Mukesh Kumar\textsuperscript{1} and Padmini Ravindra Nath\textsuperscript{2}

\textsuperscript{1}Affiliation not available
\textsuperscript{2}Associate Professor in Economics, Banaras Hindu University

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INTER-DISTRICT REGIONAL DISPARITIES IN SOCIAL AND AGRICULTURAL DEVELOPMENT OF BIHAR (INDIA)

Kumar MUKESH¹, Nath PADMINI RAVINDRA²
¹UGC-SRF, Department of Economics, Faculty of Social Sciences, Banaras Hindu University, India
²Associate Professor in Economics, Mahila Mahavidyalaya, Banaras Hindu University, India
Corresponding e-mail: nathravindra1007@gmail.com

Abstract
The poor management of river and rainwater has resulted in the periodic occurrence of floods in the northern districts and drought in the southern districts of Bihar. This phenomenon has led to unbalanced growth across the regions in terms of both social and agricultural development of the state. The successful implementation of three consecutive 'agricultural roadmaps' (2008 to 12, 2012 to 17, and 2017 to 22) and two consecutive ‘Saat Nischay’ schemes (Saat Nischay Part – I started in 2015 and ongoing Saat Nischay Part – II started in 2021) has tried to establish the regional balance to some extent. In this study, we aim to analyse the inter-district disparities in terms of social and agricultural development by computing the composite index and identifying the backward regions through the principal component analysis method. For this, we have used the secondary data on selected seven-seven indicators of both the dimensions of social and agricultural development taken from the Department of Economics and Statistics, Government of Bihar and State Level Banker’s Committee, Bihar for the year 2019-20. The results from the analysis show that there is a high degree of social and agricultural disparities across the regions such as Patna, Muzaffarpur, and Nalanda are the very highly developed districts while Kaimur, Jamui, and Banka are the very low-developed districts in terms of social development. Similarly, Begusarai, Sheohar, and Madhepura are very highly developed districts while Kaimur, Rohtas, and Jamui are very low-developed districts in terms of agricultural development. The result of Spearman’s rank correlation test (.331) also states that both ‘social’ and ‘agricultural’ development show a medium level of significant positive association which means a higher level of social development may induce a higher level of agricultural development. Thus, to establish balanced growth across the regions for ensuring societal harmony the government should frame and interlink the social and agricultural development policies together.

Keywords: regional disparities, agricultural development, social development, Bihar

Introduction
Since its formation in 1912, Bihar is one of the major states of India, located in the eastern region. It was endowed with fertile plains, an abundance of river basins, and minerals deposits but the unbalanced economic growth among different regions led to the separation demands and resulted in the carving out of minerals-rich districts in Jharkhand in 2000 and left ‘agriculture and allied activities’ as the lender to the last resort for the people of Bihar.

Bihar has the 12th largest geographical area, third-largest population, and 14th largest GDP but the extent of disparity is that it has the lowest per capita income and least literacy rate in India.
After fragmentation till the present, Bihar’s economy is predominantly agricultural as, among the total geographical area of 94,163 km$^2$, 54.2% of the land is under crop cultivation as the net sown area. According to the Census (2011), 88.7% of the population resides in rural areas, and 75% of the total workforce is engaged in the primary sector but the situation becomes fraught when combined with the fact that the share of the 'agriculture and allied sector' in GSDP is around a meagre 18.7% in 2019-20 (Bihar Economic Survey, 2022-23).

There are three main geographical regions in the state namely, 1. North alluvial plain, 2. Northeast alluvial plain, 3A. Southeast alluvial plain, and 3B. Southwest alluvial plain based on agro-climatic characteristics (Sattar et al., 2019). An alternative natural boundary is the river ‘Ganga’ which bifurcates the state into North and South Bihar, each with its distinct climatic, physical, and cultural characteristics. This is despite the state being blessed with a natural locational advantage by virtue of its being situated in the fertile Gangetic plains the state lagged in capturing the fruits of the green revolution (Joshi & Haque, 1980; Mittal & Devi, 2015) due to the lack of proper water management and irrigation infrastructure. These advantages have led researchers like Pandey (2012) to refer to Bihar as the sleeping giant as far as its potential for agricultural growth is concerned.

Now, we are moving forward to conceptualize the term ‘regional disparities’, ‘social development’, and ‘agricultural development’ and will also investigate the nature of the relationship between social and agricultural development.

**Review of literature**
This section tries to describe the term ‘regional disparities’ ‘social development’ and ‘agricultural development’. It also tries to understand the nature of the relationship between social and agricultural development. Lastly, it will explore some key studies on the regional disparities in terms of social and agricultural development across the India and the world.

**Conceptualizing regional disparities, social development, and agricultural development**
The term ‘region’ can be taken broadly to mean a group – be it of nations, states, districts, blocks, and sometimes even villages that possess homogeneity, contiguity, and functional integration. While an ‘area’ is always associated with at least four properties, namely scale, location, content, and boundary. The term ‘difference’ stands for the variation between the individuals of the unit or regions based on biological or natural characteristics. On the other hand, ‘disparity’ is a man-made phenomenon that shows the inequalities between individuals, groups, or regions due to unfair treatment or unjust systems. Therefore, ‘regional disparities’ mean wide differences in terms of income, health, education, industrialization, etc. between different regions. These regions can either be states in themselves or within states (West, 1966; Fisher, 1969; Meinig, 1978; Groenman, 1972; Ginsburg, 1968; Richardson, 1969 & 1973; Hoover, 1971; Harrison et.al., 2007; Gupta & Hiran, 1973; Sharma, 1974).

The term ‘social development’ is often used by psychologists to describe the bringing up of a kid in society it denotes the social behaviour and intelligence development phenomena in a child. As far as social development is concerned in economics, it is the process of changing
humans into human resources with the help of various social infrastructure services like – health, education, communication, transportation facilities, etc. While on the other hand the term ‘agricultural development’ stands for the increase in the land and labour productivity to meet the food demands of the increasing population in lieu of decreasing cropping area due to the shiftation of land for other uses. It can be done with the help of various agricultural infrastructures like – irrigation, energy, credit, inputs, machines, cold storage, market chains, and advanced agricultural extension services.

In the pieces of literature of development economics, social infrastructure is a necessary pre-condition for the development of the agriculture, industry, or services sector. The disparities across regions occur due to variations in the levels of infrastructural services (Thakur and Chauhan, 2010). Infrastructure is the base on which the economic development of any country or region stands. Both social and agricultural infrastructure are deeply correlated with each other and also possess a causal relationship. The social infrastructure provides direct and indirect support to increase the level of agricultural development. The increased level of agricultural development leads to high economic growth and this will bring the high demand for social infrastructure in the economy and this will create a cycle of forward and backward effects of development as per the theory of ‘Cumulative Causations’ propounded by Gunnar Myrdal in 1956 (Westlund, 2020).

After the fragmentation in 2000, Bihar lagged due to a lack of investment because of naxalism and poor law-in-order conditions (Ripudaman, 2015). There was a lack of both social and agricultural infrastructure in Bihar. The state was also suffering from poor management of river and rainwater and this has resulted in the periodic occurrence of floods in the northern districts and drought in the southern districts. This phenomenon has led to unbalanced growth among the districts and has caused regional disparities in terms of both social and agricultural development. But, the successful implementation of three consecutive ‘agricultural roadmaps’ (2008 to 12, 2012 to 17, and 2017 to 22) and two consecutive ‘Saat Nischay’ schemes of social development (Saat Nischay Part – I started in 2015 and ongoing Saat Nischay Part – II started in 2021) has tried to establish the regional balance to some extent (Nain, 2018; Sharma 2021).

Assessing some studies on inter-district regional disparities in different states of India
Bhagat (1983) has tried to examine the extent of inter-regional disparities in the agricultural development in undivided Bihar with the help of cross-sectional data of 31 districts for the period of 1976-7. His findings revealed that infrastructure was the significant determinant of agricultural productivity and due to that as compare to the Chhotanagpur plateau region, the farmers of plain regions achieved a higher level of agricultural productivity with the use of new agricultural practices in lieu of infrastructure endowments. The study of Singh (1990) has also reflected the similar findings. She described that in the study year 1982-83 the districts of the Chhotanagpur Plateau were covered under the backward regions; districts of North Bihar plains were under the developed and developing region, and the districts of South Bihar plains were under the very developed regions.
Narain et al., (2002) in their paper measured the level of development of the various districts of Madhya Pradesh. The Composite Index of socio-economic development was constructed based on 47 indicators out of which 23 indicators were directly connected with agricultural development. They identified nine districts from the northwestern and central part of the state as being agriculturally better developed as compared to the districts in the northeastern part. An important takeaway from this study is their finding that overall socio-economic development is found to be positively associated with agricultural development.

Raychaudhuri and Haldar (2009) have investigated the inter-district regional disparities in all 17 districts of West Bengal in terms of physical and social infrastructure. The findings suggest that over the period of 15 years (1991-2005), the disparities have shown declining trends in the first ten years of analysis and have increased in the last five years of analysis. It also indicates that the social infrastructure can play a significant role in the growth prospects of the districts of West Bengal due to human capital generation while the physical infrastructure has a greater impact on income distribution.

Sandeep (2009) has also tried to analyse the inter-district regional disparities in terms of 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 were in the least developed category.

Swain et al., (2009) have used the method of Composite Index computed based on nine indicators of agricultural development to illustrate the diversity of agricultural development in Orissa. They have identified four coastal regions (Balasore, Cuttack, Puri, and Ganjam) and two central tableland areas (Sambalpur and Bolangir) as more developed in agriculture than the other regions. Their analysis of the causes of regional inequalities in agricultural development in Orissa suggests that irrigation is the important factor that makes the difference in the level of development.

Raman & Kumari (2012) have analysed the regional disparity in agricultural development amongst fifty-four districts of Uttar Pradesh. The district-level secondary data on 13 carefully chosen indicators, has been used to construct a composite index for the two-time period 1990-91 and 2008-09. Methodologically, it was one of the earliest studies of regional disparity in Uttar Pradesh to use the UNDP methodology to standardize the agricultural indicators. They have pointed out the existence of high and persistent disparity in the state with agricultural development remaining polarised in the Western region of the state.

Ohlan (2013) has tried to assess regional disparities in terms of socioeconomic development by taking district-level secondary data. The author has constructed the composite index of development by applying Wroclaw Taxonomic Method. The socio-economic development index thus constructed shows that India’s southern region has been highly and symmetrically developed in comparison to the Central and Northern regions. The level of development is
assessed separately for agriculture as well as other sectors. The author of this study suggests
that activities should be undertaken to enhance agricultural production in less developed
districts by providing modern inputs and external support facilities.

Shafiqullah (2013) has measured the inter-district disparities in the overall agricultural
development of Uttar Pradesh by applying the standard score additive model to secondary data.
According to this study, the spatial distribution of agricultural development shows glaring
disparities. The majority of the northeastern and southern districts are underperforming in the
light of selected agricultural indicators whereas the western, central, and southern districts are
in a more favourable position.

Jena (2014) has tried to measure the levels of agricultural development for the state of Odisha
with the help of secondary data taken from the various sources of public domains for the year
2010. Findings suggest that 7 districts of the state are in backward regions, 8 districts of the
states are in underdeveloped, 6 districts are in developing regions, and the remaining 9 districts
are in developed regions.

Kumari (2014) has tried to identify the regional disparities at the inter-district level in Bihar.
The author has taken 34 indicators from four sectors i.e., agriculture, services, education, and
health. She has applied the PCA for measuring the inter-district variations and based on the
composite score it can be said that there is a huge gap between the capital district and the other
districts in terms of development. Therefore, the resources should mobilize to the backward
regions at the district and sub-district level to achieve balanced growth.

Ripudaman (2015) has analysed the pattern of district-level regional disparities in the level of
economic development in post-reform India. Using the two steps technique of the HDI report
author has worked out the deprivation score and again composite development score for the
593 districts on four indicators i.e., population above the poverty line, female literacy rate, the
population of non-agricultural rural workers, and the degree of urbanization for the year 2001.
Findings suggest that the development has been clustered into some specific regions such as
north-western, western, southern, and some eastern areas of India. The central and eastern
regions lagged due to a lack of investment because of bad political intentions, naxalism, and
poor law-in-order conditions. To foster balanced growth, it is necessary to boost financial
strength via the effective role of local governmental bodies in rural and urban areas.

Kumari (2016) has investigated regional disparity at the district level in Uttar Pradesh and
Bihar. Principal Component Analysis and Cluster analysis have been applied to making
comparisons in both states incorporating indicators from all four sectors of the economy -
agriculture, services, health, and education between 2001 and 2011. Her findings indicate that
there is more disparity in agricultural development in Uttar Pradesh as compared to Bihar. The
main reason behind this is the absence of a green revolution in the whole of Bihar.

Mustaquim and Asif (2016) in their study have analysed the spatial patterns of regional
disparities in the levels of overall development among the districts of West Bengal. Findings
state that a high grade of overall development is scattered over the state and the areas of low-level development are depicted in the North Bengal region of the study area.

Das (2018) has tried to analyse the inter-district regional disparities in the level of socio-economic and demographic development of West Bengal based on the secondary data extracted from the public domain for the year 2011. The findings of the composite index state that there was a presence of wide disparities across the states in which the North Pargana district performs best and the Uttar Dinajpur district performs worse in terms of overall socio-economic and demographic development.

Kumar (2019) has tried to measure the extent of inter-district disparities in terms of economic, physical, and social infrastructure in Uttar Pradesh at two points of time 2000-01 to 2010-11. The results from the principal component analysis confirm the similar findings of wide disparities across the regions. As the districts of the western regions were the forerunners and the districts of Bundelkhand regions were backbenchers while the central and eastern districts were in the mediocre category of development scenario. The articles also advocate the improvement of economic and social infrastructure in backward regions for the acceleration of economic growth, creation of employment opportunities, and reduction of regional disparities.

Singh et al. (2021) in her study has used time-series data of GSDP by economic activities from 1993/94 to 2018/19 to study the spatial agricultural disparities across the 75 districts of Uttar Pradesh by cluster analysis. Their findings reveal that the growth trends of the agriculture sector and agricultural productivity have cyclic fluctuations due to some areas of the state lying in the Bundelkhand region (Banda, Chitrakoot, Hamirpur, Mahoba, Jalgaon, Jhansi, and Lalitpur). These districts have a high dependency on rainfall which makes agricultural productivity low and volatile. After applying the Bai Perron method, they could identify multiple structural breaks for different agricultural indicators.

The above literature review assessment includes the key studies which are representative of the research being undertaken in the field of inter-district social and agricultural disparities in different states of India including Bihar. We can draw a significant observation from the above analysis that all the studies of any particular state depict similar findings. Perhaps due to the existence of data availability constraints, there is significantly less work on the inter-district disparities in Bihar as compared to say Uttar Pradesh, West Bengal, and Orissa. Now, we are going to analyse the inter-district regional disparities in Bihar in terms of social and agricultural development one by one with the help of a multivariate analysis technique suggested by Karl Pearson’s (1901) i.e., principal component analysis. Further, we will also apply Spearman’s rank correlation

**Objectives of the Study**

The research objectives of this paper are the following:

1. To construct a composite index of social development for the districts of Bihar and identify the backward regions.
2. To construct a composite index of agricultural development for the districts of Bihar and identify the backward regions.

3. To identify the nature of the relationship between social and agricultural development in Bihar.

**Methodology**

We have extracted the secondary data on seven-seven indicators of each aspect of social and agricultural development. The data were taken for the pre-covid period year of 2019-20 to avoid the pandemic effect. The multivariate statistical technique named principal component analysis (PCA) suggested by Karl Pearson (1901) is applied to construct the two separate composite indices of ‘social development’ and ‘agricultural development’ for all 38 districts of Bihar. After computing the composite development score (CDS), the rank and quartiles transformation were performed to classify the districts into four degrees of development such as – ‘Very High’, ‘High’, ‘Low’, and ‘Very Low’. Lastly, a non-parametric Spearman’s (1904) rank correlation test was also applied to find out the nature of the relationship between social and agricultural development in Bihar. The data of 13 out of a total of 14 indicators of both dimensions were extracted from the Department of Economics and Statistics, Government of Bihar, Patna while the data of one indicator (number of bank branches in the district related to the aspect of social development) was extracted from the State Level Banker’s Committee, Bihar. The tried and tested software like ‘MS-EXCEL’ and ‘PYTHON’ has been used for the calculation and tabulation of data while the ‘PAINTMAPS' software has been used for the map visualization.

**Principal Component Analysis (PCA)**

It is a multivariate statistical tool that works on the dimension reduction technique which transforms a large set of variables into fewer sets of uncorrelated linear components and explains the variance in original data clearly. It performs better when the original variables are highly correlated to each other. It was propounded by Karl Pearson in 1901 as an analog of the principal axis theorem in mechanics and was later adopted as the technique of regionalization by geographers and economists to analyze the disparities across the regions. It was also adopted by the European Union (EU) to construct the Internal Market Index for their member countries (Tarantola, 2002).

There are some assumptions underlined by the statisticians beyond the linearity, no outliers, and no biases in indicators selection criteria. The following assumptions should be fulfilled while using this technique. The first assumption explains the minimum sample size. Lawley & Maxwell (1971) suggest a significant rule that, to support the chi-square testing the number of cases should be 51 more than the number of variables. Similarly, Nunnally (1978), Gorsuch (1983), and Bryant & Yarnold (1995) suggest that the case variable ratio should not be less than 5:1. While Hatcher (1994) suggests that the number of cases should be 100 or greater than 5 times the number of variables. The second assumption states the selection of matrix transformation and rotation criteria. One should choose the covariance matrix with the standardized value of the same measurement scale variables otherwise the correlation matrix will be chosen if the variables have different measurement scales otherwise. The correlation
matrix can be said as the standardized form of a covariance matrix. As far as the rotation method is concerned one should go with the varimax rotation criterion (Kaiser, 1958) as it works on the orthogonal transformation of the variables and maximizes the variance in such a way where the first principal component explains the maximum amount of variance and the second principal component explains comparatively the lesser amount of variance and so on (Jolliffe, 2002). The value of the determinant of the correlation matrix should be ≥ 0.00001 which means the correlation matrix is quite stable and the data is reliable to work (Field, 2013). The third important assumption is to check the Kaiser-Meyer-Olkin (KMO) statistics which measure the sampling adequacy for both individual indicators and overall. As per Kaiser & Rice (1974), it should not be less than 0.60 to make the result of the principal component analysis reliable (OECD Handbook, 2008). The fourth significant assumption is that Barlett’s test of sphericity must be significant (p-value < 0.05). It tests the null hypothesis of an uncorrelated and singular correlation matrix. The significance (p-value < 0.05) states that the correlation matrix is neither singular nor uncorrelated. It also deducts that the correlation matrix must have at least two elements with a greater than 0.30 correlation coefficient. The fifth assumption checks the proper explanation of each indicator in the analysis. It means in the communalities matrix each indicator must show the minimum extraction of 0.5 it states that the component derived in the analysis has explained 50% or more variance. The sixth significant assumptions explain the extraction of the maximum number of principal components from the analysis. The Kaiser (1960) criteria explains that we should retain all the components having eigenvalue ≥ 1. While Cattel (1966) states the graphical method of extracting the proper number of components. Under this, we should retain all those components with relatively large eigenvalues present before the break on the scree plot. Last, but not least, the seventh assumption is that in the rotated component matrix table, each component must have at least two indicators with factor loading greater than or equal to 0.5. To avoid the complexity in the structure of the analysis, it is also advisable that no indicator should have more than one factor loading greater than or equal to 0.5 across all the extracted components in the same rotated component matrix. If any indicator is not lying within the above-given assumptions, then it is advised to stop the analysis, drop that indicator and again re-check all conditions till the underlying assumption is fulfilled. The more detailed framework of the principal component analysis or factor analysis can be understood with the help of works done by notable scholars like Rummel (1970), Kim & Muller (1978a & 1978b), and Stevens (2012).

As suggested by Manly (1994) the generalized forms of calculated principal components in the linear combination of the indicators can be written as:

\[ Z_1 = a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \]

\[ Z_2 = a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \]

\[ Z_s = a_{n1}x_1 + a_{n2}x_2 + \ldots + a_{nn}x_n \]

Where,

\[ Z_1, Z_2, \text{ and } Z_s \] are the number of extracted principal components.
\(a_{ij}\) are the factor loadings associated with the \(x_j\) 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 for the construction of a particular composite index.

Now if we have extracted more than one principal component based on eigenvalue \(\geq 1\) such as - we have two principal components for constructing the social development index and three principal components for constructing the agricultural development index (see next section of results and discussion for detail) then we have to combine the various component scores into one single composite index by using the formula (suggested by Harish, 2009; Kumari, 2016):

\[
CI = W_1S_1 + W_2S_2 + \ldots + W_nS_n
\]

where,

\(CI\) = Composite index of development for the districts

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

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

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

\(V_1 = Variance\ explained\ by\ the\ first\ principal\ component\)

\(V_2 = Variance\ explained\ by\ the\ second\ principal\ component\)

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

\(S_1 = Standardized\ value\ of\ the\ component\ score\ of\ the\ first\ principal\ component\)

\(S_2 = Standardized\ value\ of\ the\ component\ score\ of\ the\ second\ principal\ component\)

\(S_n = Standardized\ value\ of\ the\ component\ score\ of\ the\ n^{th}\ principal\ component\)

The standardization of the respective component score will be done with the help following z-score technique:

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

**Spearman’s rank correlation**

After constructing the two particular composite indices of ‘social development’ and ‘agricultural development’ for all 38 districts of Bihar. We have also applied Spearman’s (1904) rank correlation method to understand the nature of the relationship between social and agricultural development in Bihar. It is a non-parametric test that shows the monotonic correlation between the respective rank of samples on two dimensions or variables. It can also be defined as the Pearson correlation between the rank variables.

\[
r_s = \rho_{R(X), R(Y)} = \frac{cov(R(X), R(Y))}{\sigma R(X) \sigma R(Y)}
\]

where,
\( \rho \) = Pearson correlation of the rank variables
\( \text{cov}(R(X), R(Y)) = \) 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:

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

where,

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

\( n = \) number of observations

Now, we are going to describe all the seven-seven indicators of social and agricultural development dimensions taken for study.

Table - 1: Social Development Indicators at a Glance.

<table>
<thead>
<tr>
<th>Name of the Social Development Indicators</th>
<th>Symbol</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of colleges per sq km</td>
<td>TC/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Total enrolment in primary and upper primary levels per sq km</td>
<td>TE/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Total number of health institutions per sq km</td>
<td>TH/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Total achievement in individual toilet construction per sq km</td>
<td>CT/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Energy consumption (million units of electricity) per sq km</td>
<td>EC/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Number of kisan credit cards issued (new and renew) per sq km</td>
<td>KCC/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Total number of bank branches (as of 31.03.2020) per sq km</td>
<td>NBB/GA</td>
<td>SLBC, Bihar</td>
</tr>
</tbody>
</table>

Table - 2: Agricultural Development Indicators at a Glance.

<table>
<thead>
<tr>
<th>Name of the Agricultural Development Indicators</th>
<th>Symbol</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross cropped area per sq km</td>
<td>GCA/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Annual rainfall (in mm) per sq km</td>
<td>ARF/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Number of farms implements per sq km</td>
<td>FI/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Number of pump sets per sq km</td>
<td>PS/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Number of threshers per sq km</td>
<td>TS/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Number of livestock immunization per sq km</td>
<td>LI/GA</td>
<td>DES, Bihar</td>
</tr>
<tr>
<td>Total milk production (in litres) per sq km</td>
<td>TMP/GA</td>
<td>DES, Bihar</td>
</tr>
</tbody>
</table>

All the indicators were divided by the geographical area of the district (in square km) to remove the biases of scale. The indicators have been selected on the basis of the above-explored literature dealing with inter-district regional disparities. The constraints of missing or unavailability of district-wise data of Bihar have limited us to do our analysis on a few numbers of variables. Earlier we selected the ten-ten indicators of both the social and agricultural dimensions but after doing the prior analysis we dropped three-three indicators of each dimension that did not match the assumptions of PCA and re-fitted the analysis.
In the social development dimension, we have dropped the ‘number of primary and upper schools per sq km’ for showing the complex structure in the rotated component matrix, ‘number of literate females per sq km (as per the previous census of 2011)’ for the same reason of showing the complex structure in the rotated component matrix, and ‘rural road network per sq km’ for not showing the minimum level of variance in communalties matrix. Similarly, in the agricultural development dimension we have dropped the ‘gross irrigated area per sq km’ and ‘fish production (in kg) per sq km’ for not showing the minimum level of sampling adequacy in anti-image matrices while the ‘total fertilizer consumption (in kg) per sq km’ for showing the complex structure in rotated component matrix. The data of all the dropped variables were also taken from the same source of DES, Bihar.

**Results and Discussions**

In this section, we are going to describe the findings of all three objectives. It will contain three sub-sections in which we will explain the findings of social development disparities, agricultural development disparities, and the nature of the relationship between social and agricultural development in Bihar.

### Table - 3: District-wise Composite Indices of Social and Agricultural Development.

<table>
<thead>
<tr>
<th>Districts of Bihar</th>
<th>Composite Index of Social Development</th>
<th>Rank</th>
<th>Composite Index of Agricultural Development</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Araria</td>
<td>-61.22921169</td>
<td>31</td>
<td>54.60084379</td>
<td>6</td>
</tr>
<tr>
<td>Arwal</td>
<td>-12.28116008</td>
<td>20</td>
<td>82.88528159</td>
<td>5</td>
</tr>
<tr>
<td>Aurangabad</td>
<td>-50.25121304</td>
<td>29</td>
<td>-63.1735477</td>
<td>33</td>
</tr>
<tr>
<td>Banka</td>
<td>-86.20997363</td>
<td>36</td>
<td>-38.2483667</td>
<td>28</td>
</tr>
<tr>
<td>Begusarai</td>
<td>64.74759013</td>
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Findings of Inter-district regional disparities in the social development of Bihar

The results of principal component analysis on selected seven indicators of social development state that we are fulfilling all the above-discussed assumptions of PCA (See Tables – A5, A6, and A7 of the Appendices).

The analysis from Tables – 3 and 4 states that Patna (343.78) was the most developed district followed by Muzaffarpur (82.47) and Nalanda (75.75) while Kaimur (-112.03) was the most underdeveloped district followed by Jamui (-88.56) and Banka (-86.21). The visual inspection of the map in Figure – 1 depicts that in terms of social development the districts of the central region are highly developed as compared to the districts of other regions. Especially, the districts of eastern regions are the least developed. It is because of the predominance of higher social infrastructure in the central region and neighbouring districts of Patna (the capital district of Bihar). The findings of Kumari (2014) are supporting our results.

Figure – 1: Map showing the degrees of Social Development in Bihar.
Table - 4: Inter-district regional disparities in the degrees of social development in Bihar.

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Findings of Inter-district regional disparities in the agricultural development of Bihar

The results of principal component analysis on selected seven indicators of agricultural development state that we are fulfilling all the above-discussed assumptions of PCA (See Tables – A8, A9, and A10 of the Appendices).

The analysis from Tables – 3 and 5 states that Begusarai (157.04) was the most developed district followed by Sheohar (133.81) and Madhepura (125.81) while Kaimur (-88.86) was the most underdeveloped district followed by Rohtas (-97.52) and Jamui (-79.61). The visual inspection of the map in Figure – 2 depicts that in terms of agricultural development some districts of the central east region are highly developed as compared to the districts of other regions. Especially, the districts of southern regions are the least developed. It is because of the predominance of fertile alluvial soil and river basins in the central, eastern, and northern regions of the state while the districts of the southern region have the least water availability.
and comparatively less fertile soil deposition due to the prevalence of Chhotanagpur plateau. The findings of Bhagat (1983) and Singh (1990) is still supporting our results.

Figure – 2: Map showing the Degrees of Agricultural Development in Bihar.

Table - 5: Inter-district regional disparities in the degrees of agricultural development in Bihar.

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Result of the Spearman’s rank correlation
From the analysis of Table – 3 (and also Table – A11) it is clear that there is a medium-level significant positive correlation between the social and agricultural development scenario among the districts of Bihar. It means a higher level of social development may induce a higher level of agricultural development. Thus, to establish balanced growth across the regions for
ensuring societal harmony the government should frame and interlink the social and agricultural development policies together.

**Conclusion and Suggestions**
From the above analysis, it is clear that the districts of central regions are highly developed in terms of social development while the districts of central east regions are highly developed in terms of agricultural development. On the other hand, the districts of the eastern region are highly backward in terms of social development while the districts of southern regions are highly backward in terms of agricultural development. It means there is a high level of inter-district regional disparities in Bihar which is being supported by the older works of literature. It depicts that the root of disparities is very old and should be fairly removed with the help of a balanced allocation of government funds in building the social and agricultural infrastructure in lagging regions. The programs of social development should be interlinked with the programs of agricultural development to smooth the forward and backward linkages effects and attain a higher level of growth. The districts like Kaimur and Jamui which is highly backward in terms of both social and agricultural development must need special attention from the policy planners.

**Declaration of conflicting interests**
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**Data references**
References


Mustaquim, M., and Asif (2016): Regional Disparities in the Levels of Development in West Bengal- An Inter-District Analysis, Annals (NAGI), Vol. XXXVI, 120-152


# Appendices

Table – A1: Descriptive statistics of the social development indicators taken for study.

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Table – A3: Descriptive statistics of the agricultural development indicators taken for study.

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<th>Districts of Bihar</th>
<th>GCA</th>
<th>ARF</th>
<th>FI</th>
<th>PS</th>
<th>TS</th>
<th>LI</th>
<th>TMP</th>
<th>GA</th>
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<tr>
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<td>274650000</td>
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<td>1014000</td>
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<td>Jamui</td>
<td>679.6</td>
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<td>PS/GA</td>
<td>TH/GA</td>
<td>LI/GA</td>
<td>TMP/GA</td>
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<td>0.197985</td>
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<tr>
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<td>0.018875</td>
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<td>Bhojpur</td>
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<td>0.032864</td>
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Table – A4: Relative value of the agricultural development indicators taken for study.
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<tr>
<th>District</th>
<th>KMO</th>
<th>Bartlett's Test Statistic</th>
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<tr>
<td>Buxar</td>
<td>0.359765</td>
<td>0.262125</td>
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<td>Darbhanga</td>
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<tr>
<td>E. Champaran</td>
<td>0.3629352</td>
<td>0.081009</td>
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<td>Gaya</td>
<td>0.3216799</td>
<td>0.144768</td>
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<tr>
<td>Gopalgarj</td>
<td>0.22260874</td>
<td>0.146091</td>
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<tr>
<td>Jamui</td>
<td>0.8912944</td>
<td>0.144615</td>
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<tr>
<td>Jehanabad</td>
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<tr>
<td>Kaimur</td>
<td>0.43589647</td>
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<td>Katihar</td>
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<td>Madhepura</td>
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<td>Madhubani</td>
<td>0.3300443</td>
<td>0.053749</td>
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<td>Munger</td>
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<td>Muzaffarpur</td>
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Table – A5: KMO and Bartlett's test statistics for the social development indicators.
### Table – A6: Correlation and other measures for social development indicators.

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<th></th>
<th>TC/GA</th>
<th>TE/GA</th>
<th>TH/GA</th>
<th>CT/GA</th>
<th>EC/GA</th>
<th>KCC/GA</th>
<th>NBB/GA</th>
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</thead>
<tbody>
<tr>
<td>TC/GA</td>
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<td>TE/GA</td>
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<td>.620</td>
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<td>.523</td>
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<td>KCC/GA</td>
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<td>.534</td>
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<td>.072</td>
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<tr>
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<td>.864</td>
<td>.628</td>
<td>.793</td>
<td>.621</td>
<td>.703</td>
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</table>

Communalities: .926, .687, .689, .739, .949, .676, .957

### Table – A7: Summary of PCA analysis for social development indicators.

<table>
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<th>PC 1</th>
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<tbody>
<tr>
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</table>

Eigenvalues: 3.871, 1.754

% of Variance: 55.293, 25.064

Cumulative %: 80.357

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

### Table – A8: KMO and Bartlett's test statistics for the agricultural development indicators.

<p>| | |</p>
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<td>Kaiser-Meyer-Olkin Measure of Sampling Adequacy</td>
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<td>Bartlett's Test of Sphericity (Approx. chi-square)</td>
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<td>Sig.</td>
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</table>
### Table – A9: Correlation and other measures for agricultural development indicators.

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<th>FI/GA</th>
<th>PS/GA</th>
<th>TS/GA</th>
<th>LI/GA</th>
<th>TMP/GA</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCA/GA</td>
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<td>MSA</td>
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<td>.738*</td>
<td>.632*</td>
<td>.652*</td>
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<td>.713*</td>
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### Table – A10: Summary of PCA analysis for agricultural development indicators.

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<th>PC3</th>
</tr>
</thead>
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<td>15.081</td>
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<td>Cumulative %</td>
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<td>60.118</td>
<td>75.199</td>
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Rotation method: Varimax with Kaiser normalization.
Component loadings > 0.5 have been highlighted.

### Table – A11: Descriptive results of Spearman's rank correlation analysis.

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<th>Spearman's rho</th>
<th>Social Development</th>
<th>Agricultural Development</th>
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<tr>
<td></td>
<td>Sig. (2-tailed)</td>
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<td></td>
<td>N</td>
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</table>

Correlation is significant at the 0.05 level (2-tailed).
The variables Social Development and Agricultural Development are significantly and moderately positively correlated $r = .331$, N = 38, $p < .05$
Figure – A1: Scree plot showing the eigenvalues of PCs in the social development analysis.

Figure – A2: The loadings plot showing the relationship of social development indicators with the PCs.
Figure – A3: Scree plot showing the eigenvalues of PCs in the agricultural development.
Figure – A4: The loadings plot showing the relationship of agricultural development indicators with the PCs.
The first agricultural roadmap (2008 to 2012) was formulated to initiate the process of rainbow revolution in the field of agriculture by integrating crop farming, horticulture, forestry, fishery, poultry, and animal husbandry as a whole. The second agricultural roadmap (2012 to 2017) was to ensure the safety of food grains and nutrition and to augment the incomes of farmers. It paid special attention to providing road connectivity to the rural population which enables them to sell their products directly. The first and second agricultural roadmaps were successful to a large extent. The Government of India acknowledged these successes by conferring the “Krishi Karman Award’ on the state of Bihar, for outstanding production of Rice in 2012, Wheat in 2013, and Maize in 2016. The third agricultural roadmap (2017 to 2022) launched on November 08, 2017, placed special emphasis on organic farming, equitable agricultural growth with a focus on gender and human aspects, and the optimal use of natural resources for ensuring the sustainability of the production systems. The creation of an organic corridor in the districts along the Ganga River is a remarkable idea. Initially, the concluding year of the third roadmap was 2022, but it received an extension of one year till March 31, 2023. The upcoming fourth agricultural roadmap (2023 to 2027) will be paired with the national and international millet plan and aimed to promote millet production and to pave the agricultural diversification towards this ‘miracle crop’. As the experts say millet is a ‘miracle crop’ because it grows in drought condition, rich in fibre, and prevent many diseases.