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Inter-District Regional Disparities in Agricultural and Social Development in Bihar

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ABSTRACT

The poor management of rivers and rainwater has led to regular floods in the northern districts and droughts in the southern districts of Bihar. This has further led to unbalanced growth in the state's various agricultural and social development regions. After forming a development-oriented government in 2005, the successful implementation of three consecutive Agricultural Roadmaps (2008 onwards) and two consecutive Saat Nischay Schemes (2015 onwards) has helped establish a regional balance for inclusive development to some extent. However, despite these efforts for agricultural and social transformation, the level of development varies significantly across all districts and regions of the state. Therefore, to understand the root cause of regional imbalance, this study analyses the inter-district agricultural and social development disparities through principal component analysis. For this, the secondary data on 12 indicators related to each dimension were extracted from the 'Directorate of Economics and Statistics, Department of Planning and Development, Government of Bihar,' and 'State Level Bankers' Committee' of Bihar for 2021-22. The analysis revealed a high degree of disparities across regions. For example, in the case of agricultural development, the districts in the central-eastern region were categorised as highly developed, while those in the southern region were classified as the least developed. In terms of social development, the districts of the central region were categorised as highly developed, while those of the southern and northeastern regions were classified as the least developed. Furthermore, the significant value of Spearman's rho (0.645) also indicates a strong positive correlation between agricultural and social development in Bihar. Thus, to ensure regional balance and societal harmony, the government should frame the district-specific policies with interlinkages between the agricultural and social development policies.

Keywords: Regional disparities, agricultural development, social development, principal component analysis, Bihar

JEL Codes: C38, I30, O18, Q10, R12

I

INTRODUCTION

Since its formation in 1912, Bihar has been one of India's major states, located in the eastern region. It was endowed with fertile plains, abundant river basins, and mineral deposits. However, the unbalanced economic growth among different regions led to demands for separation. It resulted in the carving out of minerals-rich districts in Jharkhand in 2000 and left 'agriculture and allied activities' as the lender of the last resort for the people of Bihar. Bihar has the 12th-largest geographical area, the third-largest population, and the 14th-largest GDP. However, the extent of disparity is that it has the lowest per capita income and literacy rate in India. After fragmentation, Bihar's economy has remained predominantly agricultural, with 54.2 per cent of its total geographical area under crop cultivation in the form of net sown area. According to the 2011 census, 75 per cent of the workforce was in the primary sector. However, the situation becomes fraught when combined with the fact that the share of the

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'agriculture and allied sector' in GSDP was around a meagre 20.6 per cent in 2021-22 (Bihar Economic Survey, 2023-24). Based on the agro-climatic characteristics, the state has three main geographical regions: 1. North alluvial plain, 2. Northeast alluvial plain, 3A. Southeast alluvial plain, and 3B. Southwest alluvial plain (Sattar et al., 2019). The flow of the river Ganga also creates an alternative natural boundary that bifurcates the state into North and South Bihar, each with its distinct climatic, physical, and cultural characteristics. However, despite being blessed with a natural locational advantage in the fertile alluvial plains of the River Ganga, the state lagged in capturing the benefits of the Green Revolution (Joshi & Haque, 1980; Mittal & Devi, 2015). It led researchers, such as Pandey (2012), to refer to Bihar as the sleeping giant in terms of its agricultural potential. The poor management of rivers and rainwater has caused regular floods in the northern districts (Singh, 2014) and drought in the southern districts of Bihar. It has further resulted in unbalanced growth among the state's different regions in terms of agricultural and social development. We have already discussed how this development divide led to the demands for separation in mineral-rich districts of Jharkhand. Following the fragmentation in 2000, Bihar also lagged due to a lack of investment, exacerbated by Naxalism and poor law-and-order conditions (Ripudaman, 2015).

The formation of a new development-oriented government in 2005 led to some strategic transformation in the state's policy paradigm. The successful implementation of three consecutive 'Agricultural Roadmaps' (Agricultural Roadmap I - 2008 to 2012; Agricultural Roadmap II - 2012 to 2017, and Agricultural Roadmap III - 2017 to 23) and two consecutive 'Saat Nischay' Schemes (Saat Nischay I - 2015-20 and Saat Nischay - 2021 onwards) has tried to establish the regional balance for inclusive development somewhat (Nain, 2018; Sharma, 2021). However, despite these efforts for agricultural and social transformation, Bihar has still been unable to catch up with its contemporaries. Therefore, this study aims to analyse inter-district disparities in the state's 'agricultural' and 'social' development to determine their possible remedies for the policy suggestions. The research objectives of this paper are to calculate a composite index of agricultural development for the districts of Bihar and identify the backward regions, to calculate a composite index of social development for the districts of Bihar and identify the backward regions and to identify the nature of the relationship between agricultural and social development of the districts in Bihar.

II

REVIEW OF LITERATURE

This section will conceptualise the terms "region," "regional disparities," "agricultural development," and "social development." It will also try to understand some linkages between agricultural and social development. Lastly, it will explore some key studies on the analysis of regional disparities in India and the World.

2.1 Conceptualising the Linkages between Agricultural and Social Development

Since its origin, agriculture has been the backbone of every civilisation; it is a pivot on which the other sectors of an economy run. According to the classifications of FAO, agriculture and allied activities comprise four sub-sectors: 1. crops, 2. livestock, 3. forestry and logging, 4. fishing and aquaculture. Therefore, 'agricultural development' is a multidimensional term referring to the sustainable increase in the quantity and quality of food items, aimed at reducing hunger and poverty. In this way, it is directly linked with the phenomenon of social development through goals 2 and 12 of the Sustainable Development Goals (Conway & Barbie, 1988; Krishna, 1992; Naylor, 2011; Resolution, 2015). In light of the decreasing cropping area due to land conversion for industrialisation and urbanisation, agricultural development can be achieved through advancements in various agricultural infrastructures, including irrigation, energy, credit, inputs, machines, cold storage, market chains, and farm extension services. On the other hand, the term social development is often used to describe the temporal transformation of society from the primitive to the mature stage. The discourse of social development began in the 1950s to promote social welfare in the Global South. Later, it gained pace with the declaration of the United Nations' Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) programs in 2000 and 2015, respectively. Social development is a comprehensive term that encompasses the social behaviour and intelligence development phenomena in an individual or child, in light of fundamental social values, such as peace, integrity, and equality. Conclusively, it is transforming humans into human resources through various social infrastructure services, such as health, education, and communication (Midgley, 1995, 2017).

The growth of the agricultural sector is a prerequisite for the overall development of a developing region because this sector not only feeds the people and contributes to national income but also influences the other sectors through forward and backward linkages (Stamoulis & Zezza, 2003; Byerlee et al., 2009; Ugwu & Kanu, 2012). The surplus generated from the agricultural sector helps create industrial and social infrastructures within the economy through the reinvestment process (Timmer, 1988; Zepeda, 2001). Subsequently, social infrastructure development also provides direct and indirect support in the agricultural development process. The advanced level of social infrastructure helps to increase agricultural productivity by providing better human and physical inputs, leading to higher economic growth (Pinstrup-Andersen & Shimokawa, 2006; Srinivasu & Rao, 2013). As both agricultural and social development are deeply correlated and possess a causal relationship, it is necessary to develop higher standards of agricultural and social infrastructure to achieve better and more balanced economic growth.

2.2 Studies Related to the Regional Disparities from the Rest of the World

The study by O'Gorman and Pandey (2010) revealed that between 1965 and 2000, the disparity in agricultural labour productivity increased steeply across the selected 79 countries worldwide. According to them, this inequality can be attributed to the variation in the diffusion of high-yielding variety (HYV) seed technology across the regions. Similarly, Tvrdoň and Skokan (2011) have examined regional disparities among four countries: the Czech Republic, Hungary, Poland, and Slovakia, utilising secondary data. They found that the regional disparities among regions were growing. Subsequently, Sandu (2011) analysed the state of regional imbalances across the communes and cities of Romania by computing an index of social development. The results from the study explained that demographic and rural-urban differences were the prime factors behind the disparities. Likewise, Davis et al. (2014) have used the Rural Income Generating Activities (RIGA) dataset of the FAO to analyse the disparities in rural income across Sub-Saharan African countries. The findings revealed that households in high-integration areas obtained a greater portion of their income from non-farm activities. In contrast, in low-integration areas, farm activities were the prime source of household income. This shows that farming does not hold much promise in unfavourable conditions. Like previous studies, Klamár (2016) evaluated regional disparities in the level of socio-economic development among the 13 districts of Slovakia's self-governing regions, using 11 indicators and applying the Gini and Coefficient of Variation methods. The findings revealed that the western districts have a comparatively higher level of development, largely due to FDI inflows, which provide better motorway facilities, increased tourist footfall, and employment generation opportunities. Again, Salvati et al. (2017) have identified that the topography, climate, and urban settlement are majorly responsible for socio-economic and environmental disparities in Italy. Moreover, Adamopoulos and Restuccia (2022) have tried to account for agricultural productivity differences across countries by using gridded micro-geography data from the Global Agro-Ecological Zones (GAEZ). They contend that despite considerable heterogeneity in land quality across space, low agricultural land productivity is not due to unfavourable geographic endowments. They added that if the ten richest and ten poorest countries produced current crops according to their potential yields, the rich-poor agricultural yield gap would decline from 21.4 per cent to 5 per cent. The study highlights the potential for achieving additional aggregate productivity gains through spatial reallocation and adjustments in crop production. Finally, road infrastructure plays a vital role in social and economic development, as Wahyuni et al. (2022) found that an increase in the rural access index has led to a decrease in regional inequality in rural areas of Indonesia. They have suggested that to sustain this benefit of regional convergence, the government should improve the nationwide road infrastructure to increase private investment and tax collections.

2.3 Some Key Studies Related to the Inter-State Regional Disparities in India

Regarding the debate on balanced development, Dasgupta et al. (2000) have tried to examine the convergence in the economic performances of Indian states. They revealed that between the analysis period of 1960-61 to 1995-96, the states were converging in sectoral SDP and diverging in per capita SDP. Similarly, Das and Barua (1996) have also examined the pattern of state-wise regional inequalities among all the sectors of the Indian economy. Their results showed that the unorganised sector has contributed to rising income inequalities since 1991 due to the government's focus on achieving faster growth rather than inclusive growth. Again, Kurian (2000) has also assessed the inter-state economic and social disparities and found that interstate regional disparities were increasing due to the prevalence of the vicious poverty cycle in the 'BIMARU' states of India. He further described that states like Kerala and Tamil Nadu were at a comparatively higher level of social development, even with a lower level of economic development. The author suggested eradicating the problems of corruption, inefficiency, and high population growth to enhance public and private investment in the backward regions. Subsequently, Abdul and Bhole (2000) tried to measure the inter-state differentials in rural development in India using PCA, cluster analysis, and other statistical techniques for 1991-92. They found that the benefits of development were very unevenly distributed in India. In such a manner, Bihar was the most backward state, followed by Orissa, Uttar Pradesh, and Assam, while Punjab was the most developed state, followed by Haryana, Kerala, and Karnataka. Likewise, Ghosh (2006) also examined the regional disparities in agricultural development across fifteen central states of India in four sub-periods from 1962 to 2002. His findings suggest that the nine states (viz., Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh) were sharing a common steady-state path with 'all-India' the remaining six states (viz., Haryana, Kerala, Punjab, Orissa, Tamil Nadu, and West Bengal) were on the path of regional divergence. Furthermore, Jose (2019) examined the inter-state regional disparities in the case of macroeconomic aggregates, socio-economic infrastructure, and human development indicators. He suggested that the backward regions require substantial investment in education, healthcare, and infrastructure development programs to support the growth process. In addition to others, Kumar and Rani (2019) examined the inter-state regional disparities in social development among India's 28 states and seven union territories. They found that unfair resource allocation was the primary reason for increasing inter-state disparities between states like Haryana and Bihar. Finally, Majumder et al. (2023) have described regional disparities as a multi-dimensional phenomenon. By applying the Wroclaw Taxonomic and K-means clustering techniques on the inter-state data of 31 indicators, they explained that six southern and western states (Kerala, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, and Gujarat) have met up the sustainable development level and were in the 'leaders' category, the four central and eastern states (West Bengal, Assam, Odisha, and Madhya Pradesh) were showing the mixed effect of development and were in 'potential leaders' category while the nine eastern and north-eastern states (Bihar, Jharkhand, Chhattisgarh, Rajasthan, Nagaland, Tripura, Arunachal Pradesh, Meghalaya, and Jammu & Kashmir) were in 'potential adopter' category due to lagging in developmental process.

2.4 Examining District-Level Studies on Regional Disparities in Different Indian States

The study of Narain et al. (2002) from Madhya Pradesh revealed that the overall socio-economic development index was positively associated with the agricultural development index. Similarly, Raychaudhuri and Haldar (2009) have noted that social infrastructure can significantly influence the growth prospects of districts through human capital generation. In contrast, physical infrastructure has a greater impact on income distribution. They further described that over the 15 years (1991-2005), the inter-district disparities in West Bengal have shown a declining trend in the first ten years of analysis and an increase in the subsequent five years. Like earlier studies, Sandeep (2009) has also tried to analyse the inter-district regional disparities regarding agricultural and economic development in Uttar Pradesh. The study reveals that the districts of the western region were in the most developed category, the districts of the eastern region were in the moderately developed category, the districts of the central region were in the less developed category, and the district of the Bundelkhand region was in the least developed category. Likewise, Ohlan (2013) has attempted to assess regional disparities in socioeconomic development using district-level secondary data. His socio-economic development index based on the Wroclaw Taxonomic method shows that India's southern region was highly and symmetrically developed compared to the Central and Northern regions. The study suggested that providing modern inputs and extension services in low-developed districts helps to increase agricultural production. Subsequently, Ripudaman (2015) analysed the pattern of regional disparities in the level of economic development in the post-reform era for 593 districts of India. His findings suggest that the development was clustered into regions such as north-western, western, southern, and some eastern areas of India. Meanwhile, the central and eastern regions were lagging due to low investment, stemming from poor political intentions, Naxalism, and inadequate law and order conditions. The author suggested improving financial strength through the effective role of local governmental bodies in both rural and urban areas, thereby fostering balanced growth. Furthermore, Kumar (2019) has attempted to measure the extent of inter-district disparities in terms of economic, physical, and social infrastructure in Uttar Pradesh at two points in time: 2000-01 and 2010-11. His findings were based on principal component analysis (PCA), which indicated that the districts in the western regions were the forerunners, while the districts in the Bundelkhand regions were the backbenchers, and the central and eastern districts fell into the mediocre category of development. The study advocates for improving economic and social infrastructure in backward regions to reduce regional disparities. Lastly, Singh et al. (2021) utilised time-series data on GSDP by economic activity from 1993/94 to 2018/19 to investigate spatial disparities in agricultural development across the 75 districts of Uttar Pradesh through cluster analysis. Their findings reveal that there were high fluctuations in the state's agricultural growth due to low and volatile productivity in the rainfed districts of the Bundelkhand region.

2.5 Assessing District-Level Studies on Regional Development in Bihar

Bhagat (1983) first examined the extent of inter-regional disparities in agricultural development in undivided Bihar. Using cross-sectional data from 31 districts for 1976-77, the author revealed that, compared to the Chhotanagpur plateau region, farmers in the plain regions achieved a comparatively higher level of agricultural productivity by utilising high-yielding inputs rather than relying on infrastructure endowments. Similarly, Singh's study (1990) also shared common findings. Her findings described that during the study year 1982-83, the districts of the Chhotanagpur Plateau were classified as backward regions; the districts of the North Bihar plains were categorised as developed and developing regions, and the districts of the South Bihar plains were classified as significantly developed regions. Subsequently, Kumari (2014) attempted to identify regional disparities at the inter-district level in Bihar. Her study revealed a significant gap between the capital district (Patna) and the other districts in terms of agricultural, service, health, and educational development. She further suggested that the resources should be mobilised to the backward regions at the district and sub-district levels to achieve balanced growth. Moreover, Singh (2014) also noted that the frequent floods in the northern districts made agricultural growth in Bihar unsustainable. Again, Kumari (2016) compared the regional disparity at the district level between Uttar Pradesh and Bihar. Her findings revealed a greater disparity in agricultural development between Uttar Pradesh and Bihar. The primary reason behind this phenomenon was Bihar's lack of benefits from the Green Revolution. Likewise, Hoda et al. (2017) explained that, despite using high productivity-augmenting inputs, the state suffered from the paradox of low agricultural productivity. Finally, the findings of Ahmad et al. (2017) and Kannan and Pohit (2021) revealed that high irrigation costs due to huge dependency on diesel pump sets, poor public investment in the power sector, lack of all-weather rural roads, weak implementation of agricultural projects, absence of agricultural produce marketing infrastructure, lack of technical research & extension services, strategic deficiencies in livestock diversification, and non-functioning producer collectives are the significant factors responsible for the low level of agricultural development in the state.

Based on the literature explored above, Bihar was one of the least developed states in India in terms of various dimensions of development. It also suffered from many disparities across the regions or districts. Improvements in fundamental sectors, such as agriculture, health, and education, are essential elements in reducing disparities. The newly formed government in 2005 tried to improve the state's situation by implementing several agricultural and social development schemes. Despite these efforts, the benefits of development were not uniform across all districts or regions of the state. Therefore, to understand the root cause of the regional imbalance, this paper intends to analyse the level of inter-district regional disparities in Bihar in terms of 'agricultural' and 'social' development after fifteen years of forming a development-oriented government. For this, the two separate composite indices of 'agricultural' and 'social' development for all 38 districts of the state have been calculated using Karl Pearson's (1901) principal component analysis method. Furthermore, to understand the nature of the relationship between the two dimensions of development, Spearman's (1904) rank correlation test has also been applied.

III

METHODOLOGY

This section provides a detailed discussion about the indicators and data sources, along with the tools, techniques, and software used for the analysis.

3.1 Indicators and Data Sources

For calculating the composite indices of 'agricultural' and 'social' development to analyse the inter-district regional disparities among the 38 districts of Bihar, the twelve indicators of each dimension were extracted from the 'Directorate of Economics and Statistics (DES), Department of Planning and Development, Government of Bihar,' and the 'State Level Banker's Committee (SLBC), Bihar. The above-mentioned literature on inter-state or inter-district regional disparities has informed the selection of indicators. To remove the biases of scale, the selected indicators were divided by the geographical area of the district, measured in square kilometres, and then normalised using the z-score technique. The absence of the latest demographic data due to the postponement of the 2021 national census compelled us to use the district's geographical area instead of the district-wise population. Table 1 provides a detailed description of the agricultural development indicators, and Table 2 presents a detailed description of the social development indicators.

TABLE 1. DESCRIPTION OF THE AGRICULTURAL DEVELOPMENT INDICATORS USED FOR THE STUDY

Indicators	Rationale for selection of the indicator	Data source
GCA/KM^2	It represents the gross cropped area per unit of geographical area, which equals the percentage of total agricultural land in each district. The size of the agricultural land is one significant determinant of the level of crop cultivation.	DES, Bihar
GIA/KM^2	It represents the gross irrigated area per unit of geographical area, which equals the percentage of total irrigated land in each district. Irrigation is one of the major determinants of agricultural productivity.	DES, Bihar

Table 1 (Contd.)

TABLE 1 (CONLD.)

Indicators	Rationale for selection of the indicator	Data source
FC/KM^2	It stands for the total NPK fertiliser consumption in tonnes per square kilometre of the district's geographical area. Fertiliser consumption is one of the major determinants of agricultural productivity.	DES, Bihar
TR/KM^2	It represents the number of tractors per square kilometre of the geographical area, which may indicate the intensity of farm mechanisation in the district. Farm mechanisation is one of the major determinants of agricultural productivity.	DES, Bihar
AIL/KM^2	It represents the number of livestock artificially inseminated per square kilometre of the district's geographical area. As livestock is one of the significant subsectors of agriculture, the level of artificial insemination is a major determinant of livestock production.	DES, Bihar
LT/KM^2	It stands for the number of livestock treated per square kilometre of the district's geographical area. As livestock is one of the significant subsectors of agriculture, the scale of livestock treatment is a major determinant of livestock health.	DES, Bihar
LI/KM^2	It stands for the number of livestock vaccinated per square kilometre of the district's geographical area. As livestock is one of the significant subsectors of agriculture, the scale of livestock immunisation is one of the major determinants of livestock health.	DES, Bihar
TMP/KM^2	It represents the total amount of milk production by cows, buffaloes, and goats in tonnes per square kilometre of the district's geographical area. As livestock is one of the significant sub-sectors of agriculture, the level of milk production is a major determinant of livestock wealth.	DES, Bihar
FP/KM^2	It represents the total amount of fish production per square kilometre of the district's geographical area. As fisheries and aquaculture are significant sub-sectors of agriculture, the level of fish production is one of the major determinants of the wealth in fisheries and aquaculture.	DES, Bihar
FA/KM^2	It represents the forest area per unit of geographical area, which equals the percentage of total forest land in each district. Forestry and logging are significant agricultural sub-sectors, providing fruits, timber, and other byproducts, while also contributing to biodiversity and soil conservation. Thus, the size of the forest cover represents the agroecological balance.	DES, Bihar
RRN/KM^2	It represents the length of rural roads per square kilometre of geographical area, indicating the district's rural road density. Rural road infrastructure is significant for the smooth transportation of agricultural goods.	DES, Bihar
FUACPA/KM^2	It stands for the funds utilised under the annual credit plan for agriculture in rupees crores per square kilometre of the district's geographical area. The size of the agricultural plan outlay is one of the major determinants of the level of agricultural development.	DES, Bihar

Source: Author's conceptualisation

TABLE 2. DESCRIPTION OF THE SOCIAL DEVELOPMENT INDICATORS USED FOR THE STUDY

Indicators	Rationale for the selection of the indicator	Data source
THI/KM^2	It stands for the total number of health institutions per square kilometre of the district's geographical area. It includes all kinds of health institutions, ranging from village to district headquarters, such as primary health centres, sub-divisional hospitals, and district-level hospitals. The presence of health institutions is one of the major determinants that influence the level of social development.	DES, Bihar
TD/KM^2	It stands for the total number of doctors per square kilometre of the district's geographical area. It includes all regular and contractual doctors working in any kind of health institution in the district. The availability of doctors represents the strength of health facilities, which is one of the major determinants for measuring the level of social development.	DES, Bihar
TEI/KM^2	It represents the total number of educational institutions per square kilometre of the district's geographical area. It includes the district's total number of primary, upper primary schools, and colleges. The presence of educational institutions is one of the primary determinants of a country's level of social development.	DES, Bihar
TT/KM^2	It stands for the total number of teachers per square kilometre of the district's geographical area. It includes all the teachers teaching in primary and upper primary schools. The availability of teachers represents the strength of educational facilities, which is one of the major determinants for measuring the level of social development.	DES, Bihar
$PDEGM/KM^2$	It represents the number of person-days of employment generated under MGNREGS per square kilometre of the district's geographical area. The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) provides a 100-day employment guarantee to rural workers. It was implemented in India in 2006. Employment is one of the primary determinants of a country's level of social development.	DES, Bihar
$PDSD/KM^2$	It stands for the number of public distribution system dealers per square kilometre of the district's geographical area. The dealers of the public distribution system (PDS) provide subsidised food grains to the marginalised population of society under the National Food Security Act (NFSA-2013) of the Government of India. The presence of PDS dealers represents the foodgrain distribution facilities and is one of the significant determinants of measuring social development in society.	DES, Bihar
EC/KM^2	It represents the energy consumption in million units per square kilometre of the district's geographical area. As electricity consumption represents the economy's growth trend, it is one of the major determinants of social development.	DES, Bihar
TBB/KM^2	It stands for the total number of bank branches per square kilometre of the district's geographical area. Asking for coverage represents the strength of the economy's financial inclusions, one of the major determinants for measuring social development.	SLBC, Bihar

Table 2 (Contd.)

TABLE 2 (CONLD.)

Indicators	Rationale for the selection of the indicator	Data source
RD/KM^2	It represents the total length of all types of road infrastructure per square kilometre of geographical area, indicating the district's road density. It includes the total length of national highways, state highways, major district roads, and rural roads. Road infrastructure is crucial for efficiently transporting goods and services within the economy. It is one of the significant determinants for measuring social development.	DES, Bihar
RV/KM^2	It stands for the total number of registered vehicles per square kilometre of the district's geographical area. It includes the district's total number of two-wheeler, three-wheeler, and four-wheeler vehicles. As vehicle availability and usage represent the intensity of transport facilities, they are significant determinants for measuring the level of social development.	DES, Bihar
TBSH/KM^2	It stands for the total number of beds in shelter homes per square kilometre of the district's geographical area. As the availability of beds represents shelter facilities for the homeless and poor, it is one of the major determinants for measuring the level of social development.	DES, Bihar
FUDACP/KM^2	It stands for the funds utilised under the district annual credit plan in rupees crores per square kilometre of the district's geographical area. The size of the district plan outlay is one of the major determinants of the level of social development.	DES, Bihar

Source: Author's conceptualisation

3.2 Tools and Techniques

To calculate the composite indices of 'agricultural' and 'social' development for the districts of Bihar, the principal component analysis technique was applied to the extracted indicators. Furthermore, to classify the districts into four degrees of development, namely 'Very High,' 'High,' 'Low,' and 'Very Low,' the rank and quartile transformation was also performed on the scores of the composite indices. Lastly, Spearman's rank correlation test was also applied to determine the relationship between social and agricultural development in Bihar.

3.2.1 Principal Component Analysis

It is a multivariate statistical tool that utilises the dimension reduction technique, transforming a large set of variables into a smaller set of uncorrelated linear components, thereby clearly explaining the variance of the original data. It performs better when the original variables are highly correlated with each other. It was propounded by Karl Pearson in 1901 as an analogue of the principal axis theorem in mechanics. Geographers and economists later adopted it as a regionalisation technique to analyse the regional disparities. In this way, it was also adopted by the European Union (EU) to construct the Internal Market Index for its member countries (Tarantola, 2002). As suggested by Manly (1994), the generalised forms of calculated principal components in the linear combination of the indicators can be written as:

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

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

$$Z_s = a_{n1}x_1 + a_{n2}x_2 + \ldots.. + a_{nn}x_n$$

Here,

$Z_1, Z_2, and\ Z_s$ are the number of extracted principal components

a_{ij} are the factor loadings associated with the indicators on a particular principal component

x is the value of the indicator of the particular case or sample

n is the total number of indicators taken to calculate a particular composite index

The statisticians highlight some additional assumptions in the selection criteria beyond linearity and the absence of bias. Our analyses have met all those required criteria in the following manner, as the principal component analysis was conducted on the 12 indicators, each of agricultural and social development, with 38 cases (districts), which states that we have satisfied the assumption of 'minimum case-variable (indicator) ratio of 1:3 to support the Chi-square testing (OECD Handbook, 2008). The Kaiser–Meyer–Olkin (KMO) measure verified the sampling adequacy for the analysis; the KMO values obtained were 0.662 and 0.738 for the agricultural and social development analyses, respectively. According to Kaiser & Rice's (1974) criterion, this value falls under the' moderate' category and is well above the acceptable limit of 0.6 (OECD Handbook, 2008). Again, the significant Bartlett's test of sphericity with p-value < 0.05 in both cases verifies that the indicators taken for the study significantly impact describing the composite indices (see Table A1 and A4 of the Appendix section). Moreover, we have chosen the covariance matrix after standardising indicators using Varimax rotation criteria, which provides maximum variances with Orthogonal rotation (Kaiser, 1958). Again, in both cases, the commonalities value for each indicator is ≥ 0.5, which shows that all the selected indicators are significantly represented in the analysis (See Tables A2 and A4 in the Appendix section).

Furthermore, based on Kaiser's (1960) criterion of Eigenvalues≥ 1, we have extracted four principal components in the agricultural development analysis and three principal components in the social development analysis (see Table A3 and A6, as well as Figures A3 and A6 in the Appendix section). This method also satisfied the assumption of Jolliffe (2002) that the percentage of variance explained by the first component must be greater than the percentage of variance explained by the subsequent components and so on. Moreover, it also satisfies the extraction criterion of Cattell (1966), who suggests the graphical extraction method by retaining all principal components lying before the break on the Scree plot (see Figures A2 and A4 in the Appendix section). Lastly, in both analyses, no indicators have highlighted their significant loadings (loadings ≥ 0.5) on more than one extracted component. This means we also avoid the complexity problem (See Table A3 and A6 in the Appendix section). In case of the extraction of more than one principal component, the composite indices have been calculated with the help of the following suggested formula by Harish (2009) and Kumari (2016):

$$CI = W_1S_1 + W_2S_2 + \ldots\ldots + W_nS_n$$

Here,

CI = Composite index of development for the districts

$W_1 = V_1/(V_1 + V_2 + \ldots\ldots + V_n)$

$W_2 = V_1/(V_1 + V_2 + \ldots\ldots + V_n)$

$W_n = V_1/(V_1 + V_2 + \ldots\ldots + V_n)$

$V_1 = Variance\ explained\ by\ the\ first\ principal\ component$

$V_2 = Variance\ explained\ by\ the\ second\ principal\ component$

$V_n = Variance\ explained\ by\ the\ n^{th}\ principal\ component$

S_1 = Standardised value of the component score of the first principal component

S_2 = Standardised value of the component score of the second principal component

S_n = Standardised value of the component score of the n^{th} principal component

The standardisation process has been done with the help of the following z-score technique:

$$Z_{(Standardization)} = \frac{(Actual\ value - Mean\ value)}{Standard\ Deviation}$$

3.2.2 Spearman's Rank Correlation

After calculating the two composite indices for the districts of Bihar, we have also applied Spearman's (1904) rank correlation test to understand the nature of the relationship between the districts' agricultural and social development. It is a nonparametric test that shows the monotonic correlation between the respective ranks of samples on two dimensions or variables. It can also be defined as the Pearson correlation between the rank variables.

$$r_s = \rho R(X), R(Y) = \frac{cov(R(X), R(Y))}{\sigma R(X) \sigma R(Y)}$$

Here,

ρ = Pearson correlation of the rank variables

$cov(R(X), R(Y))$ = Covariance of the rank variables

$\sigma R(X) \sigma R(Y)$ = Standard deviation of the rank variables

If all the n ranks are distinct integers, then we can also calculate Spearman's rank correlation by using the following formula:

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Here,

$d_i = R(X_i) - R(Y_i)$ is the difference between the two ranks of each observation

n = number of observations

3.2.3 Software Used

Tried-and-tested software, such as MS Excel and Python, has been used for calculating, tabulating, and graphically presenting data, while Paintsmap software has been used for map visualisation.

IV

FINDINGS OF THE STUDY

The analysis of Table 3 reveals that, according to the composite index of agricultural development, Vaishali (rank 1) was the most developed district in the state, followed by Patna (rank 2) and Purnea (rank 3). In contrast, Munger (rank 38) was the least developed district, followed by Jamui (rank 37) and Lakhisarai (rank 36). It can be observed that the districts in the central-east region were in the highly developed category, while the districts in the southern region were in the least developed category (Figure 1). Subsequently, the analysis of Table 3 also indicates that, according to the composite index of social development, Patna (rank 1) was the most developed district, followed by Muzaffarpur (rank 2) and Vaishali (rank 3). In contrast, Kaimur (rank 38) was the least developed district, followed by Jamui (rank 37) and Banka (rank 36). Notably, the districts of the central region were predominantly in the highly developed category, while those of the southern and northeastern regions were in the least developed category (Figure 2). Furthermore, the significant value of Spearman's correlation test (0.645) also indicates a strong positive correlation between agricultural and social development in Bihar (Table A7 and Figure A7).

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	0.162	20	Low	-0.439	33	Very Low
Arwal	0.209	17	High	0.203	12	High
Aurangabad	-0.221	27	Low	-0.435	32	Very Low
Banka	-0.566	32	Very Low	-0.711	36	Very Low
Begusarai	0.426	9	Very High	0.425	5	Very High
Bhagalpur	0.166	18	High	0.302	11	High
Bhojpur	0.327	15	High	0.096	15	High
Buxar	0.400	10	High	-0.067	18	High
Darbhanga	-0.017	22	Low	0.195	13	High
E. Champaran	-0.144	25	Low	-0.258	24	Low
Gaya	-0.519	31	Very Low	-0.306	26	Low
Gopalganj	-0.358	29	Low	-0.073	19	High
Jamui	-1.205	37	Very Low	-0.735	37	Very Low
Jehanabad	0.162	19	High	0.314	8	Very High
Kaimur	-1.014	35	Very Low	-0.814	38	Very Low
Katihar	-0.031	23	Low	-0.365	29	Low
Khagaria	0.428	8	Very High	-0.141	20	Low
Kishanganj	-0.117	24	Low	-0.428	31	Very Low
Lakhisarai	-1.053	36	Very Low	-0.344	27	Low
Madhepura	0.733	4	Very High	-0.185	21	Low
Madhubani	-0.223	28	Low	-0.260	25	Low
Munger	-1.278	38	Very Low	-0.042	16	High
Muzaffarpur	0.374	13	High	0.658	2	Very High
Nalanda	0.377	12	High	0.384	6	Very High
Nawada	-0.680	33	Very Low	-0.362	28	Low
Patna	0.970	2	Very High	3.292	1	Very High
Purnea	0.869	3	Very High	-0.220	23	Low
Rohtas	-0.503	30	Very Low	-0.460	34	Very Low
Saharsa	0.379	11	High	-0.199	22	Low
Samastipur	0.446	6	Very High	0.312	9	Very High
Saran	0.353	14	High	0.140	14	High
Sheikhpura	0.435	7	Very High	0.317	7	Very High
Sheohar	-0.165	26	Low	0.484	4	Very High
Sitamarhi	0.023	21	Low	-0.051	17	High
Siwan	0.492	5	Very High	0.309	10	High
Supaul	0.222	16	High	-0.421	30	Very Low
Vaishali	1.087	1	Very High	0.501	3	Very High
W. Champaran	-0.946	34	Very Low	-0.616	35	Very Low
Spearman's (ρ)						0.645

Source: Author calculations using SPSS and MS Excel.

FIGURE 1. MAP SHOWING THE DEGREES OF AGRICULTURAL DEVELOPMENT IN BIHAR.
Source: Authors' creation

FIGURE 2. MAP SHOWING THE DEGREES OF SOCIAL DEVELOPMENT IN BIHAR.
Source: Authors' creation

V

DISCUSSION

Several factors contribute to the high levels of agricultural disparities across the state. For instance, the districts in the central-east plains are agriculturally developed due to the deposition of fertile alluvial soil by the natural flow of the river Ganga. Second, the confluences of the tributary rivers, like the confluence of the Ganga-Kosi rivers in the central east region, also ensure abundant water availability and help in the better production of agricultural products. Lastly, despite causing some social difficulties, the periodic occurrence of floods in this region acts as a recharge for soil fertility, which in turn leads to productivity growth. On the contrary, the southern districts are endowed with the least fertile soil, receive low rainfall, and suffer from drought-related issues because they lie in the natural dispersion of the Chhotanagpur plateau (Mani, 2012). This means that, compared to the other districts, the districts in the southern region are agriculturally less developed (Bhagat, 1983; Singh, 1990). Subsequently, in terms of social development, the districts of the central region are highly developed due to the predominance of higher levels of social infrastructure in the capital and neighbouring districts (Kumari, 2014), while the districts of southern and north-eastern regions are comparatively poor and least developed due to lower levels of health and educational performances (NITI, 2023). Furthermore, a strong positive correlation between agricultural and social development indicates that the agricultural sector not only acts as the lender of last resort but can also serve as a forerunner in building strong forward and backward linkages in the economy. A higher level of agricultural development may induce a higher level of social development in the world's developing regions.

VI

CONCLUSIONS AND SUGGESTIONS

Regional imbalance is a global issue. It could be found across or within the nation, state, or district. The long-term neglect of regional disparities may lead to agitation among a group of people, prompting them to demand separation and resulting in socio-political fragmentation of society, as seen in the cases of the Soviet Union and Sudan (Hooson, 1972; Roden, 1974). Therefore, correctly identifying lagging regions, understanding the root cause, and solving this problem are highly required. The analysis in this paper reveals a high level of inter-district regional disparities in Bihar. Districts such as Jamui, Khagaria, West Champaran, Banka, and Rohtas were among the least developed districts in terms of both agricultural and social development. It suggests that the roots of disparities are both natural and artificial, and this issue can be resolved through the equitable allocation of government funds for building agricultural and social infrastructure in the lagging regions. Thus, the government should frame district-specific plans with interlinkages between agricultural and social development policies to ensure regional balance and inclusive development for maintaining societal harmony.

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APPENDICES

TABLE A1. KMO AND BARTLETT'S TEST STATISTICS FOR THE AGRICULTURAL DEVELOPMENT INDICATORS.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.662
Bartlett's Test of Sphericity (Approx. chi-square)	198.165
Df	66
Sig.	0.000
Determinant of the correlation matrix	0.002

TABLE A2. CORRELATION AND OTHER MEASURES FOR AGRICULTURAL DEVELOPMENT INDICATORS.

	GCA/KM^2	GIA/KM^2	FC/KM^2	TR/KM^2	AIL/KM^2	LT/KM^2	LI/KM^2	TMP/KM^2	FP/KM^2	FA/KM^2	RRN/KM^2	FUACPA/KM^2
GCA/KM^2	1											
GIA/KM^2	.838	1										
FC/KM^2	.352	.395	1									
TR/KM^2	.180	.147	.488	1								
AIL/KM^2	.379	.235	.305	.099	1							
LT/KM^2	.078	.072	.222	.258	.320	1						
LI/KM^2	.123	.010	.442	.365	.062	.162	1					
TMP/KM^2	.431	.320	.589	.373	.591	.505	.512	1				
FP/KM^2	.178	.034	.214	.055	.196	.050	.099	.213	1			
FA/KM^2	-.341	-.166	-.527	-.591	-.301	-.433	-.375	-.525	-.230	1		
RRN/KM^2	.284	.040	.109	.296	.131	.112	.351	.206	.259	-.486	1	
FUACP/KM^2	.243	.125	.310	.435	.526	.443	.417	.514	.107	-.375	.340	1
MSA	.584[a]	.502[a]	.737[a]	.736[a]	.595[a]	.608[a]	.595[a]	.762[a]	.679[a]	.735[a]	.670[a]	.698[a]
Communalities	.890	.909	.627	.668	.779	.613	.572	.760	.652	.668	.682	.624

[a] denotes the measuring of sampling adequacy.

TABLE A3. SUMMARY OF PCA ANALYSIS FOR AGRICULTURAL DEVELOPMENT INDICATORS.

	PC 1	PC 2	PC3	PC4
GCA/KM^2	.119	.141	.897	.228
GIA/KM^2	.071	.053	.947	-.064
FC/KM^2	.617	.249	.429	-.020
TR/KM^2	.803	.126	.083	-.004
AIL/KM^2	-.097	.803	.293	.198
LT/KM^2	.234	.737	-.086	-.086
LI/KM^2	.731	.132	-.046	.133
TMP/KM^2	.431	.681	.320	.087
FP/KM^2	-.036	.123	.089	.792
FA/KM^2	-.671	-.314	-.157	-.307
RRN/KM^2	.420	.012	.007	.711
FUACPA/KM^2	.379	.675	.019	.156
Eigenvalues	4.446	1.664	1.238	1.097
% of Variance	37.050	13.869	10.313	9.142
Cumulative %	37.050	50.919	61.232	70.374

Rotation method: Varimax with Kaiser normalization. Component loadings > 0.5 have been highlighted.

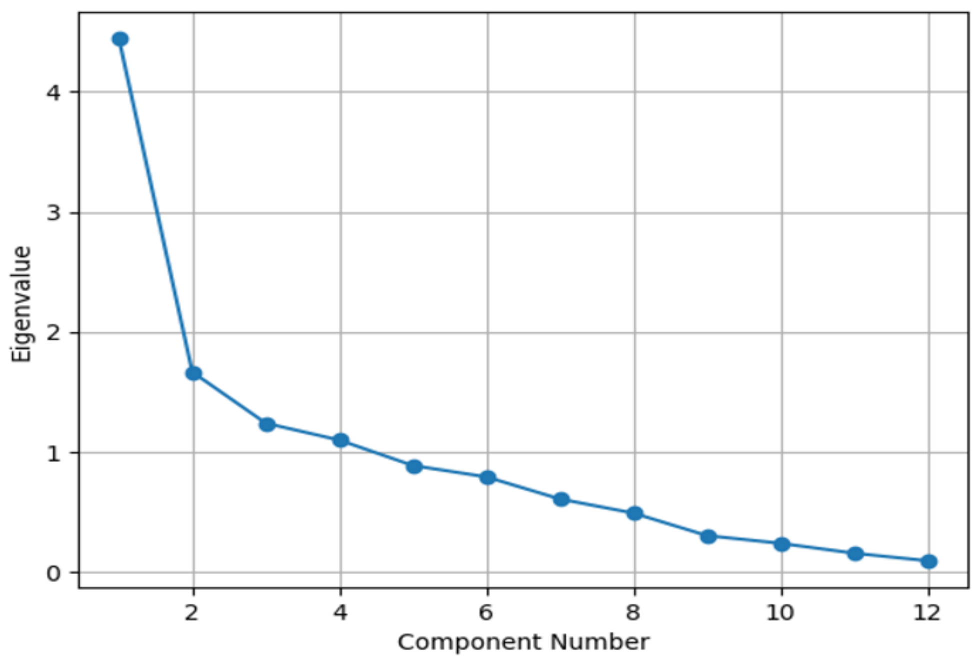

FIGURE A1. SCREE PLOT SHOWING PRINCIPAL COMPONENTS EXTRACTION ON AGRICULTURAL INDICATORS.

Source: Created with the help of Python.

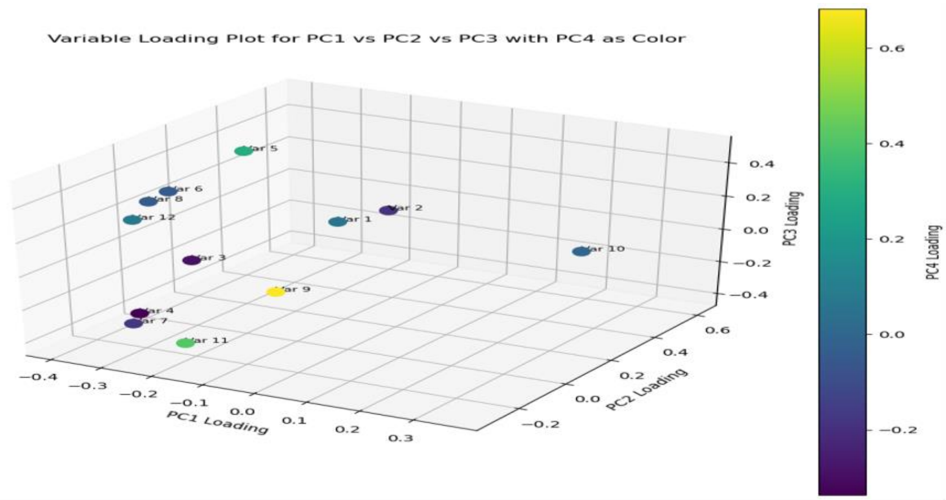

FIGURE A2. LOADING PLOT OF THE AGRICULTURAL DEVELOPMENT INDICATORS ON EXTRACTED COMPONENTS.

Source: Created with the help of Python.

TABLE A4. KMO AND BARTLETT'S TEST STATISTICS FOR THE SOCIAL DEVELOPMENT INDICATORS

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.738
Bartlett's Test of Sphericity (Approx. chi-square)	540.104
df	66
Sig.	.000
determinant of the correlation matrix	.00000005103

TABLE A5. CORRELATION AND OTHER MEASURES FOR SOCIAL DEVELOPMENT INDICATORS

	THI/ KM^2	TD/ KM^2	TEI/ KM^2	TT/ KM^2	PDE GM/ KM^2	PDS D/K M^2	EC/ KM^2	TBB /KM^2	RD/ KM^2	RV/ KM^2	TBS/ HK M^2	FUD ACP /KM^2
THI/KM^2	1.00											
TD/KM^2	.617	1.00										
TEI/KM^2	.096	.697	1.00									
TT/KM^2	.127	.642	.845	1.00								
PDEGM/ KM^2	.487	.445	.263	.257	1.00							
PDSD/K M^2	.130	.636	.719	.735	.202	1.00						
EC/KM^2	-.027	.574	.514	.263	-.037	.408	1.00					
TBB/KM^2	.089	.721	.695	.517	.085	.611	.928	1.00				
RD/KM^2	.008	.422	.716	.583	-.002	.455	.232	.363	1.00			
RV/KM^2	-.275	.408	.664	.450	-.089	.579	.780	.841	.474	1.00		
TBSH/K M^2	.750	.664	.285	.217	.357	.180	.314	.420	.041	.051	1.00	
FUDACP/ KM^2	-.015	.571	.559	.333	.021	.472	.942	.948	.280	.874	.286	1.00
MSA	.486[a]	.789[a]	.808[a]	.710[a]	.546[a]	.819[a]	.720[a]	.814[a]	.709[a]	.781[a]	.639[a]	.735[a]
Communa lities	.876	.923	.911	.849	.513	.700	.949	.982	.659	.913	.806	.962

[a] denotes the measuring of sampling adequacy.

TABLE A6. SUMMARY OF PCA ANALYSIS FOR SOCIAL DEVELOPMENT INDICATORS

	PC1	PC2	PC3
THI/KM^2	-.079	-.011	.933
TD/KM^2	.459	.494	.684
TEI/KM^2	.398	.850	.175
TT/KM^2	.150	.887	.197
PDEGM/KM^2	-.138	.216	.669
PDSD/KM^2	.339	.747	.163
EC/KM^2	.963	.127	.069
TBB/KM^2	.903	.362	.189
RD/KM^2	.121	.800	-.066
RV/KM^2	.811	.453	-.223
TBSH/KM^2	.299	-.018	.847
FUDACP/KM^2	.957	.208	.058
Eigenvalues	6.051	2.413	1.579
% of Variance	50.424	20.111	13.158
Cumulative %	50.424	70.535	83.693

Rotation method: Varimax with Kaiser normalization. Component loadings > 0.5 have been highlighted.

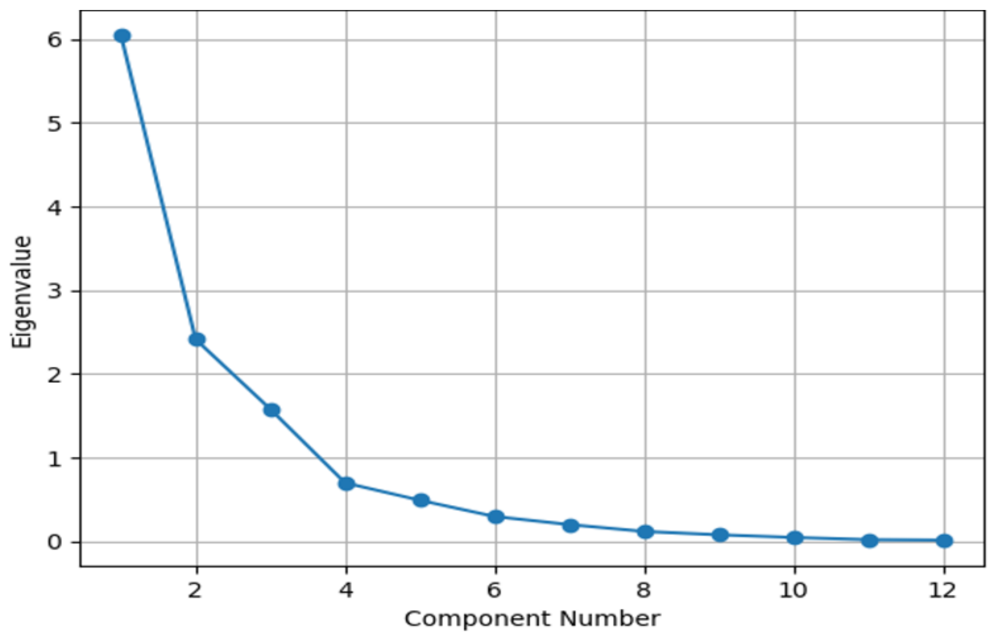

FIGURE A4. SCREE PLOT OF THE SOCIAL DEVELOPMENT INDICATORS.

Source: Created with the help of Python.

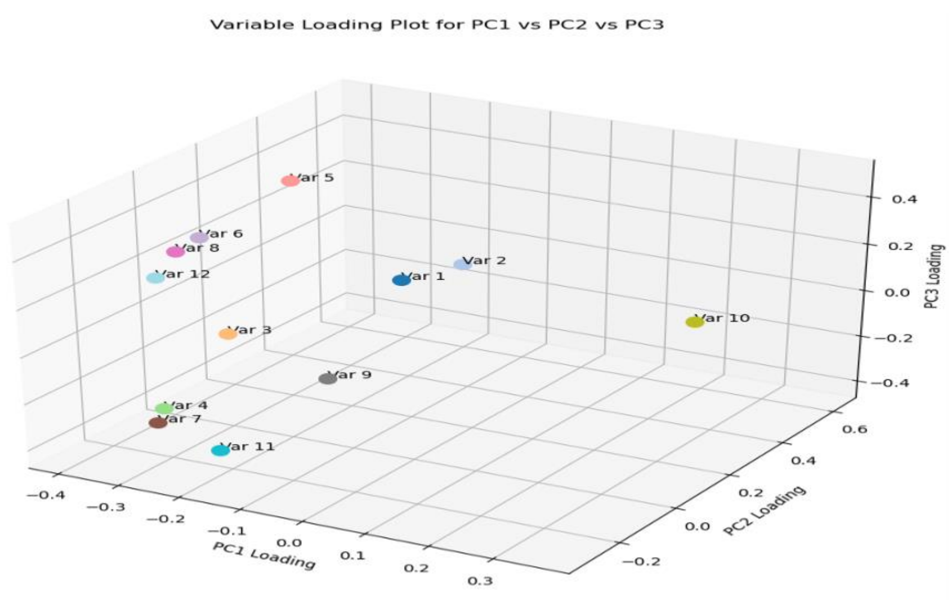

FIGURE A6. LOADING PLOT OF THE SOCIAL DEVELOPMENT INDICATORS ON EXTRACTED COMPONENTS.

Source: Created with the help of Python.

TABLE A7. DESCRIPTIVE RESULTS OF SPEARMAN'S RANK CORRELATION ANALYSIS.

Spearman's rho		Social Development	Agricultural Development
Agricultural Development	Correlation Coefficient	1.000	.645
	Sig. (2-tailed)		.000
	N	38	38
Social Development	Correlation Coefficient	.645	1.000
	Sig. (2-tailed)	.000	
	N	38	38

The variables agricultural and social development are significant and strongly positive correlated $r = .645$, $N = 38$, $p < .05$

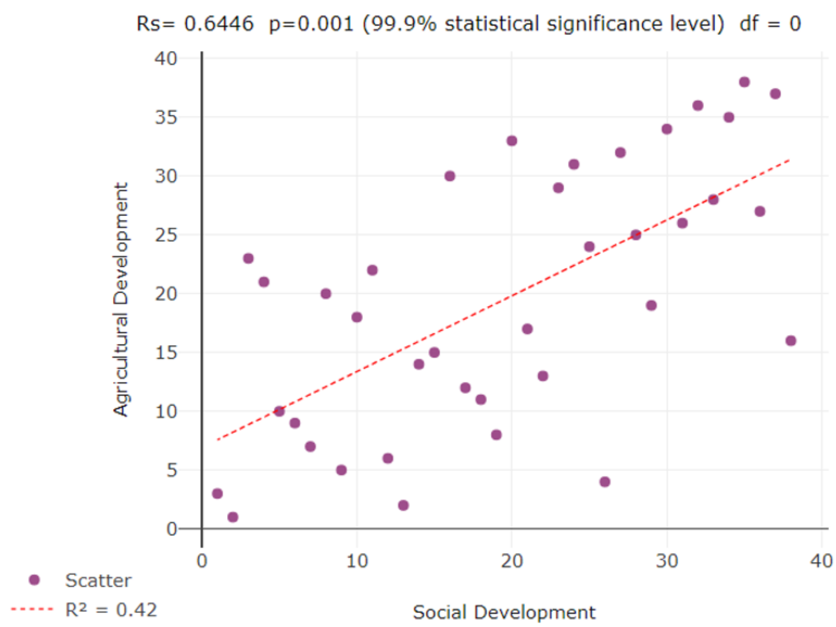

FIGURE A7. SCATTER PLOT OF THE SPEARMAN'S CORRELATION TEST BETWEEN THE RANK OF DISTRICTS.