0.050	0.020	0.013	0.287	8
Darbhanga	0.211	0.042	0.011	0.022	0.286	9
Araria	0.213	0.056	0.000	0.016	0.285	10
Vaishali	0.205	0.062	0.013	0.004	0.284	11
Lakhisarai	0.193	0.044	0.033	0.013	0.283	12
Gaya	0.205	0.054	0.018	0.002	0.279	13
East Champaran	0.185	0.050	0.034	0.009	0.278	14
Saharsa	0.190	0.062	0.016	0.009	0.277	15
Rohtas	0.206	0.062	0.006	0.003	0.277	16
Begusarai	0.202	0.047	0.017	0.008	0.275	17
Arwal	0.184	0.060	0.006	0.024	0.274	18
Bhojpur	0.193	0.063	0.008	0.009	0.274	19
Siwan	0.201	0.052	0.019	0.002	0.274	20
Banka	0.203	0.043	0.015	0.011	0.272	21
Jehanabad	0.192	0.056	0.010	0.013	0.271	22
Bhagalpur	0.210	0.033	0.022	0.005	0.270	23
Sheikhpura	0.205	0.054	0.005	0.005	0.269	24
Katihar	0.201	0.061	0.005	0.000	0.266	25
West Champaran	0.206	0.054	0.000	0.004	0.265	26
Buxur	0.183	0.065	0.008	0.008	0.264	27
Khagaria	0.183	0.066	0.014	0.001	0.263	28

Patna	0.196	0.056	0.000	0.009	0.262	29
Sitamarhi	0.189	0.050	0.022	0.000	0.260	30
Jamui	0.193	0.045	0.006	0.011	0.256	31
Muzaffarpur	0.205	0.042	0.002	0.005	0.254	32
Nawada	0.189	0.058	0.000	0.003	0.251	33
Madhubani	0.203	0.038	0.008	0.000	0.249	34
Munger	0.201	0.046	0.000	0.002	0.249	35
Kishanganj	0.190	0.038	0.012	0.005	0.246	36
Nalanda	0.185	0.044	0.000	0.000	0.229	37
Weight	45	10	15	30		

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.5. Livelihood Diversity Index (LDI)

Table 6 represents the livelihood diversity status of the district belonging to Bihar. The results from table 6 revealed that the Nalanda district has the highest livelihood diversity index score (i.e., 0.573), while the Madhubani district has the lowest livelihood diversity index score (i.e., 392). The cross-indicator analysis revealed that the highest crop diversification and higher working population in MGNREGA are the main contributing indicators for higher relative livelihood diversity in the Nalanda district compared with the Madhubani district. It is observed that about 38% of the population in the Nalanda district is working under the MGNREGA programme, while only 4.40% of the population belonging to the Madhubani district is working under the MGNREGA programme.

Table 6. District-wise Livelihood Diversity Index

District	Percentage of Participation in MGNREGA	Percentage of Farmers growing more than one crop (Crop diversification)	Area not available for cultivation	Percentage share of farm produce in HHs income	Livelihood Diversity Index	Rank
Nalanda	0.057	0.053	0.302	0.160	0.572	1
Nawada	0.074	0.053	0.298	0.130	0.555	2
Saharsa	0.012	0.026	0.311	0.190	0.539	3
Saran	0.067	0.059	0.277	0.135	0.538	4
Samastipur	0.013	0.058	0.282	0.169	0.523	5
Gaya	0.065	0.008	0.301	0.145	0.519	6
Rohtas	0.009	0.054	0.303	0.149	0.516	7
Patna	0.061	0.044	0.266	0.140	0.512	8
Purnea	0.047	0.048	0.299	0.117	0.511	9
Bhojpur	0.068	0.000	0.308	0.134	0.510	10
East Champaran	0.062	0.011	0.296	0.133	0.503	11
Sheikhpura	0.043	0.004	0.299	0.152	0.499	12
Aurangabad	0.067	0.000	0.291	0.137	0.496	13
Buxur	0.018	0.000	0.329	0.147	0.494	14
Sitamarhi	0.043	0.002	0.302	0.146	0.494	15

Jehanabad	0.048	0.028	0.314	0.099	0.489	16
Muzaffarpur	0.041	0.000	0.298	0.147	0.485	17
Araria	0.046	0.016	0.295	0.128	0.485	18
Darbhanga	0.043	0.009	0.282	0.149	0.483	19
Arwal	0.022	0.046	0.298	0.113	0.479	20
Madhepura	0.027	0.014	0.279	0.149	0.469	21
Kishanganj	0.022	0.013	0.310	0.122	0.466	22
Kaimur	0.009	0.000	0.270	0.186	0.465	23
Lakhisarai	0.022	0.001	0.299	0.143	0.465	24
Banka	0.016	0.018	0.269	0.162	0.464	25
Vaishali	0.021	0.010	0.304	0.125	0.460	26
Khagaria	0.005	0.030	0.281	0.145	0.460	27
Jamui	0.039	0.000	0.300	0.120	0.459	28
Munger	0.040	0.000	0.291	0.127	0.459	29
Gopalganj	0.053	0.000	0.284	0.104	0.440	30
Siwan	0.012	0.002	0.258	0.164	0.436	31
Katihar	0.024	0.000	0.261	0.150	0.436	32
Sup0.9aul	0.020	0.021	0.264	0.128	0.432	33
West Champaran	0.020	0.007	0.260	0.129	0.417	34
Bhagalpur	0.029	0.002	0.236	0.139	0.405	35
Begusarai	0.037	0.000	0.254	0.105	0.396	36
Madhubani	0.009	0.001	0.258	0.125	0.392	37
Weight	19	20	26	30		

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.6. Information Accessibility Index (IAI)

Table 7 depicts the information accessibility status of districts belonging to Bihar. The results show that the Saran district has the highest information accessibility index score (i.e., 0.742), while the Kaimur district has the lowest information accessibility index score (i.e., 0.237). The cross-indicator analysis revealed that farmers belonging to the Saran district are much more aware of the minimum support price (61.53%), while the lowest is aware in the Kaimur district (12.80%). Further, more than 75% of farmers belonging to the Saran district have taken information from Radio and TV, while only less than 2% of farmers have taken information from Radio and TV.

Table 7. District-wise Information Accessibility Index

District	Telephone	Aware of MSP	Percentage of farmers taken information to Radio and TV	Percentage of farmers perceived that natural calamities are cause crop loss	Information Accessibility Index	Rank
Saran	0.234	0.186	0.203	0.120	0.742	1

Buxur	0.315	0.155	0.051	0.103	0.624	2
Siwan	0.287	0.136	0.066	0.100	0.589	3
Bhagalpur	0.180	0.154	0.094	0.120	0.548	4
Madhepura	0.216	0.045	0.141	0.120	0.521	5
Supaul	0.195	0.173	0.021	0.120	0.508	6
Katihar	0.275	0.064	0.021	0.120	0.480	7
Bhojpur	0.173	0.086	0.079	0.120	0.457	8
Muzaffarpur	0.204	0.132	0.016	0.105	0.457	9
Lakhisarai	0.202	0.059	0.103	0.090	0.454	10
Sheikhpura	0.149	0.145	0.035	0.090	0.419	11
Begusarai	0.200	0.024	0.057	0.120	0.400	12
Nalanda	0.163	0.121	0.053	0.060	0.396	13
Araria	0.188	0.094	0.022	0.092	0.396	14
Darbhangha	0.232	0.078	0.022	0.060	0.392	15
Samastipur	0.256	0.129	0.000	0.005	0.390	16
West Champaran	0.189	0.075	0.000	0.120	0.385	17
Kishanganj	0.206	0.053	0.042	0.083	0.384	18
Jehanabad	0.130	0.095	0.065	0.095	0.384	19
Khagaria	0.175	0.098	0.079	0.025	0.378	20
Arwal	0.177	0.072	0.025	0.102	0.376	21
Gopalganj	0.146	0.090	0.033	0.103	0.373	22
Saharsa	0.150	0.127	0.060	0.022	0.360	23
Rohtas	0.160	0.101	0.091	0.000	0.352	24
Jamui	0.140	0.086	0.049	0.075	0.349	25
East Champaran	0.142	0.065	0.081	0.055	0.344	26
Vaishali	0.204	0.075	0.013	0.050	0.343	27
Purnea	0.200	0.078	0.053	0.000	0.330	28
Banka	0.150	0.061	0.046	0.067	0.324	29
Aurangabad	0.141	0.049	0.064	0.067	0.320	30
Gaya	0.157	0.093	0.015	0.040	0.305	31
Patna	0.211	0.085	0.000	0.000	0.296	32
Sitamarhi	0.182	0.038	0.074	0.000	0.294	33
Madhubani	0.215	0.010	0.019	0.048	0.292	34
Munger	0.200	0.084	0.000	0.000	0.284	35
Nawada	0.196	0.020	0.000	0.022	0.238	36
Kaimur	0.153	0.039	0.005	0.040	0.237	37
Weight	31	30	26	13		

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.7. Agriculture Sustainability Index (ASI)

By using equation 5, the agriculture sustainability index was calculated for the districts belonging to Bihar. The calculated agriculture sustainability index revealed that the Saran district (index score, i.e. 0.386) has the highest agriculture sustainability, while the Kaimur district has the lowest agriculture sustainability status (index score, i.e. 0.273). The cross-indices analysis revealed that the highest

index score of the information accessibility index and human resource index is the main contributing components responsible for higher agriculture sustainability in the Saran district and on the contrary, the lowest index score of the information accessibility index and human resource index are key factors responsible for lowest agriculture sustainability in Kaimur district (Table 8).

Table 8. District-wise Agriculture Sustainability Index

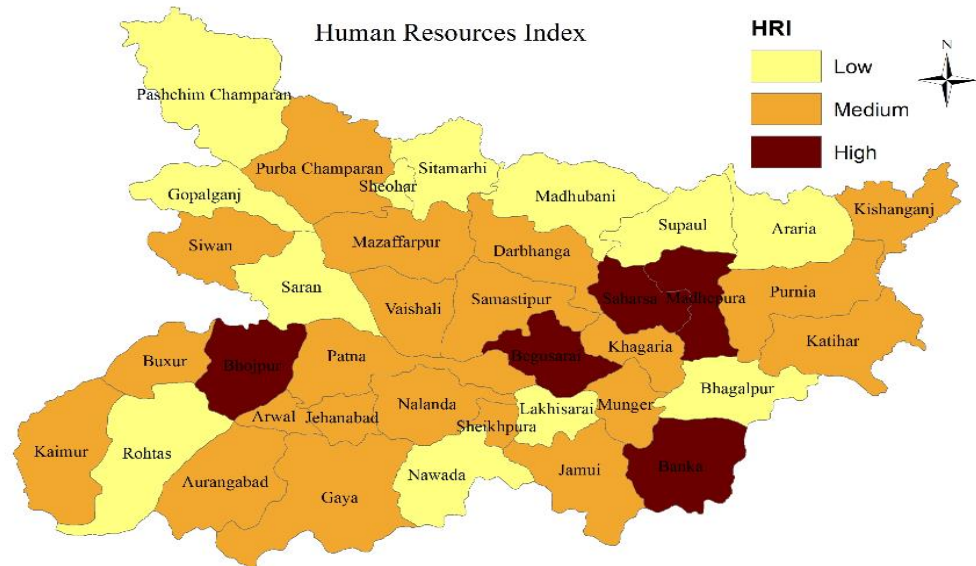
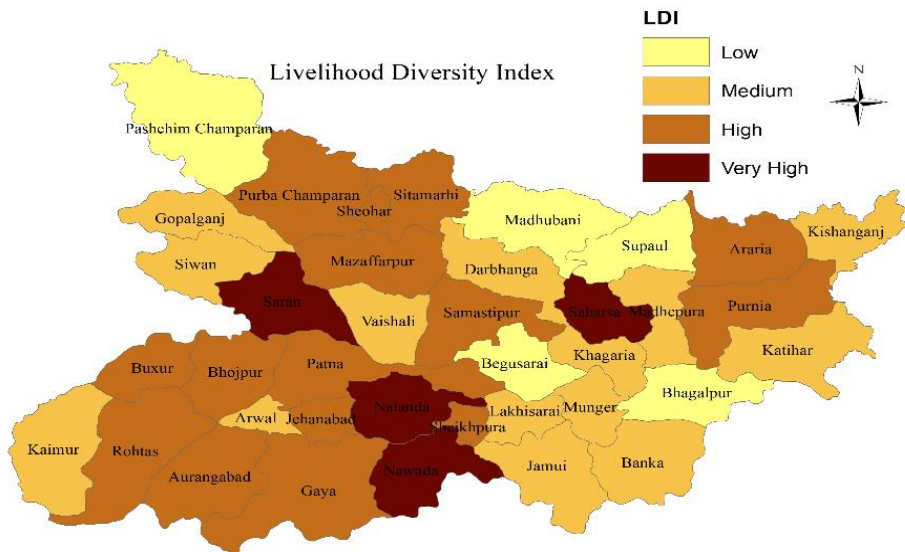
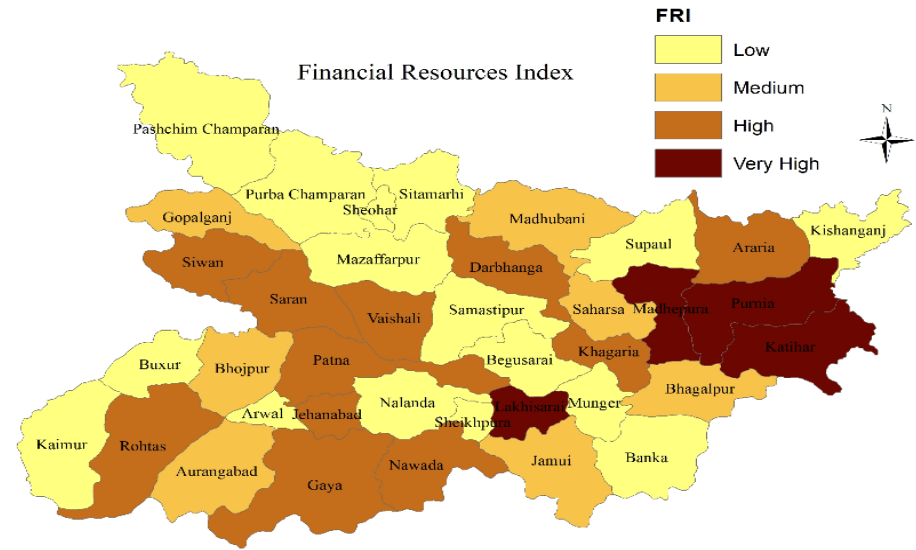
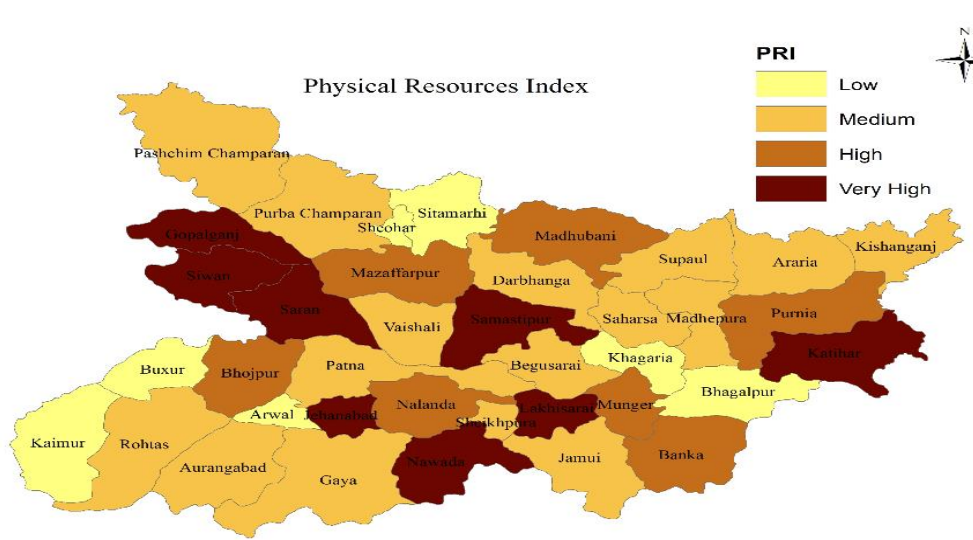
District	Physical Resources Index	Financial Resources Index	Human Resources Index	Social Resources Index	Livelihood Diversity Index	Information Accessibility Index	Agricultural Sustainability Index	Rank
Saran	0.567	0.073	0.112	0.287	0.538	0.742	0.386	1
Siwan	0.613	0.059	0.117	0.274	0.436	0.589	0.348	2
Madhepura	0.528	0.077	0.125	0.313	0.469	0.521	0.339	3
Buxur	0.487	0.038	0.121	0.264	0.494	0.624	0.338	4
Lakhisarai	0.589	0.079	0.114	0.283	0.465	0.454	0.331	5
Katihar	0.587	0.090	0.116	0.266	0.436	0.480	0.329	6
Bhojpur	0.547	0.047	0.125	0.274	0.510	0.457	0.327	7
Samastipur	0.571	0.043	0.120	0.302	0.523	0.390	0.325	8
Muzaffarpur	0.560	0.042	0.121	0.254	0.485	0.457	0.320	9
Nalanda	0.552	0.035	0.120	0.229	0.572	0.396	0.317	10
Jehanabad	0.571	0.066	0.119	0.271	0.489	0.384	0.317	11
Supaul	0.511	0.036	0.108	0.294	0.432	0.508	0.315	12
Purnea	0.539	0.080	0.120	0.300	0.511	0.330	0.313	13
Saharsa	0.529	0.046	0.127	0.277	0.539	0.360	0.313	14
Bhagalpur	0.481	0.054	0.114	0.270	0.405	0.548	0.312	15
Araria	0.522	0.063	0.114	0.285	0.485	0.396	0.311	16
Sheikhpura	0.518	0.033	0.121	0.269	0.499	0.419	0.310	17
Darbhanga	0.516	0.057	0.116	0.286	0.483	0.392	0.308	18
Rohtas	0.530	0.060	0.110	0.277	0.516	0.352	0.307	19
Gopalganj	0.576	0.046	0.111	0.287	0.440	0.373	0.306	20
Gaya	0.531	0.064	0.119	0.279	0.519	0.305	0.303	21
Aurangabad	0.528	0.047	0.124	0.302	0.496	0.320	0.303	22
East Champaran	0.525	0.039	0.123	0.278	0.503	0.344	0.302	23
Nawada	0.576	0.068	0.110	0.251	0.555	0.238	0.300	24
Vaishali	0.515	0.057	0.120	0.284	0.460	0.343	0.297	25
Banka	0.552	0.040	0.126	0.272	0.464	0.324	0.296	26
Kishanganj	0.521	0.036	0.122	0.246	0.466	0.384	0.296	27
Khagaria	0.471	0.067	0.121	0.263	0.460	0.378	0.293	28
Begusarai	0.518	0.042	0.127	0.275	0.396	0.400	0.293	29
Patna	0.501	0.064	0.124	0.262	0.512	0.296	0.293	30
Arwal	0.473	0.029	0.118	0.274	0.479	0.376	0.291	31

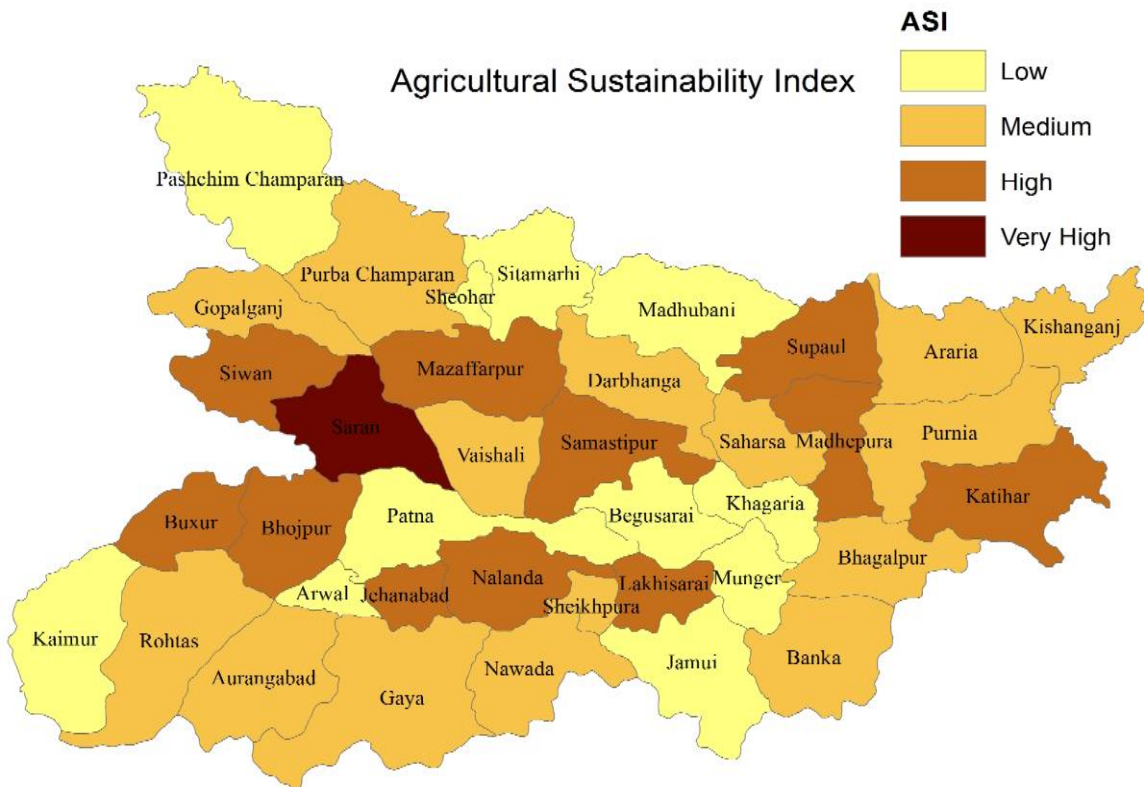
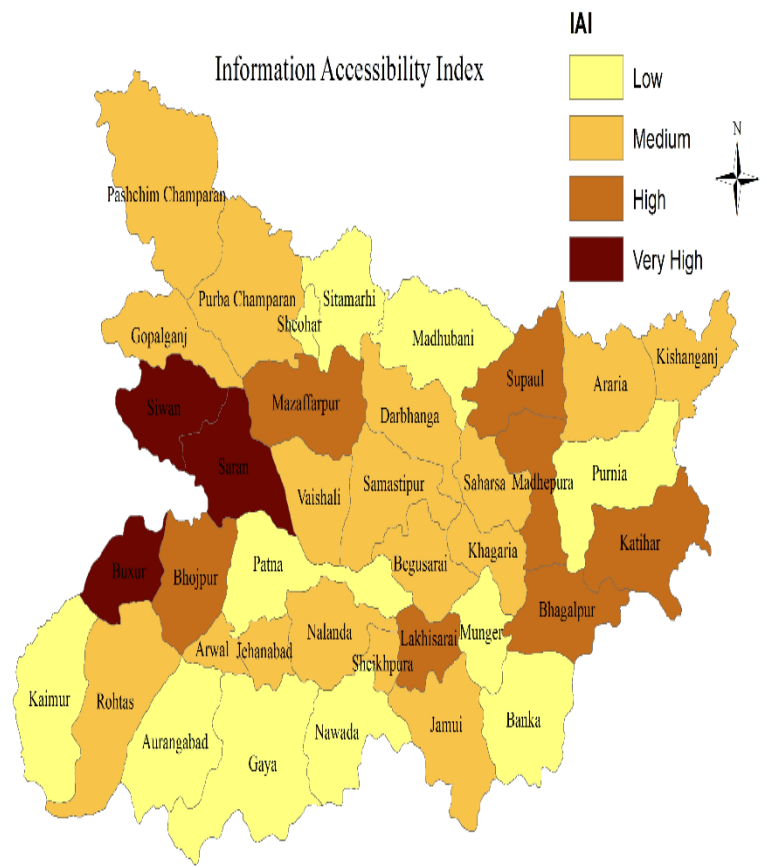
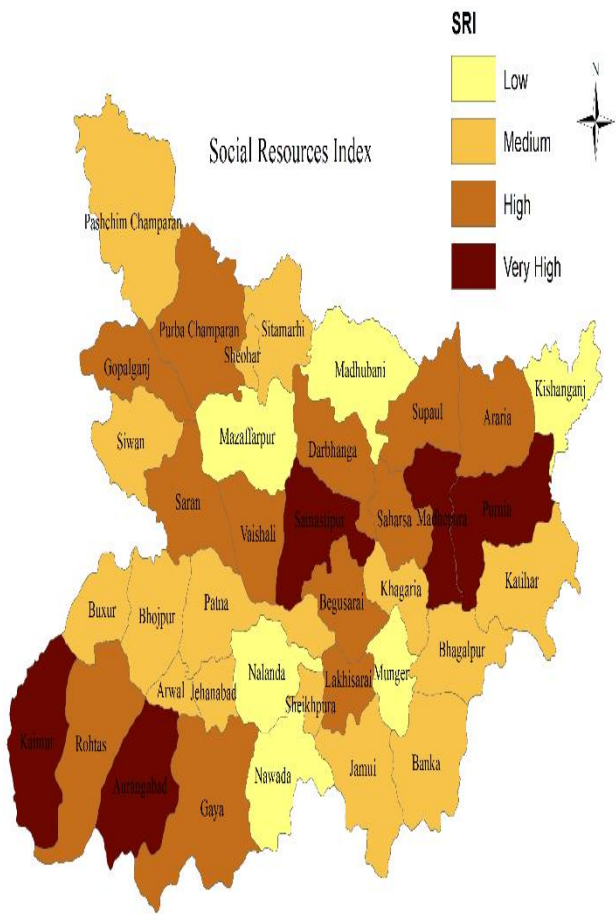
Jamui	0.506	0.046	0.118	0.256	0.459	0.349	0.289	32
West Champaran	0.508	0.028	0.112	0.265	0.417	0.385	0.286	33
Munger	0.537	0.038	0.119	0.249	0.459	0.284	0.281	34
Sitamarhi	0.463	0.035	0.111	0.260	0.494	0.294	0.276	35
Madhubani	0.545	0.054	0.113	0.249	0.392	0.292	0.274	36
Kaimur	0.477	0.041	0.118	0.303	0.465	0.237	0.273	37

Source: Author's Estimation, 2021. Note: weight values are in percentage

3.8. Group-wise Agriculture Sustainability Index

The quintile estimation technique was used to evaluate agriculture sustainability status at a disaggregate level. Based on the quintile values, districts are grouped into four groups namely low, medium, high, and very high (Fig. 1-7). As far as physical resource sustainability index is concerned, districts belonging to the southern east region (Agro-climatic zone- IIIA) relatively had lower physical resource sustainability, while districts belonging to the northeast region (Agro-climatic zone- I) relatively had higher physical resource sustainability (Fig. 1). Further, financial resource sustainability quintile estimation results show that districts (i.e., Katihar, Purnea, Lakhisarai, Madhepur, Saran, Nawada, Khagaria, Jehanabad and Gaya) had relatively higher financial sustainability (Fig. 2). As far as quintile estimation for human resource sustainability estimation is concerned, districts belonging to the northern east region (i.e., Saharsa, Begurairai, Banka, Bhojpur, Madhepura, Patna, Aurangabad, East Champaran, Kishanganj and Sheikhpura) had higher human resource sustainability (Fig. 3). Likewise, social resource sustainability index quintile results show that district belonging to the northern east region (i.e., Madhepura, Kaimur, Samastipur, Aurangabad, Purnea, Supaul, Gopalganj, Saran and Darbhanga) had highest social resource sustainability (Fig. 4). Furthermore, quintile estimation results for livelihood diversity index revealed that districts belonging to the southern west region (i.e., Nalanda, Nawada, Saharsa, Saran, Samastipur, Gaya, Rohtas, Patna and Purnea) had highest livelihood diversity than that of other regions (Fig. 5). Moreover, as far as information accessibility index status is concerned, districts belonging to the northern west region (i.e., Saran, Buxur, Siwan, Bhagalpur, Madhepura, Supaul, Katihar, Bhojpur, Muzaffarpur) had highest information accessibility than that of other districts (Fig. 6). Lastly, quintile estimation results for agriculture sustainability index revealed that districts belonging to the northern west region had highest agriculture sustainability than that of other districts (Fig. 7).





3.9. Validation of estimated district-wise Agriculture Sustainability Index

It is a pre-requisite to validate the constructed indices. It can be preferred as ‘good’ because it is significantly correlated with its associate indices. Spearman’s correlation coefficients revealed that ASI is positively associated with PRSI, FRSI, HRSI, SRSI, and LVI (Table 9). This also interpreted that agriculture sustainability depends on physical resource sustainability, financial resource sustainability, human resource sustainability, social resource sustainability, livelihood diversity, and information accessibility. Thus, significantly associated with its components. Agriculture sustainability is positively associated with physical resource sustainability. It infers that physical resource sustainability improves as physical resources increase.

Table 9. Spearman’s rank correlation statistics

Parameters	ASI	PRSI	FRSI	HRRI	SRSI	LVI	IAI
ASI	1	0.541*	0.390*	0.055 ^{NS}	0.314 ^{NS}	0.289 ^{NS}	0.775*
PSI	0.541*	1	0.415**	-0.085 ^{NS}	0.064 ^{NS}	0.184**	0.159 ^{NS}
FRI	0.390*	0.415**	1	-0.108 ^{NS}	0.289 ^{NS}	0.122 ^{NS}	0.069 ^{NS}
HRI	0.055**	-0.085 ^{NS}	-0.108 ^{NS}	1	1	0.201 ^{NS}	0.006 ^{NS}
SRI	0.314*	0.064 ^{NS}	0.289 ^{NS}	-0.004 ^{NS}	-0.004 ^{NS}	1	0.126 ^{NS}
LVI	0.289*	0.184 ^{NS}	0.122 ^{NS}	0.201 ^{NS}	0.095 ^{NS}	0.095 ^{NS}	1
IAI	0.775*	0.155 ^{NS}	0.069 ^{NS}	0.006 ^{NS}	0.126 ^{NS}	-0.140 ^{NS}	-0.140 ^{NS}

Source: Author’s Estimation, 2021. ASI, PRSI, FRSI, HRRI, SRSI, LVI and IAI indicates Physical Resource Sustainability Index, Financial Resource Sustainability Index, Human Resource Sustainability Index, Social Resource Sustainability Index, Livelihood Diversity Index, and Information Accessibility Index

4. Conclusion and Policy Recommendations

The present study encompasses the development of an agricultural sustainable index at the district level. Integrating all indicator approaches into an effort to mainstream agricultural sustainability, and developing awareness across sectors of policy commitments, are key to the overall success of the SDGs as well as boosting the agricultural sector. This study developed an Agricultural Sustainable Index (ASI) covering six important aspects: the current status, growing pressures, and actions and response of society and government to agricultural development. Agriculture sustainability is positively associated with physical resource sustainability. It infers that physical resource sustainability improves as physical resources increase. The priority is increasing awareness and creating physical infrastructure for the development of agricultural sustainability which ultimately enhances better livelihood and employment. The proposed heterogeneity indicator approach will serve as an effective tool and easily communicable policy tool to assist the development of agricultural sustainability.

Reference

- [1] Census, 2011. *District Abstract*. Office of the Registrar General & Census Commissioner, India, Ministry of Home Affairs, Government of India, New Delhi.
- [2] Jatav, S.S. 2021, “Does India Achieve Agenda 2030 Targets: A multiple Lens Analysis”, *Indian Journal of Ecology* 48(4):
- [3] Jatav, S.S., Anoop K., Bibhuti, BM. 2021, “Impact of Covid-19 on the Livelihoods of Rural Farmers in Uttar Pradesh, India” *Journal of Rural Development* 40(1):
- [4] Nayak, S. and Singh, S. 2020, “Development of gender sensitive vulnerability index for urban Indian Slums”, *Indian Journal of Traditional Knowledge* 19(3):

- [5] NSSO, 2019, “*Situation Assessment of Agricultural Households and Land Holdings of Households of Rural India*”, Ministry of Statistics & Programme Implementation, National Statistics Office, Government of India, New Delhi.
- [6] NABARD, 2020, “*Annual Report*”, National Bank for Agriculture and Rural Development, Mumbai, India.
- [7] Singh, S. 2020a, “Farmers' Perception of Climate Change and Adaptation Decisions: A Micro-level Analysis of Farmers in the Bundelkhand Region, India”, *Ecological Indicator* 116.
- [8] Singh, S. 2020b, “Bridging the Gap between Biophysical and Social Vulnerability in Rural India: the Community Livelihood Vulnerability Approach” *Area Development and Policy* 5(2): 1-23.
- [9] Singh, S. 2020c, “Assessing livelihood vulnerability of farmers’ in backward regions in India”, *Indian Journal of Agriculture Research* 54(3):
- [10] Singh, S. and Alka, S. 2019, “Escalating food security status in Gujarat state of India”. *Asian Journal of Multidimensional Research*, 8(3): 12-28.
- [11] Singh, S. and Sanatan, N. 2020, “Development of Sustainable Livelihood security index for different agro-climatic zones of Uttar Pradesh”. *Journal of Rural Development* 39(1): 110-129.
- [12] Singh, S. 2019a, “Determinants of Agriculture Production in Uttar Pradesh, India: A Regional Analysis”, *Research Review International Journal of Multidisciplinary* 4(1):
- [13] Singh, S. 2019b, “Soil Health Security in India: Insights from Soil Health Card Data”, *Research Review International Journal of Multidisciplinary* 4(3):



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