Regional model for agricultural imbalances in West Bengal, India

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Abstract Regional imbalance is a ubiquitous phenomenon in developed and developing economies. But in the latter it is more acute and glaring. It is being increasingly recognized, both on theoretical and empirical grounds, and experiences of the developing countries shows that at least in initial stage of economic development, considerable regional imbalances in development arises. Regional imbalances exist in agricultural development in West Bengal. The present studies intend to measure the extent of regional imbalances in agricultural development in West Bengal and examine the factors responsible for them. This will help to find solution to the problem of regional imbalances. The study assumes that there are two sources, i.e. input effects and spatial effect that cause variation in the level of agricultural development. The study is envisaged to the West Bengal state with 18 districts (except Kolkata) with 9 indicators is taken for that measure. The district wise related data are taken as reference period from 2009 to 2012. Principal component analysis (PCA) and method of unequal weight with beta distribution, both of the regionalization approaches have been adopted to examine the inter-regional imbalances in agricultural development and to identify the spatial pattern of agricultural development in terms of probability density function. To study the degree and cause of regional

imbalances in agricultural development in West Bengal various tool likes regional balance ration, index of inter-regional imbalances, index of intra-regional imbalances and coefficient of regional imbalance has been used. The study goes into the explanation of how agricultural development can be sub-divided into a system of agricultural regions based on development criteria. Agricultural imbalances have been examined at regional level. This paper also diagnoses the factors responsible regional imbalances in the agricultural development in West Bengal. This analysis also suggests a number of measures incorporating suitable strategy for reducing regional imbalances and for securing balanced regional development of agriculture in West Bengal. The study winds up with an epilogue on regional development and broader conclusions of the study.

Keywords Regional imbalance · Agricultural regions · Principal component analysis (PCA) · Method of unequal weight · Beta distribution

Introduction

Several studies have been carried out to identify disparity at state level using different methods and indicators. There are a number of approaches that have tested the convergence hypothesis for India. Their finding has been conflicting—we have on the one hand the works of Dholakia (1994), Cashin and Sahay (1997), Ghosh (2008) and few others who have tested for conditional and absolute convergence by including a number of alternative variables and have observed that there has been conditional convergence for the states of the Indian economy. We on the other hand have works of Sachs et al. (2002), Rao et al.

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(1999), Dasgupta et al. (2000), Aiyar (2001), Trivedi (2003), Bhattacharya and Sakthivel (2004) who claim that there has been divergence between states in the post-independence era. Nayyar (2008) in his generalised methods of moment method confirms that there is no evidence of any convergence in growth of Indian states. These authors have attempted to identify factors that have caused divergence and are seems to be in unison so far as the negative impact of structural reforms and liberalisation on disparity is concerned. The alternative approach defines convergence as a reduction in the equality of regional incomes over time. The simplest way to measure a reduction in regional income inequality is in terms of a fall in the standard deviation of the logarithm of regional (per capita) incomes. This standard deviation-based approach is also known in the literature as sigma convergence (Barro and Sala-i-Martin 1995). The list of works using different alternative methods of disparity such as Gini coefficient, Theil's entropy index, coefficient of variation, rank analysis, index of rank concordance, composite indices using factor analysis, etc. is very long. The important works include the one by Rao et al. (1999), and Ahluwalia (2000), followed by Bhattacharya and Sakthivel (2004). Almost invariably all the works have found that disparity between states no matter which inequality concept is used has increased since independence and has intensified since the launching of reforms. These works have also sought to identify different factors especially government policies that have led to the intensification of disparity.

There is great dearth of studies measuring disparity in India at the disaggregated level. There are very few works of quality available dealing with intra-state disparity. We can quote only a handful. These include the one by Shaban (2006) for the state of Maharashtra, using principle component analysis (PCA) for the benchmark years 1972–1973, 1982–1983 and 1988–1989. The study finds that regions of Vidarbha and Marathwada and the district of Ratnagiri, Raigarh Dhule and Jalgaon have been the least developed both at sectoral and the aggregate levels of development. Shastri (1988) has examined the regional disparity for the state of Rajasthan which covers a period of 23 years (1961–1984). The study delineates the 'developed' and 'underdeveloped' districts and within the districts, the 'developed' and 'underdeveloped' sectors which require the attention of the policy makers. It clearly brings out the existing inter-district imbalances in the economic development of Rajasthan and makes the need for greater emphasis on regional approach to development planning obviously. A recent study, by Diwakar (2009) examine the regional disparity at disaggregate level, using district as a unit for the state of Uttar Pradesh and find that no district in the eastern and Bundelkhand regions were in the most developed category. At the same time, many districts in the

Western and Central regions were also on the lower rungs. Jena (2014) analyses agricultural development disparities in Odisha using PCA approach to classify the districts of Odisha according to different levels of agricultural development on the basis of some selected indicators.

There are a number of attempts made at discussing backwardness of a particular region or prevalence of crisis like situation in some other but the thrust on regional disparity in agricultural development has been rather lacking. Clearly, the studies relating to backwardness of agriculture have pointed out some major problems of the agriculture sector but have failed to compare the variations in performance of different regions and the reasons thereof. Among the works that investigate causes of backwardness of agriculture/crisis of agriculture in the state and in selected regions mention may be made of the works of Vakulabharanam, Chand, Mishra and others. For example, Raman and Kumari (2012) has argued that the reduction of domestic support in terms of subsidy and credit on the one hand, and drastic price fall of agricultural commodities in the international market on the other hand, has led to distress in the farming class of the state. Mishra (2007), Reddy and Mishra (2008) emphasise that crisis in agriculture was well underway by the 1980s and economic reforms in the 1990s have only deepened it. Decline in the supply of electricity to agriculture has been regarded as major cause of distress (Chand et al. 2007). Narayanamoorthy (2007) argues that fall in wheat and rice production is not due to technology fatigue rather due to extensive mono crop cultivation and high use of fertilisers and faulty agricultural pricing. Lack of allocation of funds to irrigation development after liberalisation has also resulted in the stagnation of net area irrigated. This poor growth in surface irrigation has compelled farmers to rely heavily on groundwater irrigation. The increased dependence on groundwater irrigation increases the cost of cultivation and depletion of ground water resources and in addition to this credit unavailability for investment on inputs put farmer in further crisis. Suri (2006) and Reddy (2006) argue that agrarian distress is result of the liberalisation policies which prematurely pushed the Indian agriculture into the global markets without a level-playing field; heavy dependence on high-cost paid out inputs and the other factors such as changed cropping pattern from light crops to cash crops; growing costs of cultivation; volatility of crop output; market vagaries; lack of remunerative prices; indebtedness; neglect of agriculture by the government; decline of public investment have contributed further to agrarian crisis. Same time, they points out that technological factors, ecological, socio cultural and policy related factors have contributed for the crisis.

Further, authors argue that extensive cultivation has led to decrease in productivity, which is due to intensive use of

fertilisers, which in turn resulted in increasing cost of inputs, ultimately leading to decrease in profit margins. Ecological factors include decreasing quality of land and water resources due to intensive chemical and fertiliser use. Socio and cultural factors include the effects of globalisation and urban culture on villages had shown impact on health and education consciousness in the rural agrarian families, in order to get the access of better facilities farmers have changed their cropping pattern. Policy related factors like decrease in public investment from 4 % of agricultural gross domestic product (GDP) during 1980s to 1.86 during early 2000. Patnaik (2005) examined how neo liberal policies introduced in the 1990s affected peasant community by examining the fund allocation to the rural development and concludes that fund allocation has come down from 4 % of net national product (NNP) in 1990–1991 to 1.9 % of NNP by 2001–2002. Gulati and Bathla (2001), Chand and Kumar (2004) have studied the impact of capital formation on Indian agriculture and have found that growth in capital formation in Indian agriculture has been either stagnating or falling since the beginning of 1980s. The process has been further aggravated by the macroeconomic reforms that have squeezed public investment. Vyas (2001) examined the impact of economic reforms on agriculture and claimed that Indian farmers mostly consists of small and marginal farmer who mainly depend on agricultural price policies such as minimum support prices (MSP) subsidies on inputs and irrigation, however, after reforms the MSP has not been properly regulated by the government leading to farmers distress. A review of the studies reveals that the studies have highlighted major reasons for agricultural distress. These reasons include vagaries of nature (primarily, inadequate or excessive water), lack of irrigation facilities, market related uncertainties such as increasing input costs and output price shocks, emphasis on commercial and plantation crops due to agricultural trade liberalisation, unavailability of credit from institutional sources or excessive reliance on informal sources with a greater interest burden and new technology among other. In addition, decline in the area under cultivation, which seems to be a result of expanding urbanization and industrialisation, deterioration in the terms of trade for agriculture, stagnant crop intensity, poor progress of irrigation and fertiliser have also been stressed.

In West Bengal, productivity growth in agriculture, particularly in food grain production, contributed significantly to overall economic growth of the state since the early 1980s. Agricultural growth has a significant impact on poverty reduction (Ravallion and Datt 1996).

After a long period of stagnation, agricultural growth in West Bengal was initiated in the early 1980s with the expansion of cultivation by using high yielding seeds (HYVs) and chemicals-based technology within the frame

of more equitable distribution of land through agrarian reforms. The tenancy reforms in the shape of Operation Barga, as implemented in the state after the late 1970s, have granted the right to register tenancies and also the legal entitlement to higher crop shares in favour of the tenants through legislation. There has been a growing concern in recent years about the deceleration of agricultural output in most of the agricultural states in India since the early 1990s. The positive impulse of the fast growing yield rate to output growth of the major crops as observed in the 1980s have been petered out in the phase of neo-liberal reforms in India. In the context of agricultural growth in India, Gulati and Bathla (2001) documented that a significant fall in public sector capital formation in agriculture was a major constraint on productivity growth in agriculture. Declining trend in the supply of institutional credit in the post-reform period in India has also been responsible for near stagnation in yield levels (Vyas 2001). Adoption of HYVs technology without considering the soil and moisture conditions, inadequate rural infrastructure, and weak network of agricultural marketing, sharply skewed land distribution and tenancy laws against the tenants in most part of the country are the major impediments to agricultural growth in India (Foster and Rosenzweig 2004). The improper use of chemical fertiliser and pesticides in technology-intensive production of rice and wheat largely account for environmental degradation and erosion of soil fertility. The decline in public investment in irrigation induces over extraction of groundwater by the private operators and raises environmental costs. The study of the relationship between value of agricultural produce per hectare of net area sown and agricultural values are relevant and significant to find out the roots to pace of agricultural development. There is the coexistence of developed and developing districts in West Bengal. The changing pattern of association of agricultural development indicators for the decadal year of 2009–2012 has been analyzed. Some nine indicators have been identified at district level in West Bengal to analyze the level of agricultural development. The existence of sharp inter-district disparity in development had been recognized and brought to focus in 1971 by the Bengal Chamber of Commerce and Industry, Calcutta (BCCI 1971) when it stated: “While the Calcutta Metropolitan District or the district of Burdwan in the coal-iron ore belt represents a relatively high level of development, the outlying regions like Darjeeling, Coochbehar and Jalpaiguri in the north or Purulia, Bankura and Murshidabad in the west reflect a sorry plight of stagnation and decay. Indeed, a greater degree of intra-state regional imbalance is not witnessed in any other state of the Indian Union, as the data provided by the census of India, reveals.” After independence the centralized planning was implemented for eliminating regional inequalities, but it

remained a serious problem in India. Regional disparities in India have widened day by day (Joshi 1997; Krishan 2001; Singh 2006). The basic cause of regional disparities is the states lacking an inherent mechanism to ensure that, in the long run, the benefits of economic change are distributed equally, on a per capita basis. Regional differences are to a large extent built in due to large unequal natural endowments and lack of infrastructure facilities which form the basis for rapid economic growth (Krishnaiah and Reddy 1998). The regional disparity in India is now a matter of serious concern. There are solemn regional disparities among different states of our country. Similarly, we have regional inequalities among different regions in a state. Even in a district there are disparities among different blocks. India is a large federal nation and it is well known that there are widespread disparities in the levels of economic and social development between the different regions of the nation. The lingual states that emerged after the reorganization were socially homogeneous but economically heterogeneous (Kundu and Raza 1982; Krishan 2000).

The ninth plan (1997–2002) aimed at growth with social justice and equity. The Planning Commission in its 10th plan (2002–2007) advocates the area approach and aims to strengthen decentralization of planning. Thus, the decentralized planning policy procedure was adopted to prepare village plans by collecting village requirements at block levels and finally they were put together at district level for district plans. But such attempts were confined only on paper. Removal of regional imbalances in development has remained the avowed goal of planning in India (Mohan 2005). Chakrabarti (1986) studies 15 of the 16 districts of West Bengal where there is agricultural activity and poses the problem of how to combine them into a certain number of groups. The need for such a grouping has long been felt by planning authorities in the country for regional planning at the level of a geographical unit smaller than the state but bigger than the district.

Most of existing studies do not highlight the inter-district or inter-region variation in agricultural development and view mainly in terms of the overall state or just one region of it but, contribute in finding the variables that should be taken to measure level of agricultural development in different regions of the state. In addition to this these studies have focused mainly on the outcome and consequences of agricultural development of only green revolution areas of the regional level or historical line of agricultural development. There has not been made any logical attempt to analyze and classify the imbalances in agricultural development by underlying indicators. Against this backdrop, this work attempts to take care of some recent issues of agricultural development in West Bengal. In such scenario it is important to identify the backward

regions of the country, state and even at district level in terms of development of major components as well as to measure the level of disparities amongst different regions. The present study also gets hints and impetus from the study done so far in identifying the appropriate indicator and bridging the gap in the literature pertaining to comprehensive treatment of agricultural imbalances. In the light of this perspective the present study has great relevance and significance in national as well as regional context.

Geographic location

The state of West Bengal is located in the eastern bottle-neck of India and lies between $21^{\circ}25'N$ – $26^{\circ}50'N$ and $86^{\circ}30'E$ – $89^{\circ}58'E$ with three international boundaries, i.e. Bangladesh, Nepal and Bhutan (Fig. 1). The total geographical area is about 88,752 km². The state is mainly riverine plain land and extending from the Himalayas in the north to the Bay of Bengal. Bangladesh on the south by the Bay of Bengal and on the west by Orissa, Bihar and Nepal. According to Registrar General I (2011), its total

Fig. 1 Geographical location of West Bengal with 18 administrative districts

population is 91,347,736 (7.55 % of India's total population), density is 904 persons per km² (in terms of population density West Bengal is on the top among the Indian states). The total area under cultivation is 5,450,679.18 ha in which 2,334,257.49 ha area is under irrigation. The state accounts for 19.18 % of cultivators and 24.97 % of agricultural labourers to total (main and marginal) workers.

Database and methodology

Database

The study was conducted in 18 districts (except Kolkata) after districts of West Bengal, India lying between Himalayan mountain in north and Bay of Bengal in south. The present works claim to be fairly comprehensive and self-contained contribution to the existing knowledge in this field. We chose to focus on the regional scale for district level agricultural development assessment. West Bengal has been selected for the analysis because agriculture production is the key factors in statewide, where the state government invests a substantial part of its resources to enhance agricultural productivity.

At present, West Bengal contributes 16 billion or 24 % to the total agricultural production and 30 % to the State Domestic Product annually. Marginal and small farmers constitute 95 % of the 5.7 million farmers. For each district, nine individual indicators associated with the three main components such as sensitivity, exposure and

adaptive capacity were collected from the publications of Govt. of West Bengal for the period year 2009–2012 and presented in Table 1. This study describes the data that have been used to perform the research, and methodology adopted for analysis of agricultural development.

Selection of the agricultural indicators

The developments profile is constructed by combining indicators for adaptive capacity like fertilizer consumption to total gross cropped area (GCA) (%), average wage rate for male agricultural field labourers (Rs) (%), gross irrigated area (Govt. canals) to total GCA (%) and percentage of cultivable land to total land area with sensitivity like net cropped area (NCA) to total geographical area (%), area under major nine commercial crops (autumn rice, winter rice, summer rice, jute, wheat, potato, sugarcane, gram and barley) to NCA (%), cropping intensity (%), production of major nine crops (Rs/h) and average yields rate of food-grains (kg/h) indicators that take into account.

In developing the profile of developments to spatial variability, we assume that exposure (such as flooding) to spatial variations will affect the current sensitivity, either positively or negatively, and that farmers will respond to these changes in sensitivity if they have sufficient adaptive capacity. There is no independently derived measure of exposure, sensitivity or adaptive capacity. So the relevance and interpretation of these indicators depend upon the scale of analysis of the particular sector under consideration and the data availability. The indicators of exposure, sensitivity

Table 1 Indicators of agricultural development

District	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉
Burdwan	111.59	274.39	222.73	175.40	5,374.75	16.63	66.68	0.065	2,976.00
Birbhum	103.18	134.59	203.17	155.62	5,661.42	13.48	74.28	0.071	2,759.67
Bankura	105.16	120.54	204.93	140.69	5,411.52	12.42	56.18	0.046	2,725.00
Midnapore (E)	143.26	62.79	136.70	188.87	5,193.15	16.77	73.89	0.073	2,510.33
Midnapore (W)	122.93	86.22	182.15	175.49	6,358.61	15.41	64.28	0.056	2,678.00
Howrah	122.71	29.88	160.01	195.47	6,059.16	17.04	62.68	0.058	2,128.00
Hooghly	112.07	96.57	283.76	251.16	10,276.09	21.59	69.20	0.068	2,954.67
24-Parganas (N)	132.79	7.50	186.02	206.57	14,113.71	14.69	67.88	0.058	2,670.00
24-Parganas (S)	132.20	44.90	119.97	146.74	4,344.48	12.19	39.98	0.038	2,184.33
Nadia	137.44	0.00	154.80	235.06	1,4805.35	15.89	76.83	0.075	2,556.67
Murshidabad	128.05	28.69	173.78	226.26	93,879.60	17.52	75.02	0.074	2,650.33
Uttar Dinajpur	136.98	0.80	202.21	174.12	9,266.36	13.66	89.40	0.088	2,801.33
Dakshin Dinajpur	101.76	0.00	165.53	164.47	6,504.59	13.33	85.65	0.084	2,672.67
Malda	129.81	0.00	225.76	196.96	11,550.38	14.17	76.72	0.060	2,823.33
Jalpaiguri	130.73	54.35	209.49	163.56	7,817.63	10.38	56.34	0.054	2,087.33
Darjeeling	110.92	3.61	106.16	145.39	6,909.03	3.73	48.77	0.041	2,106.33
Coochbehar	124.06	0.00	92.38	204.34	9,340.68	17.37	78.51	0.076	2,288.00
Purulia	89.52	22.46	72.62	106.62	4,569.16	9.35	70.44	0.044	2,124.33

and adaptive capacity chosen were based on previous studies and responsible for agricultural development in entire West Bengal. The indicators reflect relevant properties influencing developments of the agricultural sector to spatial variations and sensitivity where the sensitivity relied on the criterion of economic dependence of agricultural. The rationale for selection of each indicator is elaborated in Table 2.

Methodology for agricultural development

A number of studies are available on world-wide distribution of crops, type of rural economy, and the nature of the problems associated with them. From time to time attempt have been made to study regional variations in measurable as well as observable forms of agriculture of the various parts of the world. However, such studies may be carried out by employing different methods for the analysis and interpretation of distributions, which in turn serve different purpose in agricultural planning. The territorial differences in agriculture may be identified by regionalizing agriculture with application of underlying indicators based methods. Henceforth, a cursory look at the set of nine indicators (Table 2) reveals that they have either direct or inverse relationship. Some of these indicators are

in ratio form and others in percentage form. In view of this, each indicator considered in agricultural development computation is first required to be normalized. The data were arranged in the form of matrix and normalized using functional relationship. Obviously, the scaled values, y_{id} , vary from zero to one and it indicates the relative position of districts with reference to a selected indicator. Thus in case of each indicator, in view of its nature, the best (max) value and the worst (min) value are identified which are then used to transform by using the following expression (Khan et al 2013).

Let X_{id} represent the size or value of the i th indicator in the d th district of the state ($i = 1, 2, \dots, m : d = 1, 2, \dots, n$, say). The standardization/normalization is achieved by employing the following formula:

$$y_{id} = \frac{X_{id} - \min_d X_{id}}{\max_d X_{id} - \min_d X_{id}} [\uparrow] \quad (1)$$

where $\min_d X_{id}$ and $\max_d X_{id}$ are, respectively, the minimum and maximum of $(x_{i1}, x_{i2}, \dots, x_{in})$.

If, however, x_i is negatively associated with agricultural development, as, for example, the mean annual rainfall which should decline as the state agricultural development, then (Eq. 1) can be written as

Table 2 Nine important indicators and their sources

Notation	Indicator	Source
X_1	Average wage rate for male agricultural field labourers (Rs)	Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2009–2012)
X_2	Area irrigated by govt. canals to GCA	Directorate of Irrigation and Waterways, Govt. of West Bengal (2009–2012)
X_3	Consumption of fertilizer per unit of gross cropped area (kg/ha)	(1) Directorate of Agriculture (Manure and Fertilisers) Govt. of West Bengal (2009–2012) (2) Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2009–2012)
X_4	Percentage of cropping intensity	Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2009–2012)
X_5	Production of major nine commercial crops (Rs/ha)	Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2009–2012)
X_6	Percentage of area under major nine commercial crops to net cropped area (NCA)	Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2009–2012)
X_7	Percentage of cultivable land to total reporting area	(1) Bureau of Applied Economics and Statistics, Govt. of West Bengal (2) Directorate of Agriculture (Evaluation), Govt. of West Bengal (2009–2012)
X_8	Percentage of net cropped area to total reporting area	(1) Bureau of Applied Economics and Statistics, Govt. of West Bengal (2) Directorate of Agriculture (Evaluation), Govt. of West Bengal (2009–2012)
X_9	Average yields rate of foodgrains (kg/ha)	Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2009–2012)

Table 3 The normalized scores of the indicators

District	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Burdwan	0.411	1.000	0.711	0.476	0.012	0.722	0.534	0.54	1.00
Birbhum	0.254	0.491	0.618	0.339	0.015	0.546	0.689	0.67	0.76
Bankura	0.291	0.439	0.627	0.236	0.012	0.487	0.334	0.16	0.72
Midnapore (E)	1.000	0.229	0.303	0.569	0.009	0.730	0.681	0.69	0.48
Midnapore (W)	0.622	0.314	0.519	0.476	0.022	0.654	0.492	0.36	0.66
Howrah	0.618	0.109	0.414	0.615	0.019	0.746	0.480	0.41	0.05
Hooghly	0.420	0.352	1.000	1.000	0.066	1.000	0.582	0.60	0.98
24-Parganas (N)	0.805	0.027	0.537	0.692	0.109	0.614	0.559	0.40	0.66
24-Parganas (S)	0.794	0.164	0.224	0.278	0.000	0.474	0.000	0.00	0.11
Nadia	0.892	0.000	0.389	0.889	0.117	0.681	0.744	0.73	0.53
Murshidabad	0.717	0.105	0.479	0.828	1.000	0.772	0.702	0.73	0.63
Uttar Dinajpur	0.883	0.003	0.614	0.467	0.055	0.556	1.000	1.00	0.80
Dakshin Dinajpur	0.228	0.000	0.440	0.400	0.024	0.538	0.960	0.93	0.66
Malda	0.750	0.000	0.725	0.625	0.080	0.585	0.788	0.44	0.83
Jalpaiguri	0.767	0.198	0.648	0.394	0.039	0.373	0.326	0.32	0.00
Darjeeling	0.398	0.013	0.159	0.268	0.029	0.000	0.184	0.06	0.02
Coochbehar	0.643	0.000	0.094	0.676	0.056	0.764	0.801	0.76	0.23
Purulia	0.000	0.082	0.000	0.000	0.003	0.315	0.608	0.13	0.04

$$y_{id} = \frac{\text{Min}_d X_{id} - X_{id}}{\text{Max}_d X_{id} - \text{Min}_d X_{id}} \quad (2)$$

Upon receiving normalized values (Table 3), the next step was to assign factor loadings and weights. Weights to indicators can be assigned in a number of ways. One can judge the significance of an indicator and accordingly assigned weight which is based on the value judgment of an individual.

On the other hand, one can assign equal weights to all the indicators or assign unequal weights to different indicators according to significance of an indicator. The weightage in computation of an agricultural development index (ADI) in the present study are determined by incomplete beta distribution approach. In case of PCA, the values of indicators (x) have been underlined to verify the spatial factors for agricultural development at district level.

Method of unequal weights

On the basis of normalized values, we consider a method of unequal weights followed by Iyengar and Sudarshan (1982). The agricultural development was obtained as a weighted average of the values of underlying indicators. The agricultural development values for a district are simple averaged to compute composite agricultural development for the concerned district where all the components have equal weights of unity. Based on and composite agricultural development values, the districts were grouped into arbitrary definite classes. Thus method suffers from

two major discrepancies. Firstly, it emphasizes the entire component equally while computing the composite index.

From the matrix of scaled values $Y = (y_{id})$, researchers may construct a measure for the level or stage of development for different districts as follows:

$$\bar{y}_d = w_1 y_{1d} + w_2 y_{2d} + \dots + w_m y_{md} \quad (3)$$

where the w_i 's ($0 < w_i < 1$), and $w_1 + w_2 + \dots + w_m = 1$, are arbitrary weights reflecting the relative importance of the individual indicators. A special case of this is when the weights are assumed equal.

However, a more rational view would be to assume that the weights vary inversely as the variation in the respective indicators of agricultural development. More specifically, author shall assume:

$$w_i = \frac{k}{\sqrt{\text{Var}(y_i)}} \quad (4)$$

$$\text{where, } k = \left[\sum_{i=1}^m \frac{1}{\sqrt{\text{Var}(y_i)}} \right]^{-1} \quad (5)$$

The overall districts index $\bar{y}_d$ also varies from zero to one. Also, if $y_1, y_2, \dots, y_m$ are independent, then

$$\text{Var} = (\bar{y}_d) = \sum_{i=1}^m w_i^2 \text{Var}(y_i) \quad (6)$$

which is constant, equals to mk^2 for all the districts.

The choice of the weights in this manner would ensure that large variation in any one of the indicators would not unduly dominate the contribution of the rest of the indicators and distort inter-districts comparisons. It is well

Table 4 Indicators and respective estimated weights of the scaled variable

Notation	Indicator	Weight
X_1	Average wage rate for male agricultural field labourers (Rs)	0.105
X_2	Area irrigated by govt canals to gross cropped area (GCA) (ha)	0.113
X_3	Consumption of fertilizer per unit of gross cropped area (GCA) (kg/ha)	0.115
X_4	Percentage of cropping intensity	0.114
X_5	Production of major nine commercial crops (Rs/ha)	0.126
X_6	Percentage of area under major nine commercial crops to net cropped area (NCA)	0.132
X_7	Percentage of cultivable land to total reporting area	0.112
X_8	Percentage of net cropped area to total reporting area	0.099
X_9	Average yields rate of foodgrains (kg/ha)	0.084

known that, in statistical comparisons, it is more efficient to compare two or more means after equalizing their variances. Table 4 presents the indicators used and their respective estimated weights of the scaled variable.

Principal component analysis

For this study, PCA has been used to measure district-wise agricultural development differential at various principal component levels as well as the aggregate level of development for the year 2009–2012. PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by some projection of the data comes to lie on the first coordinate [called the first principal component (PC-1)], the second greatest variance on the second coordinate, etc. In this analysis, agricultural environmental data matrix x , with column-wise zero empirical means (the sample mean of each column has been shifted to zero), where each of the n rows represents a different repetition of the experiment, and each of the p columns gives a particular kind of datum (say, the results from a particular sensor). Mathematically, the transformation is defined by a set of p dimensional vectors of weights or *loadings* $w_k = (w_1 \dots w_p)_{(k)}$ that map each row vector x_i of x to a new vector of principal component *scores* $t_i = (t_1 \dots t_p)_{(i)}$, given by $t_{k(i)} = x_{(i)}w_{(k)}$ in such a way that the individual variables of t considered over the data set successively inherit the maximum possible variance from x , with each loading vector w constrained to be a unit vector (Chatterjee et al. 2016).

First component

The first loading vector w_i thus has to satisfy

$$w_{(1)} = \arg \max_{\|w\|=1} \left\{ \sum_i (t_1)_{(i)}^2 \right\} = \arg \max_{\|w\|=1} \left\{ \sum_i (x_{(1)}w)^2 \right\} \quad (7)$$

Equivalently, writing this in matrix form gives

$$w_{(1)} = \arg \max_{\|w\|=1} \left\{ \|xw\|^2 \right\} = \arg \max_{\|w\|=1} \left\{ w^T x^T x w \right\} \quad (8)$$

Since w_i has been defined to be a unit vector, it equivalently also satisfies

$$w_{(1)} = \arg \max \left\{ \frac{w^T x^T x w}{w^T w} \right\} \quad (9)$$

The quantity to be maximised can be recognised as a Rayleigh quotient. A standard result for a symmetric matrix such as $x^T x$ is that the quotient's maximum possible value is the largest eigenvalues of the matrix, which occurs when w is the corresponding eigenvector.

With $w_{(1)}$ found, the first component of a data vector x_i can then be given as a score $t_{1(i)} = x_{(i)}w_{(1)}$ in the transformed co-ordinates, or as the corresponding vector in the original variables, $\{x_{(i)}w_{(1)}\}_{w_{(1)}}$.

Further component

The k th component can be found by subtracting the first $k-1$ principal components from x ,

$$\hat{x}_k = x - \sum_{s=1}^{k-1} x w_{(s)} w_{(s)}^T \quad (10)$$

and then finding the loading vector which extracts the maximum variance from this new data matrix

$$w_k = \arg \max_{\|w\|=1} \left\{ \|\hat{x}_k w\|^2 \right\} = \arg \max_{\|w\|=1} \left\{ \frac{w^T \hat{x}_k^T \hat{x}_k w}{w^T w} \right\} \quad (11)$$

It turns out that this gives the remaining eigenvectors of $x^T x$, with the maximum values for the quantity in brackets given by their corresponding eigenvalues. Thus the loading vectors are eigenvectors of $x^T x$.

The k th component of a data vector $x_{(i)}$ can therefore be given as a score $t_{k(i)} = x_{(i)}w_{(k)}$ in the transformed co-ordinates, or as the corresponding vector in the space of the

original variables, $\{x_{(i)w(k)}\}w_k$, where $w_{(k)}$ is the k th eigenvector of $x^T x$.

The full principal components decomposition of x can therefore be given as

$$T = xw \quad (12)$$

where w is a $p \times p$ matrix whose columns are the eigenvectors of $x^T x$ of agricultural environmental data.

Continuous beta distribution

For classificatory purposes, a simple ranking of the districts based on the indices $\bar{y}_d$ would be enough. However, a more meaningful characterization of the different stages of agricultural development would be in terms of suitable fractile classification from an assumed distribution of y . It appears appropriate to assume that y has a beta distribution in the range $(0, 1)$. The beta distribution is generally skewed, and perhaps, relevant to characterize positive valued random variables.

A random variable, Z has a beta distribution in the interval $(0, 1)$ if its probability density function, $f(z)$, can be written as:

$$f(z) = \frac{1}{B(a, b)} z^{a-1} (1-z)^{b-1}, \quad (13)$$

$$0 < z < 1 \quad \text{and} \quad a, b > 0$$

where $B(a, b)$ is the integral

$$B(a, b) = \int_0^1 z^{a-1} (1-z)^{b-1} dz \quad (14)$$

Let, $(0, z_1)$, (z_1, z_2) , (z_2, z_3) , (z_3, z_4) ; and $(z_4, 1)$ be linear intervals, such that each interval has the same probability weight of 20 %. These fractile groups can be used to characterize the various stages of agricultural development. Suppose researchers adopt the following definitions of agricultural development, excluding the extreme values $z = 0, 1$.

V.	Less developed	if	$0 < \bar{y}_d \leq z_1$
IV.	Moderately developed	if	$z_1 < \bar{y}_d \leq z_2$
III.	Developed	if	$z_2 < \bar{y}_d \leq z_3$
II.	Highly developed	if	$z_3 < \bar{y}_d \leq z_4$
I.	Very highly developed	if	$z_4 < \bar{y}_d < 1$

The parameters (a, b) in the assumed beta distribution can be estimated by solving the following the simultaneous equations:

$$(1-y)a - yb = 0$$

$$(y - m_2)a - m_2b = m_2 - y \quad (15)$$

where y is the overall mean of the district indices and m_2 is given by

$$m_2 = s_y^2 + y^2 \quad (16)$$

where s_y^2 is the variance of the district indices. The cut off points z_1 – z_4 can be obtained from tables of incomplete beta function, from table of the F distributions with degrees of freedom $(2a, 2b)$, which are readily available.

If $F_{n_1, n_2; p}$ is the value of F statistics with n_1 and n_2 degrees of freedom corresponding to probability, i.e.

$$Pr(F \leq F_{n_1, n_2; p}) = p \quad (17)$$

then,

$$F_{n_1, n_2; p} = \frac{n_2}{n_1} \frac{1 - z_p}{z_p} \quad (18)$$

where z_p is the p th fractile of the corresponding beta distribution.

Hence, in our case, z_p is given by

$$z_p = \frac{1}{1 + \frac{b}{a} F_{n_2, n_1; p}} \quad (19)$$

Since, $n_1 = 2a$, $n_2 = 2b$. Extensive tables are available for computing the fractile points on the F distributions for selected values of (n_2, n_1) and p . For values of F distributions not readily available in the tables a two-way interpolation is needed. A straightforward procedure would be as follows:

For values of $p < 0.5$, let $F_{n_{2k}, n_{1k}}$ be the tabulated value of the F ratio with degrees of freedom (n_{2k}, n_{1k}) for a given fractile point on the F distribution. Taking $k = 1$ and $k = 2$, researchers wish to compute, say, F_{n_2, n_1} for values of (n_2, n_1) .

Where $n_{21} < n_2 < n_{22}$ and $n_{11} < n_1 < n_{12}$. It is easy to show that

$$F_{n_2, n_1} = F_{n_{21}, n_{11}} + \frac{n_2 - n_{21}}{n_{22} - n_{21}} (F_{n_{22}, n_{11}} - F_{n_{21}, n_{11}})$$

$$+ \frac{n_1 - n_{11}}{n_{12} - n_{11}} (F_{n_{21}, n_{12}} - F_{n_{21}, n_{11}})$$

$$+ \frac{(n_2 - n_{21})(n_1 - n_{11})}{(n_{22} - n_{21})(n_{12} - n_{11})}$$

$$[F_{n_{21}, n_{11}} + F_{n_{22}, n_{12}} - F_{n_{21}, n_{12}} - F_{n_{22}, n_{11}}]$$

However, for $p \geq 0.5$ the following result holds:

$$F_{n_1, n_2; p} = \frac{1}{F_{n_1, n_2; 1-p}}.$$

Methodology for regional imbalances in agricultural development

There are various theories, which explain the causes and course of regional disparities. There is a need for intensive look into the regional disparities in agricultural development in order to secure balanced regional agricultural development and to raise the level of agricultural with an

aim no bringing about economic prosperity in West Bengal. Attempts are made to analyze the degree and course of variation within the perspective of tolerability inequality. It will examine factors responsible for the variation so that measure be suggested for balanced agricultural development. There are various methods of measuring the degree of regional imbalances and these measures range from the conventional ones like mean, range, standard deviation, coefficient of variation, index of regional imbalance index of inter-regional variation, etc.

In the present analysis, use of the methods like balance ratio, index of regional imbalance and coefficient of regional imbalance has been made to measure the extent of regional disparities in agricultural development in West Bengal. Values of all these techniques are non-negative. Both index of inter-regional imbalance and index of intra-regional imbalances have been used for broad comments only as they do not have operational utility. In the present study, coefficient of imbalances (CI) has been adopted as an important tool of analysis as it has operational significance to deciding priorities among different indicators. The objective of balanced development requires higher priorities to the relative indicators having higher coefficient.

In the present study, West Bengal as a whole has been taken as norm region and the administrative districts are sub-region. The agricultural regions delineate by method of unequal weight with continuous beta distribution has been taken as regions. However, analysis has also been carried out to district level of West Bengal. Underlie indicators structure is presented in Table 5.

Let us

s = Norm region

r = Region

k = Sub-region

N = Non-negative numerator indicator

D = Non-negative denominator indicator

X = Indicator

Y = Balance ratio

C = Coefficient of imbalance

R = Index of regional imbalance

I = Index of intra-regional imbalance.

Then,

N_{sj} = j th numerator indicator of norm region

N_{rj} = j th numerator indicator of region

N_{kj} = j th numerator indicator of sub-region

D_{sj} = j th denominator indicator of norm region

D_{rj} = j th denominator indicator of region

D_{kj} = j th denominator indicator of sub-region.

The non-identical indicator i is:

(a) Norm region

$$X_{si} = \frac{N_{sj}}{D_{sj}} \quad (20)$$

(b) Region

$$X_{ri} = \frac{N_{rj}}{D_{rj}} \quad (21)$$

(c) Sub-region

$$X_{ki} = \frac{N_{kj}}{D_{kj}}. \quad (22)$$

Balance ratio

Balance ratio with respect to indicator i is:

(a) Norm region

$$Y_{si} = \frac{N_{si}}{D_{si}} = 1 \quad (23)$$

(b) Region

$$Y_{ri} = \frac{N_{ri}}{D_{ri}} \quad (24)$$

(c) Sub-region

$$Y_{ki} = \frac{N_{ki}}{D_{ki}}. \quad (25)$$

Table 5 Details of underlie indicators structure by numerator and denominator indicators of a respective district

Indicator (X_i)	Non-negative numerator indicator (N_i)	Non-negative denominator indicator (D_i)
X_1	Total wage rate for male agricultural field labourers (Rs)	Total agricultural field labourers (n)
X_2	Area irrigated by government canals (ha)	Gross cropped area (ha)
X_3	Total fertilizers consumption (kg)	Gross cropped area (ha)
X_4	Gross cropped area (ha)	Net sown area (ha)
X_5	Total money value of major nine crops (Rs)	Total reporting area (ha)
X_6	Total area of major nine crops (ha)	Net cropped area (ha)
X_7	Total cultivable land area (ha)	Total reporting area (ha)
X_8	Net cropped area (ha)	Total reporting area (ha)
X_9	Total yield of foodgrains (kg)	Total area under foodgrains (ha)

Coefficient of imbalance

Coefficient of imbalance in i th indicator is:

(a) Norm region

$$C_{si} = \frac{[\sum_{k=1}^m (Y_{ki} - 1)^2 / m]^{1/2}}{\text{Disaggregated at district level}} \times 100 \quad (26)$$

$$C_{si} = \frac{[\sum_{r=1}^l (Y_{ri} - 1)^2 / m]^{1/2}}{\text{Disaggregated at regional level}} \times 100 \quad (27)$$

(b) Region

$$C_{ri} = \left[\sum_{k=1}^m (Y_{ki} - 1)^2 / m \right]^{1/2} \times 100 \quad (28)$$

where m = number of sub-region within the norm region,
 l = number of regions in the norm region.

Index of inter-regional imbalance

Index of regional imbalance is:

(a) Region

$$R_r = \left[\sum_{l=1}^n (Y_{ri} - 1)^2 / n \right]^{1/2} \times 100 \quad (29)$$

(b) Sub-region

$$R_k = \left[\sum_{l=1}^n (X_{ri} - 1)^2 / n \right]^{1/2} \times 100 \quad (30)$$

where n = number of indicators.

Index of intra-regional imbalance

Index of intra-regional imbalance is:

(a) Norm region

$$I_s = \frac{[\sum_{i=1}^n \sum_{r=1}^l (Y_{ri} - 1)^2 / n \times l]^{1/2}}{\text{Disaggregated at regional level}} \times 100 \quad (31)$$

$$I_s = \frac{[\sum_{i=1}^n \sum_{k=1}^m (Y_{ki} - 1)^2 / n \times m]^{1/2}}{\text{Disaggregated at sub-regional level}} \times 100 \quad (32)$$

(b) Region

$$I_r = \left[\sum_{i=1}^n \sum_{k=1}^m (Y_{ki} - 1)^2 / n \times m \right]^{1/2} \times 100. \quad (33)$$

The role of such methods in the agricultural regionalization and in the interpretation of geography of agriculture is quite significant because it is with the help of these that the various aspects of agriculture at a spatio-temporal scale can be investigated. After having integrated these aspects, area of homogeneity can be demarcated within region, state or country. Therefore, keeping in view the importance of

agricultural regionalization, said methods are important for highlighting and interpreting the regional variations and magnitude of imbalances in the levels of agricultural development in an area.

Methodological robustness

The method of unequal weights and beta function are simpler and probable a better alternative to the conventional approach, such as the PCA, which are based on rather restrictive assumptions that the variable indicators are linearly related. When non-linearity is present, the PCA is not appropriate. Further, one cannot assign any specific economic meaning to the transformed variables. They are artificial orthogonal variables not directly identifiable with a particular development magnitude. This transformation may appear similar to the practice of measuring the deviation from the mean in units of standard deviation, often resorted to in applied statistical work. But the late practice has certain disadvantages as far as the interpretation is concerned. On the other hand, the transformation employed here has a natural meaning in the context of measurement of development, which is always a relative concept.

Balance ratio, index of regional imbalance and coefficient of regional imbalance techniques are simple and lucid and provide sufficient clue to the extent of regional imbalances. They give logical interpretation for formulating region-specific strategies. The CI has an added advantage as it is sensitive to the real units into consideration and this aspect is of vital importance.

However, the entire discussion begins with comparative account of the levels of agricultural development in the district level. Therefore, the imbalance in the availability of selected indicators in regional scale (district level) of West Bengal has been examined.

Results and discussion

In recent years agricultural developments has threatened the sustainability of subsistence agriculture and dependent farmers in West Bengal. Systematic methodology to assess the developments of the agricultural sector is currently not available. Towards this end, the present work deals with the assessment of agricultural developments to spatial variations in 18 districts of West Bengal state. For this purpose, a composite developments index (0.0–1.0) has been developed on the basis of interrelationship amongst nine indicators related to agricultural development. Thus present will provide an important basis for policy makers to develop appropriate adaptation strategies to minimize the risk of agricultural sector to spatial variability. The role of

Table 6 Pearson correlation matrix of nine indicators of agricultural development

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1	−0.305	0.073	0.522	0.190	0.296	0.057	0.246	−0.010
X_2		1	0.447	−0.117	−0.152	0.230	−0.229	−0.095	0.448
X_3			1	0.434	0.048	0.459	0.151	0.258	0.743
X_4				1	0.414	0.774	0.359	0.527	0.407
X_5					1	0.252	0.173	0.246	0.132
X_6						1	0.418	0.554	0.542
X_7							1	0.884	0.484
X_8								1	0.506
X_9									1

Bold values indicate at 0.05 level of significance

indicators on agricultural development in West Bengal has been assessed in three ways; firstly, the interrelationship among the indicators during the periods 2009–2012 has been described. Secondly, an attempt is made to determine the precise role of various indicators of agricultural development with the help of PCA, and thereby indicating the actual development of agriculture during the periods 2009–2012. Thirdly, the actual level of agricultural through the application of beta distribution has been work out. For this purpose author has selected nine indicators to assess the level of agricultural development.

Interrelationship among independent indicators

The Interrelationship among independent indicators is shown in Table 6. It has observed that significant positive correlation at 0.05 level of significance are agreement between average wage rates for male agricultural field labourers with percentage of cropping intensity (0.522), percentage of cropping intensity with percentage of area under major nine commercial crops to NCA (0.774), percentage of cropping intensity with percentage of NCA to total geographical area (0.527), percentage of area under major nine commercial crops to NCA with percentage of NCA to total geographical area (0.554), percentage of cultivable land to total land area with percentage of NCA to total geographical area (0.884), consumption of fertilizer per unit of GCA (kg/ha) with average yields rate of foodgrains (kg/ha) (0.743), percentage of area under major nine commercial crops to NCA with average yields rate of foodgrains (kg/ha) (0.542), percentage of cultivable land to total land area with average yields rate of foodgrains (kg/ha) (0.484) and percentage of NCA to total geographical area with average yields rate of foodgrains (kg/ha) (0.506). These relations may highly contribute on agricultural development or any component.

Construction of agricultural development indices

Principal component analysis is considered to be a robust technique in determining the role of various components

of agricultural development of the study region, because by this technique indicators can adequately be described by smaller set of components. The relationship between each variable with the component can be calculated by dividing each indicator's total correlation by the square root of the total sum of the correlation. In PCA these values are known as factor loading and they represents the correlation between original indicator and new indicator. The factor loading can be further processed by varimax rotation method which gives a set of new factor loading (rotated factor) for better explanation. Varimax rotation is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the indicators (rows) in a factor matrix, which has the effect of differentiating the original indicators by extracted factor. Each factor will tend to have either large or small loadings of any particular variable. A varimax solution yields results which make it as easy as possible to identify each variable with a single factor. This is the most common rotation option. By one rule of thumb in confirmatory factor analysis, loadings should be 0.700 or higher to confirm that independent variables identified a priori are represented by a particular factor, on the rationale that the 0.700 level corresponds to about half of the variance in the indicator being explained by the factor. However, the 0.700 standard is a high one and real-life data may well not meet this criterion, for this author, particularly for exploratory purposes, used a lower level such as 0.500 for the central factor. In any event, factor loadings must be interpreted in the light of theory, not by arbitrary cut-off levels.

In the present analysis, nine indicators which are chosen and considered to be suitable indices of agricultural development are collapsed into each other and rotated further to assess the agricultural development in West Bengal. The calculation has been done through R-package on computer alpha system. This analysis is carried out for considered periods 2009–2012. The values of nine indicators have been computed for 18 districts and collapsed into 18×9 data matrix for the period 2009–2012.

Table 7 Factor loadings of agricultural development after varimax rotation method

Notation	Indicator	PC-1	PC-2	PC-2
X_1	Average wage rate for male agricultural field labourers (Rs)	0.821	−0.115	−0.044
X_2	Area irrigated by govt canals to gross cropped area (GCA) (ha)	−0.317	0.805	−0.232
X_3	Consumption of fertilizer per unit of gross cropped area (GCA) (kg/ha)	0.180	0.848	0.102
X_4	Percentage of cropping intensity	0.823	0.315	0.302
X_5	Production of major nine commercial crops (Rs/ ha)	0.552	−0.031	0.150
X_6	Percentage of area under major nine commercial crops to net cropped area (NCA)	0.554	0.548	0.369
X_7	Percentage of cultivable land to total reporting area	0.083	0.028	0.981
X_8	Percentage of net cropped area to total reporting area	0.284	0.155	0.894
X_9	Average yields rate of foodgrains (kg/ ha)	0.065	0.793	0.464
Eigenvalue		3.741	1.930	1.244
Variance explained (%)		41.57	21.45	13.82
Cumulative variance explained (%)		41.57	63.02	76.84

Bold values indicate the values 0.500 or greater values

Table 8 Standardized factor scores of agricultural development

District	PC-1	PC-2	PC-3	Total component	Rank
Burdwan	−0.900	2.312	−0.300	1.112	5
Birbhum	−1.322	0.867	0.633	0.177	11
Bankura	−1.107	0.938	−0.897	−1.066	14
Midnapore (E)	0.723	−0.274	0.252	0.701	7
Midnapore (W)	−0.034	0.527	−0.425	0.068	12
Howrah	0.547	−0.404	−0.499	−0.355	13
Hooghly	0.705	2.009	0.103	2.817	1
24-Parganas (N)	0.829	−0.007	−0.235	0.587	8
24-Parganas (S)	0.349	−0.617	−2.157	−2.424	16
Nadia	1.212	−0.451	0.576	1.337	4
Murshidabad	1.949	−0.132	0.436	2.254	2
Uttar Dinajpur	0.077	−0.255	1.665	1.488	3
Dakshin Dinajpur	−1.200	−0.459	1.962	0.303	9
Malda	0.402	0.248	0.391	1.041	6
Jalpaiguri	0.247	−0.289	−1.225	−1.267	15
Darjeeling	−0.833	−1.446	−1.327	−3.606	18
Coochbehar	0.425	−1.109	0.963	0.280	10
Purulia	−2.068	−1.459	0.082	−3.445	17

Before working out the scores of the three principal components, it is necessary to see that whether they can interpreted as a meaningful dimension or not? This interpretation part of the analysis is done through the factor loading, which are the coefficient of correlation of a component with each of the given indicators. The principal components with eigenvalues >1 have been retained (Table 7). As such, three PCs have been obtained. The scores of each PC for each of the districts have also been calculated. All the results in principal components are extracted by varimax rotation technique this well known and robust rather than conventional PCA. The results of PCA are present in Table 8.

Index of agricultural output

The PCA of the indicators for the period 2009–2012 indicates that 76.84 % of the total variance is explained by three components in Table 7. PC-1 explains 41.57 % of the total variance. The positive signs of the indicators are associated with higher development of agriculture. Average wage rate for male agricultural field labourers, consumption of fertilizer per unit of GCA (kg/ha), percentage of cropping intensity and production of major nine crops (Rs/ha), all load high and positively on this component.

The highest positive loading (>0.500) is shown by percentage of cropping intensity (0.823), average wage rate

for male agricultural field labourers (0.821) followed by percentage of area under major nine commercial crops to NCA (0.554) and production of major nine crops (Rs/ha) (0.552). And negative loading (<-0.500) shows in area irrigated by government canals (-0.317).

The positive relationship among these indicators of agricultural development is obvious as the percentage of cropping intensity, average wage rate for male agricultural field labourers, percentage of area under major nine commercial crops to NCA and production of major nine crops (Rs/ha) in this plain area of West Bengal. Percentage of area under major nine commercial crops to NCA has an important role in state wide agricultural development, because crops money value run by area extends under commercial crops than other crops. Average wage rate for male agricultural field labourers is sign of standard of living and customary livelihood to daily wagers. Ultimately high cropping intensity provides fewer variations in agricultural development among the district as well as farmers herself. As these indicators can be consider as the agricultural efficiency and so this factor may be called as index of agricultural output.

In order to depict the spatial variation in the state, factor scores have been divided into five grade of very high (1.21–1.95) high (0.54–1.21), medium (-0.83 to 0.54), low (-2.06 to -0.83) and very low (0 to -2.06). The very high factor scores are concentrated in the most middle parts of the state. This includes only district of Murshidabad. The

areas having high grade factor extended over the south eastern part of the region, it comprises the district of Hooghly, Midnapore (E), 24-Parganas (N) and Nadia. The areas of medium factor scores are scattered over southern parts and northern parts also. It consists of the district of, Midnapore (W), 24-Parganas (S), Malda, Uttar Dinajpur, Jalpaiguri and Coochbehar. The factor scores having in the district of Bankura, Burdwan, Birbhum, Dakshin Dinajpur and Darjeeling and very low factor score has been found in Purulia is shown by Fig. 2.

Index of agricultural input

Second principal component (PC-2) account 21.45 % of the total variance explained. It is strongly loaded on about 27.00 % of the indicators. The factors which shows high positive loading are consumption of fertilizer per unit of GCA (kg/ha) (0.848), Area irrigated by government canals (0.805) and average yields rate of foodgrains (kg/ha) (0.793). It is obvious fact that in the region where use of fertilizer per unit of GCA and irrigation is high, ultimately the average yields rate of foodgrains will also be high. The indicators which have negative loadings are average wage rate for male agricultural field labourers (-0.115). All these correlation indicates towards high yields rate with good agro-mechanization, suggesting a name for it as index of agricultural input.

Fig. 2 Spatial patterns of factor scores by first principal component

Fig. 3 Spatial pattern of factor scores by second principal component

The spatial variation PC-2 based on factor scores are depicted in Fig. 3. The factor score have been divided into five grades of very high (0.94–2.31), high (0.25–0.94) medium (–0.25 to 0.25), low (–1.10 to –0.25) and very low (–1.46 to –1.10). Figure shows that very high factor scores are spread over in only districts of Burdwan. The high factor score, consisting south and northern parts includes the district of Bankura, Midnapore (W), Birbhum, medium factor scores are extend over 24-Parganas (N), Murshidabad and Malda, low factor scores are found over Midnapore (E), 24-Parganas (S), Nadia, Uttar Dinajpur, Dakshin Dinajpur and Jalpaiguri while the very low grade of factor scores lies in the district of Purulia, Darjeeling, Coochbehar.

Index of agricultural intensity

Third principal component (PC-3) comprises for 13.82 % of the total variance explained. It is positively high loaded on 18.00 % of the indicators. The rotated factor shows highest positive loading with percentage of cultivable land to total land area (0.981) and percentage of NCA to total geographical area (0.894). All these correspondences indicate towards high cropland occupancy with net cropped and geographic area, this factor may be named as index of agricultural intensity.

The spatial variation of factors scores have been shown in Fig. 4. The factor scores have been divided into five

grades of very high (0.96–1.96), high (0.44–0.96), medium (–0.23 to 0.44), low (–1.22 to –0.23) and very low (–2.16 to –1.22). Figure shows that very high factor scores in two district namely, Uttar Dinajpur and Dakshin Dinajpur, whereas high factor scores extended over isolated patterns in the district of Nadia, Birbhum and Coochbehar, medium factor scores extended over Midnapore (E), Hooghly, Purulia, Murshidabad and Malda, low factor scores absolute over the Bankura, Midnapore (W), Burdwan, Howrah, 24.Parganas (N), 24.Parganas (S), and the low factor scores found in remaining districts viz. Darjeeling and Jalpaiguri.

The method of simple averages gives equal importance for all the indicators which are not necessarily correct. Hence many authors prefer to give weights to the indicators. Iyengar and Sudarshan (1982) developed a method to work-out a composite index from multivariate data and it was used to rank the districts in terms of their economic performance. This methodology is statistically robust and well suited for the development of composite index of agriculture also. The unequal weights reflect the importance of the individual indicators. Further, the choice of the weights in this manner would ensure that large variations in any one of the indicators would not unduly dominate the contribution of the rest of the indicators and distort inter-district comparisons. We emphasise the spatial aspects of agricultural development by adopting a simple method for

Fig. 4 Spatial pattern of factor scores by third principal component

measuring the level or stage of development. A practical application of this method by using selected indicators. It has proved that this method is a simple and probable a better alternative to the conventional approach such as PCA, which is based on rather restrictive assumptions.

Delineation of agricultural development regions

For classificatory purposes, a simple ranking of the districts based on the indices $\bar{y}_d$ would be enough (Table 9). However, a more meaningful characterization of the different regions of agricultural development would be in terms of suitable fractile classification from an assumed distribution of y . It appears appropriate to assume that y has a beta distribution in the range (0, 1). The beta distribution is generally skewed, and perhaps, relevant to characterize positive valued random variables. The estimated parameters derived from Eq. 13 are representing in Table 10.

Method of unequal weights with continuous beta distribution

The indices of agricultural development are presented in (Table 9) for all the districts considered, along with their

Table 9 The normalized scores of the indicators for principal component analysis (PCA) and method of unequal weight

Principal component analysis			Method of unequal weight		
District	Score	Rank	District	Score	Rank
Hooghly	1.000	1	Burdwan	0.065	1
Murshidabad	0.912	2	Birbhum	0.046	2
Uttar Dinajpur	0.793	3	Murshidabad	0.045	3
Nadia	0.770	4	Uttar Dinajpur	0.042	4
Burdwan	0.735	5	Midnapore (E)	0.036	5
Malda	0.724	6	Nadia	0.034	6
Midnapore (E)	0.671	7	Malda	0.032	7
24-Parganas (N)	0.653	8	Dakshin Dinajpur	0.031	8
Dakshin Dinajpur	0.609	9	Hooghly	0.030	9
Coochbehar	0.605	10	24-Parganas (N)	0.029	10
Birbhum	0.589	11	Coochbehar	0.029	11
Midnapore (W)	0.572	12	Midnapore (W)	0.026	12
Howrah	0.506	13	Bankura	0.026	13
Bankura	0.395	14	Howrah	0.020	14
Jalpaiguri	0.364	15	Jalpaiguri	0.017	15
24-Parganas (S)	0.184	16	24-Parganas (S)	0.011	16
Purulia	0.025	17	Purulia	0.009	17
Darjeeling	0.000	18	Darjeeling	0.008	18

Table 10 Continuous beta distribution of the first-type with estimated parameters and 20 % cut-off points

Method	Estimated parameters		20 % fractile cut-off point			
	<i>a</i>	<i>b</i>	20	40	60	80
Method of unequal weights	3.87	125.91	0.017	0.024	0.031	0.041
Principal component analysis	10.82	20.79	0.179	0.402	0.630	0.843

Table 11 Classification of district wise agricultural development index based on unequal weights value using beta distribution of single type

District	Development scores ($\bar{y}_d$)	Linear intervals ($z_4, 1$)	Agricultural regions	% of frequency of each class
Burdwan	0.065	$z_4 < \bar{y}_d < 1$	Very highly developed	22.22
Birbhum	0.046			
Murshidabad	0.045			
Uttar Dinajpur	0.042			
Midnapore (E)	0.036	$z_3 < \bar{y}_d \leq z_4$	Highly developed	22.22
Nadia	0.034			
Malda	0.032			
Dakshin Dinajpur	0.031			
Hooghly	0.030	$z_2 < \bar{y}_d \leq z_3$	Developed	27.78
24-Parganas (N)	0.029			
Coochbehar	0.029			
Midnapore (W)	0.026			
Bankura	0.026	$z_1 < \bar{y}_d \leq z_2$	Moderately developed	11.11
Howrah	0.020			
Jalpaiguri	0.017			
24-Parganas (S)	0.011			
Purulia	0.009	$0 < \bar{y}_d \leq z_1$	Less developed	16.67
Darjeeling	0.008			

rankings. These index was classified into different categories using the continuous beta distribution of the first-type, with estimated parameters $a = 3.87$ and $b = 125.91$. The 20 % cut-off points were estimated to be—0.017, 0.024, 0.031, 0.041 and the 18 districts of West Bengal were classified into five clusters based on their stages of development (Table 11).

According to continuous beta distribution very highly developed districts were Burdwan, Birbhum, Murshidabad and Uttar Dinajpur and these districts comprises about 22.22 % to total development. Highly developed districts were Midnapore (E), Nadia, Malda and Dakshin Dinajpur and these districts comprises about 22.22 % to total development. Developed districts were, Hooghly, 24-parganas (N), Coochbehar, Midnapore (W) and Bankura and this district comprises 27.78 % to development. Moderately developed district was Howrah and Jalpaiguri and it comprises 11.11 % to total agricultural development. Less developed districts were 24-Parganas (S), Purulia and Darjeeling and shares 16.67 % to total development in Fig. 5.

Principal component analysis with continuous beta distribution

In this method district wise component scores have been extracted by varimax rotation method. Thereafter, first three components score was added to get total component scores and scores of total component would be normalized (Table 9) before applying continuous beta distribution of the first-type, because of beta function is a probability density function which values ranges 0.000–1.000 presented. Afterwards, all the districts considered, along with their rankings. These index was classified into different categories using the continuous beta distribution of the first-type, with estimated parameters $a = 10.82$ and $b = 20.79$. The 20 % cut-off points were estimated to be—0.179, 0.402, 0.630, 0.843 and the 18 districts of West Bengal were classified into five clusters based on their stages of development (Table 12).

In this section PCA approach has been adopted to classify the districts of West Bengal according to different levels of agricultural development on the basis of some

Fig. 5 Agricultural development regions using method of unequal weight

Table 12 Classification of district wise agricultural development index based on three principal components value using beta distribution of single type

District	Development scores ($\bar{y}_d$)	Linear intervals ($z_4, 1$)	Agricultural regions	% of frequency of each class
Hooghly	1.000	$z_4 < \bar{y}_d < 1$	Very highly developed	11.11
Murshidabad	0.912			
Uttar Dinajpur	0.793	$z_3 < \bar{y}_d \leq z_4$	Highly developed	33.33
Nadia	0.770			
Burdwan	0.735	$z_2 < \bar{y}_d \leq z_3$	Developed	27.78
Malda	0.724			
Midnapore (E)	0.671	$z_1 < \bar{y}_d \leq z_2$	Moderately developed	16.67
24-Parganas (N)	0.653			
Dakshin Dinajpur	0.609	$0 < \bar{y}_d \leq z_1$	Less developed	11.11
Coochbehar	0.605			
Birbhum	0.589			
Midnapore (W)	0.572			
Howrah	0.506			
Bankura	0.395			
Jalpaiguri	0.364			
24-Parganas (S)	0.184			
Purulia	0.025			
Darjeeling	0.000			

selected indicators. According to continuous beta distribution very highly developed districts were Hooghly and Murshidabad and this district comprises about 11.11 % to

total development. Highly developed districts are Uttar Dinajpur, Nadia, Burdwan, Malda, Midnapore (E) and 24-Parganas (N) and they comprise about 33.33 % to total

Fig. 6 Agricultural development regions using principal component analysis

area. Developed districts were Dakshin Dinajpur, Coochbehar, Birbhum, Midnapore (W) and Howrah and they comprise about 27.78 % to total area. Moderately developed districts are Bankura, Jalpaiguri and 24-Paganas (S) and they have to share about 16.67 % to total areas less developed are incorporates in the district of Purulia and Darjeeling and shares only 11.11 % to total areas in Fig. 6.

This analysis shows an overview of how many districts need to be considered to formulate the revised policy and programmes strategies to improve those indicators which contribute to low level development. It is thus averaged (both methodological cases) that 13.89 % out of 18 districts of West Bengal have come under the category of less developed districts, 13.89 % districts moderately developed, 27.78 % districts developed 27.77 % districts highly developed and 16.67 % in very highly developed categories, showing thereby that large regional disparities exist in levels of agricultural development in the State. Agricultural development is the highest in Burdwan/Hooghly (unequal weight and PCA, respectively) district and the lowest in Darjeeling (both cases) district. The result suggests that proper steps be taken by the Government of West Bengal to reduce the disparities level in a phased manner by prioritizing the districts for each critical indicator under study.

Imbalances in agricultural development

The findings do not appear contrary to what one may expect. Rather they are reflective of the general notion about the agricultural development of different districts. It is seen from the PCA and method of unequal tables that a few very developed and developed districts are remain somewhat stable in their position in the entire period by gaining or losing their position within themselves. Obviously so far agricultural development is concerned (method of unequal), Burdwan, Birbhum, Murshidabad and Uttar Dinajpur district are the most developed districts among the all districts among of West Bengal. On the other hand, Purulia and Darjeeling districts are the two plateau-hilly districts where the growth of agricultural development is not satisfactory.

The system of regions presented here is based on the varying degrees of development indicators. The overall state position shows considerable regional or districts wise differences in terms of average wage rate for male agricultural field labourers (Rs), area irrigated by government canals, consumption of fertilizer per unit of GCA (kg/ha), percentage of cropping intensity, production of major nine crops (Rs/ha), percentage of area under major nine commercial crops to NCA, percentage of cultivable land to total land area, percentage of NCA to total geographical area and average yields rate of foodgrains (kg/ha). The area

having a good deal of modernization, more facilities to purchase modern inputs, other infrastructural facilities to the farmers and high cropping intensity have indicated steady progress, whereas the areas without having above mentioned facilities exhibit low and unsteady progress. The present exercise thus established the existence of regional disparities in the level of agricultural development of West Bengal. Although the present analysis could not cover all the variables associated with the agricultural development, it can safely demand that a reasonably wider domain of ADI has been taken care of. If the agricultural plans are formulated and implemented in accordance with the diversities of different regions, the distance between districts and regions would be narrowed down and the cherished goal of regional balance can be achieved. It would help utilize the resources in an efficient manner and thereby achieve the objectives of regional balance without affecting economic efficiency. The agricultural development potentials of districts would also help formulate and execute district plans. In the following section, regional imbalance in West Bengal agricultural development will be analysed at region with the help of balance ratio, CI, index of regional imbalance and index of intra-regional imbalance.

Regional balance ratio

The balance ratio of relative indicators is given in Table 13 for agricultural regions. It can be observed from this table that very highly developed region are favourable in the balance ratio in all most all relative indicators except average wage rate for male agricultural field labourers (Rs) while in highly developed region the balance ratio is balanced except area irrigated by government canals, consumption of fertilizer per unit of GCA (kg/ha), and production of major nine

crops (Rs/ha). The balance ratio of relative indicators is satisfactory for developed and. In the both less developed region and moderately developed region, the balance ratio is very deficient in the case of all indicators.

Coefficient of regional imbalance

The CI of different indicators can be seen from Table 14 for agricultural regions. CI shows once again similar pattern among agricultural regions. So far indicators are concern area irrigated by government canals and production of major nine crops (Rs/ha) are associated with high magnitude of the CI.

The CI are widely varied both between regions and for different indicators within a region except in cases of average yields rate of foodgrains (kg/ha), average wage rate for male agricultural field labourers (Rs), percentage of cropping intensity and percentage of NCA to total geographical area.

Inter-regional imbalance

The inter-regional imbalance has been measured by taking values of different indicators at region-levels. It may be observed from Table 15 that among agricultural regions, very highly developed region has shown the maximum degree of diversity and it is followed by less developed, highly developed, moderately developed and developed region, respectively.

Intra-regional imbalance

The intra-regional imbalances in different regions can be seen from Table 16. These imbalances have been explained by taking data at district-level. As compared to regions,

Table 13 Balance ratio of indicators in delineated agricultural regions

Notation	Indicators	Agricultural regions				
		Very highly developed	Highly developed	Developed	Moderately developed	Less developed
X_1	Average wage rate for male agricultural field labourers (Rs)	0.993	1.060	0.988	1.049	0.918
X_2	Area irrigated by government canals to gross cropped area (GCA) (ha)	2.040	0.292	1.157	0.784	0.440
X_3	Consumption of fertilizer per unit of gross cropped area (kg/ha)	1.163	0.990	1.102	1.072	0.578
X_4	Percentage of cropping intensity	1.012	1.086	1.083	0.993	0.736
X_5	Production of major nine commercial crops (Rs/ha)	2.259	0.753	0.720	0.549	0.417
X_6	Percentage of area under major nine commercial crops to net cropped area (NCA)	1.079	1.059	1.147	0.966	0.593
X_7	Percentage of cultivable land to total reporting area	1.109	1.154	0.980	0.871	0.770
X_8	Percentage of net cropped area to total reporting area	1.191	1.162	0.968	0.893	0.654
X_9	Average yields rate of foodgrains (kg/ha)	1.102	1.040	1.049	0.830	0.842

Table 14 Coefficient of imbalance at regional level

Notation	Indicators	Agricultural regions				
		Very highly developed	Highly developed	Developed	Moderately developed	Less developed
X ₁	Average wage rate for male agricultural field labourers (Rs)	5.21	6.82	4.28	1.96	6.40
X ₂	Area irrigated by government canals to gross cropped area (GCA) (ha)	106.23	41.02	48.79	10.47	25.92
X ₃	Consumption of fertilizer per unit of gross cropped area (kg/ha)	9.05	9.16	19.41	5.35	16.38
X ₄	Percentage of cropping intensity	6.87	7.78	11.53	2.95	10.70
X ₅	Production of major nine commercial crops (Rs/ha)	152.85	18.55	19.59	15.21	18.44
X ₆	Percentage of area under major nine commercial crops to net cropped area (NCA)	6.98	5.30	13.83	7.90	19.15
X ₇	Percentage of cultivable land to total reporting area	7.70	8.05	5.86	4.69	6.80
X ₈	Percentage of net cropped area to total reporting area	11.06	10.09	8.88	3.76	10.70
X ₉	Average yields rate of foodgrains (kg/ha)	5.25	2.94	5.15	5.67	5.55

Table 15 Index of inter-regional imbalances in West Bengal

Agricultural regions	Index of inter-regional imbalances
Very highly developed	55.36
Highly developed	26.42
Developed	12.73
Moderately developed	18.73
Less developed	37.58

Table 16 Index of intra-regional imbalances in West Bengal

Agricultural regions	Index of intra-regional imbalances
Very highly developed	62.41
Highly developed	16.40
Developed	20.06
Moderately developed	7.55
Less developed	20.91

imbalances at district levels are not such significant. The very highly developed region once again is most heterogeneous followed by less developed, Developed, highly developed and moderately developed region.

Factors responsible for imbalances

Among the factors, which affect imbalances in the region and West Bengal as a whole irrigation and production of major nine crops (Rs/ha) were found dominating factors. Among individual indicators mention may be made of use of fertilize and irrigation facility. The cropping intensity

does not show the imbalance in a significant way. The degree of gross value of agricultural intensities does not explain imbalances in agricultural development. The factors considered in the analysis are not exhaustive. However, a clue to factors, which affect imbalance, may be obtained from the examination of the effects of these indicators. The present study has its limitations, as it could not take into account some of the other factors, which may be responsible for imbalances in agricultural development in West Bengal. However, it may be inferred that man-made factors such as irrigation facilities, use of HYV seeds, and use of fertilizer, etc., have greater impact on occurrence of imbalances in agricultural development. It goes to support the hypothesis that imbalance is largely man-made. The lower degree of imbalance at region level may be attributed to the success of schematic planning in the state. It also suggests lack of efforts towards striking balance between areal units. No attempt has been made in West Bengal to take spatial diversification of different areas into account either in formulation, execution or in monitoring of agricultural development plans. The District Planning has been started only recently and it has still to take a concrete shape. These observations underline the role of human effort in achieving regional balance and balanced agricultural development.

The macrolevel disparities have been analyzed with the help of the index of intra-regional imbalance and the CI with respect to different relative indicators. It is observed that the degree of intra-regional imbalances is higher in underlie district level than in the agricultural region. Further, the degree of intra-regional imbalance in delineated agricultural region is higher than the district level. It is observed from the table that intra-regional imbalance in agricultural region. Therefore, if it compares the intra-

regional disparity in agricultural regions it goes to suggest that the problem of regional disparities in agricultural development is to be tackled at district level where regions was delineated by taking some agricultural development indicators and regional-division may be not suitable for pursuing a policy for regional balance in agricultural development.

Moreover, due to recurrent flood also, the irrigation facility is not so easily be used in a satisfactory manner in all the districts of West Bengal. These reasons also explain the higher degree of imbalances in case of HYV seeds use and consumption of fertilizer. The disparities in terms of mechanization use are also significant. In terms of agricultural region net area shown, gross value of agricultural production, regions are almost balanced in respect of the above relative indicators.

If the degree of imbalances in all nine relative indicators are compared, it can be seen that in terms of regional level they are more pronounced than in case of individual agricultural region. The pattern of dispersal of different indicators does not differ in a marked way at natural region and district level. In the case of district level also there is highest degree of imbalances in respect of gross irrigated area in comparison to all other relative indicators. The total fertilizer consumption, irrigation facility indicates highest level of imbalance in both agricultural region and in the underlie district level. Imbalances in the net area shown are found to be lower in both agricultural region and in the underlie district level. The cropping pattern shows considerable degree of imbalance at district level than the regional level. This can be seen from the CI. It may due to the fact that soil in a district may be more suitable to food crops or non-food crops while aggregation at regional level makes balanced distribution of areas under food crops and non-food crops possible.

The low extent of imbalance at agricultural regional level in comparison to that at the district level may be attributed besides other factors to the macro-sectoral approach to agricultural planning which is still vague. Such an approach takes into consideration the totality of a region and does not take care of the diversity existing in the constituent areal units of a region. Therefore, from these three conclusions may be derived. In order to tackle the problem of disparities in agricultural development, the problem must be viewed at lower areal levels. Approach to agricultural planning should be area-specific and in conformity with the problems, potentialities priorities of the area. The problem or imbalance is not natural alone, it is rather more men created phenomenon.

This goes to suggest that the problem of imbalance should be viewed and tackled at area-levels. Instead of macro-planning there should be area based planning which would take proper care of the disparity of different areas in

the frame of their potentialities, needs and priorities in order to ensure regional balance. Thus the hypothesis that there is considerable degree of imbalance in agricultural development in West Bengal necessitating area-based planning gets substantiated.

Conclusion

Principal component analysis and method of unequal weight with beta distribution, both of the regionalization approaches have been adopted to examine the inter-regional imbalances in agricultural development and to identified the spatial pattern of agricultural development in terms probability density function. To study the degree and cause of regional imbalances in agricultural development in West Bengal various tool likes regional balance ration, index of inter-regional imbalances, index of intra-regional imbalances and coefficient of regional imbalance has been used. However, development or imbalances being a complex multi-dimensional phenomenon, one cannot altogether avoid using different indicators simultaneously, which may appear redundant at first sight and which may in fact be not quite so. Any index of imbalance based on multivariate data has its own limitation. A major limitation arises from the assumption made about the indicators themselves and their weightage in the aggregate index; researchers believe that any inter-districts comparison of levels of imbalance would be more efficient when the variability in the composite index stabilized. However, in the analysis researchers have considered the distribution of weights among various indicators appears more or less uniform. It is also found that the clustering of the districts is not unduly affected by assigning equal weightage. One possible explanation for this can be that the original variable (x) are already weighted once by using the respective ranges as a measure of variability in arriving at the scaled variables (y). Thus it appears that, for all practical purpose, it does not matter whether one used a weighted average or a simple average of the scaled values for constructing the composite index. Graduation using a normal distribution could have been restored to, but the beta distribution was preferred because of its skewness and its finite range. And these are precisely the properties to look for in statistical models suitable for analysing economic size distribution. It is noted that, in our analysis, researcher do not regard any district as fixed for purposes of comparison. The determination of such standard district or norm would be statistically and conceptually very difficult. Also, certain indicators in this analysis may not be spatially comparable since the district sizes are unequal. In spite of the limitations, this analysis brings out aspects of district level agricultural imbalances. The framework presented provides policy makers and

stakeholders a means for evaluating the spatial imbalance of the agricultural development sector in geographical districts/states at a sub-national level. However, there is an urgent need to continuously improve parameterization of the major components-exposure, sensitivity and adaptive capacity for more in-depth-imbalance analysis in future.

This study makes an attempt to examine the inter-regional disparity in agricultural development in West Bengal. The study also tries to know the degree and cause of regional imbalances in agricultural development in West Bengal. Moreover, it also tries to examine the spatio temporal dynamism in the level of agricultural development of the state. But the study suffers from a number of limitations.

1. First the present study could not take into account several others indicators such as quality of soils, impact of family size of the agricultural labours, impact of hired labour, cropping pattern of different districts, impact of holding size of the farmers, etc. Thus leaving the scope for further widening the purview of the study.
2. The present study based on the secondary data collected from published sources. The validity of the result of the study is therefore based on the degree of reliability of the secondary data.
3. The present study suffers from the inherent limitations of the econometric method themselves, used in the analysis.
4. The proposed studies also suffer from the limitations inherent of the assumptions underlying the estimation of indicators dependent as well as independent.

Thus in view of the aforesaid limitations, whatever conclusion has been drawn in every stages of the present study, are subject to criticism and therefore be seldom all inclusive or final. It may be referred only as an exercise to tackle the problem in hand.

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