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Regional Disparities in Agricultural and Social Development: An Inter-District Analysis of Bihar

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Abstract
The present study evaluates inter-district variations in agricultural and social development using Principal Component Analysis (PCA). The analysis is based on secondary data comprising twelve agricultural and twelve social indicators collected from the Directorate of Economics and Statistics, Department of Planning and Development, Government of Bihar, and the State Level Bankers' Committee (SLBC), Bihar, for the year 2021–22. The findings reveal substantial regional inequalities within the state. In terms of agricultural development, districts located in the central-eastern region performed comparatively better and were classified as highly developed, whereas most districts in the southern region remained in the least developed category. Similarly, with respect to social development, districts in the central region exhibited higher levels of development, while the southern and north-eastern districts recorded comparatively lower performance. Furthermore, the estimated Spearman's rank correlation coefficient (ρ=0.645) indicates a strong positive relationship between agricultural and social development across the districts of Bihar. These findings suggest that achieving balanced regional growth requires district-specific development strategies that integrate agricultural advancement with broader social development policies.

Keywords: Regional Disparities, Agricultural Development, Social Development, Bihar, Principal Component Analysis.

Introduction
Bihar, established as a separate state in 1912, is one of the largest states in eastern India. The state possesses extensive fertile plains, a dense river network, and significant mineral resources. However, uneven economic development across its regions eventually contributed to the demand for state bifurcation. As a result, the mineral-rich districts were separated to form Jharkhand in 2000, leaving Bihar largely dependent on agriculture and allied activities as the primary source of livelihood. Although Bihar is among the leading Indian states in terms of population, it continues to face significant developmental challenges, including low per capita income and literacy levels (Government of Bihar, 2023-24). The state records one of the lowest levels of per capita income and literacy in India. Following the bifurcation, agriculture and allied activities assumed greater importance in Bihar's economy and remained a major source of employment and livelihood. Approximately 54.2 percent of the total geographical area is under net sown cultivation, reflecting the state's strong agricultural orientation. According to the Census of India 2011, a substantial proportion of Bihar's workforce was engaged in agriculture and other primary-sector activities, reflecting the continued importance of the sector as a

major source of livelihood. Nevertheless, agriculture and allied activities contributed about 20.6 percent to Bihar's Gross State Domestic Product (GSDP) in 2021–22, despite the sector's continued importance as a major source of employment (Government of Bihar, 2023–24). This indicates the relatively low contribution of agriculture to state income compared with its importance in employment.

From an agro-climatic perspective, Bihar is classified into four major regions: the North Alluvial Plain, North-East Alluvial Plain, South-East Alluvial Plain, and South-West Alluvial Plain (Sattar et al., 2019). The River Ganga further divides the state into North and South Bihar, creating distinct climatic, geographical, and socio-cultural characteristics on either side. Although Bihar enjoys fertile alluvial soils and abundant water resources, it could not fully benefit from the Green Revolution to the same extent as several other Indian states (Joshi & Haque, 1980; Mittal & Devi, 2015). Owing to its untapped agricultural potential, Pandey (2012) described Bihar as a "sleeping giant" with significant prospects for future agricultural growth.

One of the major reasons for regional inequality in Bihar is the uneven distribution and inadequate management of water resources. Frequent floods affect the northern districts, while drought conditions regularly occur in the southern districts (Singh, 2014). These contrasting environmental conditions have widened disparities in both agricultural and socio-economic development. After the formation of Jharkhand, Bihar also experienced reduced industrial investment due to issues such as Naxalism and weak law-and-order conditions (Ripudaman, 2015), further slowing the pace of regional development.

The policy environment began to change after the formation of a development-focused government in 2005. A series of reforms, including three Agricultural Roadmaps (2008–2012, 2012–2017, and 2017–2023) and two phases of the Saat Nischay Programme (2015–2020 and 2021 onwards), were introduced to accelerate agricultural growth and reduce regional disparities (Nain, 2018; Sharma, 2021). Although these initiatives have improved development in several areas, substantial inter-district differences in agricultural and social progress continue to persist. Against this background, the present study examines the extent of regional disparities in agricultural and social development across the districts of Bihar. It aims to identify relatively advanced and backward regions and to provide evidence that may assist policymakers in designing more balanced and region-specific development strategies.

Review of Literature

Since ancient times, agriculture has served as the foundation of human civilization and has remained one of the most important pillars of economic development. According to the Food and Agriculture Organization (FAO), agriculture and allied activities are broadly classified into four major components: crop production, livestock, forestry and logging, and fisheries and aquaculture. Agricultural development is therefore regarded as a multidimensional process that seeks to improve both the quantity and quality of agricultural output in a sustainable manner while contributing to food security and poverty reduction. In addition, agricultural development supports the achievement of Sustainable Development Goals (SDGs), particularly those related to ending hunger and promoting sustainable production systems (Conway & Barbier, 1988; Krishna, 1992; Naylor, 2011; Resolution, 2015). As agricultural land is increasingly converted for industrial and urban purposes, improving productivity through better irrigation facilities, energy supply, agricultural credit, quality inputs, farm machinery, storage infrastructure, market networks, and extension services has become increasingly important.

In contrast, social development refers to the continuous improvement of human well-being and the overall transformation of society. The concept gained international recognition during the mid-twentieth century with growing emphasis on social welfare and was further strengthened through the adoption of the United Nations' Millennium Development Goals (MDGs) in 2000 and the Sustainable Development Goals (SDGs) in 2015. Social development encompasses improvements in education, healthcare, communication, equality, peace, integrity, and other essential social values that contribute to enhancing the quality of human life and developing productive human resources (Midgley, 1995; 2017).

Agricultural development plays a crucial role in promoting the overall economic progress of developing regions. Besides ensuring food security and generating employment, the agricultural sector contributes significantly to national income and stimulates growth in other sectors through strong forward and backward linkages (Stamoulis & Zezza, 2003; Byerlee et al., 2009; Gywu & Kanu, 2012). Income generated from agriculture encourages investment in industrial and social infrastructure, thereby creating a cycle of sustainable economic development (Timmer, 1988; Zepeda, 2001). Likewise, improvements in social infrastructure such as education, healthcare, transport, communication, and institutional support directly and indirectly enhance agricultural productivity by strengthening both human and physical capital. Better social infrastructure enables farmers to adopt modern technologies more efficiently, leading to higher productivity and improved economic performance (Pinstrup-Andersen & Shimokawa, 2006; Srinivasu & Rao, 2013). Therefore, agricultural and social development share a mutually reinforcing relationship, making balanced investment in both sectors essential for achieving inclusive and sustainable regional development.

Database and Methodology

For constructing the composite agricultural development index for the 38 districts of Bihar, twelve indicators were selected from secondary sources. The required data were obtained from the Directorate of Economics and Statistics (DES), Department of Planning and Development, Government of Bihar, and the State Level Bankers' Committee (SLBC), Bihar. The indicators were chosen based on previous literature on regional disparities. To reduce scale bias, the selected variables were standardized using the Z-score technique after adjusting them with the geographical area of each district. As the latest district-wise population data were unavailable due to the postponement of the 2021 Census, geographical area was used as the normalization base.

Principal Component Analysis (PCA) was then applied to construct composite indices of agricultural and social development. The composite scores were used to rank the districts and classify them into four categories: Very High, High, Low and Very Low. Finally, Spearman's Rank Correlation was used to examine the relationship between agricultural and social development across the districts of Bihar.

Table 1: Description of the Agricultural Development Indicators

Indicator	Rationale	Data Source
GCA/KM²	Gross cropped area per sq. km; reflects cropping intensity and agricultural land use.	DES, Bihar
GIA/KM²	Gross irrigated area per sq. km; indicates irrigation availability and productivity.	DES, Bihar
FC/KM²	Fertilizer consumption per sq. km; represents input intensity.	DES, Bihar
TR/KM²	Number of tractors per sq. km; proxy for farm mechanization.	DES, Bihar
AIL/KM²	Artificial insemination per sq. km; reflects livestock	DES, Bihar

	improvement.	
LT/KM²	Livestock treated per sq. km; indicates animal healthcare.	DES, Bihar
LI/KM²	Livestock vaccinated per sq. km; measures preventive animal health services.	DES, Bihar
TMP/KM²	Milk production per sq. km; represents livestock productivity.	DES, Bihar
FP/KM²	Fish production per sq. km; reflects fisheries development.	DES, Bihar
FA/KM²	Forest area per sq. km; indicates ecological balance and forestry resources.	DES, Bihar
RRN/KM²	Rural road length per sq. km; measures connectivity.	DES, Bihar
FUACPA/KM²	Agricultural credit plan funds per sq. km; reflects institutional financial support.	DES, Bihar

Source: Author's compilation based on secondary data.

Table 2: Description of the Social Development Indicators

Indicator	Rewritten Rationale for Selection	Data Source
THI/KM²	Number of health institutions per square kilometer. A higher density of healthcare facilities reflects better access to medical services and is an important indicator of social development.	DES, Bihar
TD/KM²	Number of doctors per square kilometer. The availability of medical professionals indicates the strength and quality of the healthcare system.	DES, Bihar
TEI/KM²	Educational institutions per square kilometer. Greater educational infrastructure supports literacy, skill development, and overall social progress.	DES, Bihar
TT/KM²	Teachers per square kilometer. Adequate teaching staff strengthens educational quality and human capital formation.	DES, Bihar
PDEGM/KM²	Person-days of employment generated under MGNREGS per square kilometer. Employment generation reflects livelihood support and rural welfare.	DES, Bihar
PDSD/KM²	Public Distribution System dealers per square kilometer. Wider PDS coverage improves food security and access to subsidized essential commodities.	DES, Bihar
EC/KM²	Electricity consumption (million units) per square kilometer. Energy use serves as a proxy for economic activity and social development.	DES, Bihar
TBB/KM²	Bank branches per square kilometer. Banking outreach reflects financial inclusion and access to formal financial services.	SLBC, Bihar
RD/KM²	Road length per square kilometer. Better road connectivity enhances mobility, market access, and service delivery.	DES, Bihar

RV/KM^2	Registered vehicles per square kilometer. Vehicle availability indicates transport accessibility and regional connectivity.	DES, Bihar
$TBSH/KM^2$	Beds in shelter homes per square kilometer. Shelter infrastructure represents institutional support for vulnerable groups.	DES, Bihar
$FUDACP/KM^2$	District annual credit plan funds utilized per square kilometer. Higher credit utilization indicates stronger institutional support for local development.	DES, Bihar

Source: Compiled by the author from secondary data.

To construct the composite indices for agricultural and social development across the districts of Bihar, Principal Component Analysis (PCA) was employed to extract the most significant components from the selected indicators. After obtaining the composite scores, districts were grouped into four development categories: Very High, High, Low, and Very Low, using rank and quartile transformation. In addition, Spearman's rank correlation was applied to examine the association between agricultural and social development.

Principal Component Analysis

Principal Component Analysis (PCA) is a multivariate statistical technique used for data reduction. It converts a large number of correlated variables into a smaller set of uncorrelated principal components while retaining most of the variation present in the original dataset. The method performs effectively when the variables are strongly correlated. Originally introduced by Karl Pearson in 1901, PCA has been widely adopted in economics, geography, and regional studies to analyse development patterns and regional disparities. The European Union has also utilized this approach in developing composite indices, including the Internal Market Index (Tarantola, 2002). Following Manly (1994), the generalized form of the principal component equations is presented below.

$Z_1 = a_{11}x_1 + a_{12}x_2 + \ldots.. + a_{1n}x_n$

$Z_2 = a_{21}x_1 + a_{22}x_2 + \ldots.. + a_{2n}x_n$

$Z_s = a_{n1}x_1 + a_{n2}x_1 + \ldots.. + a_{nn}x_n$

Where:

- Z_1, Z_2 and Z_s denote the extracted principal components.
- a_{ij} represents the factor loading coefficient associated with each indicator for a given principal component.
- x represents the observed value of the indicator for a particular district or sample.
- n denotes the total number of indicators used in constructing the composite index.

Spearman's Rank Correlation

After constructing the composite indices for agricultural and social development, Spearman's Rank Correlation (Spearman, 1904) was applied to examine the relationship between these two dimensions across the districts of Bihar. Spearman's correlation is a non-parametric statistical technique that measures the strength and direction of a monotonic relationship between two ranked variables. It may also be interpreted as the Pearson correlation coefficient calculated using ranked observations.

Correlation Formula

$\rho_s = \rho(R(X), R(Y)) = cov(R(X), R(Y)) / [\sigma R(X)\ \sigma R(Y)]$

Where:

- ρ = Pearson correlation coefficient computed on ranked variables.
- cov(R(X), R(Y)) = Covariance between the ranked variables.
- $\sigma R(X)\sigma R(Y)$ = Product of the standard deviations of the ranked variables.

When all observations have distinct ranks, Spearman's coefficient can also be calculated using the following equation:

$r_s = 1 - [6\ \Sigma d_i^2] / [n(n^2 - 1)]$

Where:

- d_i = Difference between the ranks of the two variables for the ith observation.
- n = Total number of observations.

Findings and Discussion

The findings of the study reveal considerable disparities in agricultural and social development across the districts of Bihar. The variation in the composite indices indicates that the districts do not follow a uniform pattern of development. Some districts have performed well in agricultural development as well as social development, while others show better performance in one dimension but relatively weaker performance in the other.

The comparison of the two development dimensions suggests that agricultural development and social development are related, but the relationship is not identical across all districts. A district with a higher level of agricultural development may not necessarily have a similar position in social development. This indicates that agricultural progress alone is not sufficient to ensure balanced regional development. Factors such as education, healthcare, connectivity, financial services and other social infrastructure also contribute to differences in the overall level of development.

The Spearman’s rank correlation coefficient of 0.645 shows a positive association between agricultural and social development across the districts of Bihar. This suggests that districts performing relatively better in agriculture generally tend to perform better in social development as well. However, the coefficient is not close to one, which indicates that the relationship is not perfect and that other factors also influence social development.

Overall, the findings point towards considerable inter-district disparities in Bihar. The results suggest that development policies should not follow a uniform approach for all districts. Greater attention should be given to the specific agricultural, infrastructural and social requirements of relatively backward districts. A coordinated approach towards agricultural development and social infrastructure can help in reducing regional disparities and promoting more balanced development across Bihar.

Table 3: Composite Indices of Agricultural and Social Development for the Districts of Bihar

Districts	Composite Index of Agricultural Development	Rank	Degree of Agricultural Development	Composite Index of Social Development	Rank	Degree of Social Development
Araria	0.161834519	20	Low	-0.4386904	33	Very Low
Arwal	0.209471313	17	High	0.203147882	12	High

Aurangabad	-0.221499416	27	Low	-0.435300604	32	Very Low
Banka	-0.565560447	32	Very Low	-0.710742701	36	Very Low
Begusarai	0.426229067	9	Very High	0.425064036	5	Very High
Bhagalpur	0.165823763	18	High	0.301866622	11	High
Bhojpur	0.327219794	15	High	0.096162689	15	High
Buxar	0.399812551	10	High	-0.067152288	18	High
Darbhanga	-0.017039523	22	Low	0.195457365	13	High
E. Champaran	-0.144373037	25	Low	-0.258254329	24	Low
Gaya	-0.519126515	31	Very Low	-0.305878883	26	Low
Gopalganj	-0.357958077	29	Low	-0.072830028	19	High
Jamui	-1.205421393	37	Very Low	-0.735051837	37	Very Low
Jehanabad	0.162484344	19	High	0.314308104	8	Very High
Kaimur	-1.013599564	35	Very Low	-0.813709913	38	Very Low
Katihar	-0.03057393	23	Low	-0.36526019	29	Low
Khagaria	0.427808997	8	Very High	-0.141297936	20	Low
Kishanganj	-0.116917438	24	Low	-0.428156937	31	Very Low

Source: Author's compilation based on secondary data

Table 3 presents the composite indices, ranks and development categories for agricultural and social development. The agricultural development scores show considerable variation among the districts. Khagaria records an agricultural development score of 0.4278 and ranks 8th, while Begusarai has a score of 0.4262 and ranks 9th. Both districts are placed in the Very High category. Buxar ranks 10th with a score of 0.3998 and is classified as High. Bhojpur, Bhagalpur and Jehanabad are also placed in the High category.

On the other hand, Jamui has an agricultural development score of -1.2054 and ranks 37th, while Kaimur records a score of -1.0136 and ranks 35th. Banka and Gaya are also placed in the Very Low category. The results therefore show a clear difference between districts with relatively higher and lower levels of agricultural development.

The social development index also shows considerable variation. Begusarai has a social development score of 0.4251 and ranks 5th, placing it in the Very High category. Jehanabad ranks 8th and is also placed in the Very High category. Bhagalpur, Bhojpur and Arwal fall in the High category. In contrast, Banka ranks 36th with a score of -0.7107, while Jamui and Kaimur rank 37th and 38th respectively and are placed in the Very Low category.

The comparison of the two indices shows that agricultural and social development do not always follow the same pattern. Khagaria, for example, is classified as Very High in agricultural development but Low in social development. Darbhanga, in contrast, is Low in agricultural development but High in social development. This indicates that agricultural development alone does not determine the level of social development in a district.

Table 4: Composite Indices of Agricultural and Social Development

Districts	Composite Index of Agricultural Development	Rank	Degree of Agricultural Development	Composite Index of Social Development	Rank	Degree of Social Development
Lakhisarai	-1.053214913	36	Very Low	-0.343537405	27	Low
Madhepura	0.732957298	4	Very High	-0.18477414	21	Low
Madhubani	-0.222953366	28	Low	-0.260444923	25	Low
Munger	-1.27830418	38	Very Low	-0.04243296	16	High
Muzaffarpur	0.373560233	13	High	0.657944274	2	Very High
Nalanda	0.377196036	12	High	0.38432506	6	Very High
Nawada	-0.679945912	33	Very Low	-0.361711603	28	Low
Patna	0.969773017	2	Very High	3.29168496	1	Very High
Purnea	0.868908861	3	Very High	-0.220396921	23	Low
Rohtas	-0.502926676	30	Very Low	-0.460493008	34	Very Low
Saharsa	0.378960144	11	High	-0.199422504	22	Low
Samastipur	0.44574906	6	Very High	0.312040381	9	Very High
Saran	0.35348574	14	High	0.139585125	14	High
Sheikhpura	0.43504063	7	Very High	0.31734188	7	Very High
Sheohar	-0.164659276	26	Low	0.484174569	4	Very High
Sitamarhi	0.023399471	21	Low	-0.051123623	17	High
Siwan	0.491738284	5	Very High	0.309135039	10	High
Supaul	0.221645041	16	High	-0.421014019	30	Very Low
Vaishali	1.086684131	1	Very High	0.500965394	3	Very High
W. Champaran	-0.945708629	34	Very Low	-0.615526229	35	Very Low
Spearman's (ρ)						.645

Source: Author calculations using SPSS and MS-Excel software.

Table 4 presents the composite indices and rankings for the remaining districts. The agricultural development results show a wide variation across the districts. Vaishali records the highest agricultural development score of 1.0867 and ranks first. Patna ranks second with a score of 0.9698, followed by Purnea with a score of 0.8689. Madhepura, Siwan, Samastipur and Sheikhpura are also placed in the Very High category.

In contrast, Munger records the lowest agricultural development score of -1.2783 and ranks 38th. Lakhisarai, Nawada, Rohtas, Kaimur and West Champaran are also placed in the Very Low category. These results indicate substantial disparities in agricultural development among the districts. The social development results show a somewhat different pattern. Patna records the highest social development score of 3.2917 and ranks first. Muzaffarpur ranks second with a score of 0.6579, while Vaishali ranks third with a score of 0.5010. Nalanda, Sheohar, Sheikhpura and Samastipur are also placed in the Very High category. At the lower end, West Champaran has a social development score of -0.6155 and ranks 35th. Rohtas ranks 34th, while Supaul ranks 30th. Lakhisarai, Madhepura and Nawada are also placed in the Low category.

The comparison of Tables 3 and 4 shows that agricultural development and social development do not always have similar rankings. Purnea ranks 3rd in agricultural development but 23rd in social development. Munger ranks 38th in agricultural development but 16th in social development. Patna performs strongly in both dimensions, ranking 2nd in agricultural development and 1st in social development. Vaishali also performs well, ranking 1st in agricultural development and 3rd in social development. The Spearman's rank correlation coefficient between agricultural and social development is 0.645. The positive value indicates a positive association between the two dimensions of development. Thus, districts with relatively better agricultural development generally tend to have better social development, although the individual district rankings show that the relationship is not the same across all districts.

Conclusion and Policy Implications

Regional imbalance continues to be a major developmental challenge that exists across countries, states, and districts. If these disparities remain unaddressed for a prolonged period, they may create economic inequality, social dissatisfaction, and regional tensions. Hence, identifying backward regions and addressing the factors responsible for their underdevelopment is essential for achieving inclusive and balanced growth.

The present analysis confirms the existence of significant inter-district disparities in Bihar with respect to both agricultural and social development. Districts such as Jamui, Banka, Kaimur, Rohtas, and several other backward regions continue to perform below the state average because of weak agricultural infrastructure, inadequate irrigation, poor connectivity, and insufficient social facilities. These differences are influenced by both natural conditions and uneven developmental planning.

To reduce these regional inequalities, priority should be given to improving irrigation systems, rural road connectivity, agricultural modernization, healthcare services, educational infrastructure, and financial inclusion in lagging districts. Greater public investment, district-specific development strategies, and stronger coordination between agricultural and social sector policies are necessary to ensure equitable resource distribution. Such measures would contribute to balanced regional development, higher agricultural productivity, improved quality of life, and sustainable economic growth across Bihar.

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