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Full Length Research Paper

Crop diversification by poor peasants and role of infrastructure: Evidence from West Bengal

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The question of sustainable income and employment in the rural areas seems to be very much dependent on the degree of diversification of land use towards cultivating various crops. In view of this, crop diversification has been an important issue of agricultural development not only in India, but also in other parts of the world. In India, the growth of area under cultivation in different states remained stagnant in the current decades and the growth of yield of various crops has reached the saturation level. Efforts are now being made in different regions of India to cultivate those crops, which are remunerative and environment friendly. To examine this, an attempt has been made in this paper to study intensively, the nature and extent of crop diversification in West Bengal, a rice-growing state of India, for the period of 1970 to 2005. A number of explanatory factors have been considered to explain this phenomenon. Our findings, primarily based on official data, suggest that marginal and small farmers play a positive role in crop diversification and that has been supported by the growth of various infrastructure networks during the period under consideration.

Key words: Crop diversification, farm size, agro-infrastructure, robust regression, median least squares, West Bengal.

INTRODUCTION

Indian agriculture is predominantly a small peasant based economy with approximately 80% of the operational holdings being below two hectares, and 34% of the agricultural land are cultivated by them (GOI, 1997). Because of small operational holdings, it is indeed very difficult by the small farmers to improve their earnings only by raising the yields of the existing crops, mainly cereals. However, with the availability of modern farm inputs in the current decades, it was possible for farmers to generate higher levels of income by introducing high value crops commonly known as cash crops in their farming units. Thus, the high value crops being more labour intensive may provide stable employment and income to a large section of the rural households who face the severe problem of seasonal unemployment and underemployment under mono-crop economy.

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The incidence of crop diversification in India, however, was very uncommon particularly before the introduction of new agricultural technology in the mid-sixties. With the advent of new agricultural technology particularly, water-seed-fertilizer technology, a significant change in land allocation towards some high value cash crops such as fruits and vegetables cultivated particularly by the small farmers is observed in India (Joshi et. al, 2006). In West Bengal also, high value crops like potato, summer paddy and mustard have got high priority among the small farmers (De, 2000).

Based on the aforementioned findings, it may be argued that the small and marginal farmers, depending on a small piece of land and having no alternative sources of employment and income due to the existence of a vast population of surplus labour in the countryside, would always try to produce the maximum output on the given piece of land. They would also try to cultivate as many crops as possible and choose such commercial crops (e.g., boro paddy, potato, vegetables and fruits), which after meeting their consumption needs, would meet

their minimum cash requirements for the maintenance of their daily life. Even the medium and large farmers approach diversification for the improvement of their living standard.

Thus the phenomenon of crop diversification in India could be viewed as the survival needs of the farmers especially of the small and marginal ones. During the current decades, the process of diversification has been wide-spread due to the combined effects of water-seed-fertilizer technology as well as some infrastructural development such as market centres, roads, transport etc., in the countryside (Vyas, 1996; Bhalla and Singh, 1997).

Given this background, an attempt is made here to examine the pattern of crop diversification across the districts of West Bengal during 1970 – 1971 to 2004 – 2005.[1] Also the role of various infrastructural factors on the spatio-temporal variations in diversification is analysed. The plan of the paper is as follows: A brief review of some relevant studies; methodology adopted and data used for the analysis; the empirical results followed by the concluding remarks.

REVIEW OF LITERATURE

A number of studies have come up in India and also at the international level that analyses the nature and spread of crop diversification both at aggregated (state level) and disaggregated (district or village level) data. Many studies analysed the spatio-temporal pattern of diversification by using various indices and also tried to find out the role of price and non-price factors in explaining the pattern of diversification. Among them Narain (1965), Boyce (1987), Narayanmoorthy (1997), Singh et al. (1997), Sawant (1997), Bhalla and Singh (1997) are some authors who had examined the role of infrastructural factors like irrigation, market, institutions, technology etc, on the variations in diversification in different places in India. Attention may also be drawn to a study by Chand (1995) who observed that infrastructure like access to motorable road, market and irrigation facilities determines the extent, success and profitability of diversification through high paying crops like off-season vegetables, while the evidences were weak regarding the role of farm size on the level of diversification.

Narain (1965), Sarkar (1988), Nayyar and Sen (1994) Vyas (1996) also observed that a significant change in the cropping pattern in the countryside was in response to changes in the relative prices of the agricultural commodities. Also market infrastructure, institutional arrangements and technological change especially in the field of irrigation contributed significantly to the changes in cropping pattern. However, the analyses of data for the period 1980 - 1981 to 1999 - 2000 can be divided it into two sub-periods 1980 - 1981 to 1989 - 1990 (post Green Revolution period) and 1990 - 1991 to 1999 -2000 (post reform period) for different states in India, Joshi and Gulati (2003) reported a negative impact of irrigation on crop diversification.

Regressing the index of gross value of horticultural commodities in 1980 - 1981 prices on infrastructure variables (market and roads), technology adoption (area under high yielding variety of cereals, irrigated area and extent of mechanization), profitability, resource endowments (that is, the proportion of small holders), rural literacy and rainfall, urbanisation, income etc, by GLS of double log equations, it was observed that the regression coefficient of the area under irrigation was significantly negative. However, crop diversification was observed more pronounced in the rain-fed areas.[2] Again, they observed that diversification in favour of horticultural commodities was more confined to the small holders. Among the infrastructural variables, markets and roads showed significantly positive influence on crop diversification.

Trimmer (1997), however, concluded that with improved commercialisation of Asian agriculture, diversification level of national production would go up, while at farm level the diversification would go down due to more specialisation, though some other studies reported mixed effects of infrastructural variables on crop diversity. De (2000) also examined the extent of crop diversification and its variation across different districts of West Bengal with the help of various indices like 'Herfindahl Index'(HI), 'Ogive Index' (OI), 'Entropy' (EI) as well as 'Modified Entropy Index' (MEI), and observed large scale variations in diversification across districts over time, depending on the growth of utilisation of improved agricultural technology.

Chand and Chauhan (2002), however, observed that the land possessed by the small and marginal peasants, significantly related to the extent of diversification of crops in India during 1968 - 1969 to 1998 - 1999. They used DIV_{mk} as the index of diversification and computed the index for two sub-periods (i) 1968 - 1969 to 1983 - 1984 and (ii) 1983 - 1984 to 1998 - 1999. Institutional credit per hectare GCA (Gross Cropped Area), electricity used in agriculture per hectare GCA, percentage of GCA under irrigation, agricultural markets per 1000 sq km area, road length per 1000 sq km area and proportion of small and marginal holdings were considered as independent variables and the regression results showed that only three variables; irrigation, road density and small and marginal holdings had significantly positive impact on agricultural diversifi-

[1] This time period has been chosen as per the availability of data both at district and state level.

[2] However, further results relating to the rainfall show a highly significant, negative coefficient of rainfall, indicating that crop diversification is limited in high rainfall areas. They ultimately came to the conclusion that crop diversification should occur in medium and low rainfall areas.

cation.

Apart from the aforementioned studies, many authors have argued that small and marginal holders initiated agricultural diversification instead of depending on the cereal based production basically for their need in order to survive. For example, a framework for assessing the flexibility of paddy lands and rice growers to respond to commercialization through seasonal or permanent diversification out of rice monoculture system has been developed by Pingali et al. (1997). According to them, small and marginal farmers need diversification of crops for meeting their cost of living, but the flexibility of farmers in responding to diversification opportunities, is in most cases, constrained by the size of markets, price risks, soil suitability, quality of irrigation infrastructure, availability and cost of labour.

Ashok and Balsubramania (2006) showed the importance of infrastructure in explaining the extent of diversification. They observed that access to motorable road, market and irrigation determines the extent, success and profitability of diversification through high paying crops. The role of farm size according to their study was insignificant.

Using data from the South Asian countries, Joshi et al. (2007) reported results similar to those observed by Pingali et al. (1997). They found that with the progressively shrinking of land holding size and with the growth in total, factor of productivity and profitability stagnating or slowing down the viability of small holders should not depend only on rice. Rice cultivation might be remunerative only for large farmers having enough resources to bear the rising cost of cultivation of the input packages. Small and marginal holders, have of course, certain advantages from the view point of availability and cheapness of family labour, which in contrast to the hired labour, is managed effectively in diversifying crops. However, the flexibility of diversification opportunities of small farmers is in most cases constrained by the availability of market and fair price, and quality of irrigation infrastructure. Hence, in many cases, they fail to achieve their targets of diversifying crops.

The most voluminous work that had been undertaken and the latest results released for West Bengal was that given by De (2003). He discussed at length the nature of changes in cropping pattern in west Bengal and the determinants of crop diversification during the period of 1970 - 1971 to 1994 - 1995. For the purpose of analysing the nature of changes in cropping pattern, he considered the rate of growth of acreage of different crops both in absolute and relative terms in time perspective. The whole period was divided into two sub-periods: 1970 - 1971 to 1981 - 1982 and 1982 - 1983 to 1994 - 1995 to understand the effect of pre and post economic reforms on crop diversification. Average annual exponential rate of growth of the area under crops was estimated by fitting regressions of the type $L_nY_{it} = \alpha + \beta t$, where Y_{it} is the area under i^{th} crop at time t. The trend equations were estimated by OLS method. The results of his analysis revealed that the cropping pattern in West Bengal in terms of allocation of acreage, remained skewed towards boro paddy, potato and oilseeds (especially mustard). These were the three important emerging cash crops between 1980's and 1990's. The other crops continued to lose their importance in the cropping pattern of West Bengal. He also noted that district-wise pattern of changes in acreage of various crops varied over time and was divergent.

The principal reason for inter-district variations in the intensity of crop diversification was that some so-called agriculturally developed districts such as Hooghly, Burdwan, Nadia and Howrah were growing faster than the others by using scientific methods of cultivation, with the intensive use of mechanical devices to exploit ground water as well as surface water.

In a similar regional study based on the data of Himachal Pradesh, Sharma (2005) argued that the adoption of high value cash crops, particularly fruit crops, helps the mountainous regions because it promotes the productive use of abundant marginal lands available in these regions. He analysed the patterns, processes and factors that facilitated the process of agricultural development and crop diversification, based on the secondary and primary data collected from different districts of Himachal Pradesh. He also studied the temporal changes in the process of diversification in terms of computing the changing share of the area under non-food grain crops and by constructing and ranking of districts using Herfindahl index. Since Herfindahl index mainly captures distribution and diversity and is not enough to capture the changes in the enterprise mix over time, he has constructed another index that measures the changes in the area allocated to different crops between two time periods as suggested by Chand and Chauhan (2002). Based on the aforementioned methodology, Sharma (2005) observed that (i) there have been inter-district variations in the level and extent of diversification; (ii) the process of crop diversification has gathered momentum after 1987 - 1988 all over the state.

Using the method of Minot (2003), Joshi et al. (2006), have shown that the main source of crop income growth in India during 1980s was the technology led growth of yields of various crops and diversification emerged as the dominant sources of growth in agricultural income during the 1990s. Diversification towards horticultural crops led to the rise in agricultural income in the 1990s more than that in the 1980s. Moreover, compared to the southern and western regions, impact of crop diversification was less in eastern region including West Bengal in 1990s.

We may now turn to some studies of other countries. Ahmad and Isvilanonda (2003) examined the regional pattern of diversification at farm level in the Thailand and also examined the impact of diversification on the farm income. Also they tried to find out the constraints faced by the farmers in different regions and production

environment. The regional disparity in agricultural development has been observed due to the farmers' inability in certain regions to diversify relatively profitable crops.

In their case studies in Mexico and Argentina, Wehbe et al. (2006) have shown that diversification of agricultural practices may be helpful in mitigating climate risk along with insurance, irrigation development and technologies that are sometimes hindered due to the limitation of financial access, poor information network and market failures. Also differences in diversification and access to coping strategies between large and small farms have been a matter of concern and thus they advocated for the role of public sector.

In recent past, government of Tanzania also undertook a feasibility review for the diversification towards various horticultural crops and also for export diversification in order to reduce the impact of declining export earnings from cotton and coffee during the period of worldwide recession that affected mostly the small farmers who constitutes the majority of farming community. Those farmers also suffer from the lack of capital and other infrastructure for the much needed diversification (IDRC, 2008; CIAT, 2005).

The majority of the existing literature as discussed, however, does not throw much light on the factors affecting diversification, considering farm size as one of the factors for explaining the variations. The purpose of this paper is to examine in Indian context, the relationship between size of holding, the intensities with which different types of infrastructure are applied and diversification prevailed in different agro-climatic zones in a state of India.

MATERIALS AND METHODS

The extent of crop diversification at a given point in time may be examined by using several indices namely, (1) Herfindahl Index (HI), (2) Simpson's Index (SI), (3) Ogive Index (OI), (4) Entropy Index (EI), (5) Modified Entropy Index (MEI), (6) Composite Entropy Index (CEI) etc. Among these indices, the HI, SI and the entropy index are widely used in the literature of agricultural diversification. All these indices are computed on the basis of proportion of gross cropped area under different crops cultivated in a particular geographical area. It should be noted that the Herfindahl index is the index of concentration and thus the higher value is an indication of specialisation of crop activities. Therefore, to obtain the index of diversification, it is subtracted from one, which is the simplified form of Simpson Index of diversification.

Here, the Herfindahl index, Simpson index, Entropy and Modified entropy index have been computed for all the districts of West Bengal for the years 1970 - 1973, 1979 - 1982, 1989 - 1992 and 2002 - 2005.[3] The first one is the earliest year for which the data are available, 1979 - 1982 is chosen as it marked as the beginning of land reforms when Marxist government came into power in 1977 in the state, 1989 - 1992 is the year of economic reforms in India and the last 2002 - 2005 is the latest year for which data are available. The values are computed from the triennia average proportions of individual crop area to total cropped area. A ranking of the districts on the basis of the computed values of these indices have been done to understand the spatial pattern of diversification. Again, to check whether the ranking pattern of the districts on the basis of these different indices are consistent or not, we have computed the spearman's rank correlation coefficient by taking the pairs of different indices and tested its level of significance. Here, the rank correlations are observed to be positive and significantly high for each pair of observations. Thus, without any loss of generality, any one of the indices can be used to describe the intensity of diversification. However, in the present study, analysis is made on the basis of computed Herfindahl indices so that the results can be compared with the earlier studies, which have, by and large, used either Herfindahl or Simpson index.

Since Herfindahl Index or Simpson Index assumes a very large (almost infinite) alternative of production choices, there exist a large number of crops, which can be accommodated in measuring diversity by this index. Thus if the total area is equally shared among the large number of alternative crops, it means that the share of each crop would be exceedingly small and almost equating to zero. The higher the value of HI, the lower is the diversification and more is the concentration and vice versa.

Data on area under crops, inputs used and various infrastructure facilities during the period of study across the districts in West Bengal have been collected from various issues of 'Statistical Abstracts and District Statistical Handbooks' published by the Bureau of Applied Economics and Statistics, and Office of the Directorate of Agriculture, Government of west Bengal [4]. It may be noted that data on acreage, production etc., of some horticultural crops like fruits, flowers and vegetables at district level are available only from the year 1999 - 2000. Thus HI is computed for the entire time series data, that is, 1970 - 1973 to 2002 - 2005 for each district without horticultural crops. However, to understand the role of horticultural crops on diversity, we have also computed HI separately for the period of 2002 - 2005, which covers acreage that are not only of major crops, but some major horticultural crops (fruits, flowers and vegetables) as well. Thus, two sets of results of diversity index have been presented here for the year 2002 - 2005 in order to understand the influence of two crops (that is, with or without horticultural crops) in the ranking of various districts in West Bengal.

Furthermore, to find out the impact of different factors on the level of diversification over time in different parts of rural West Bengal, a multiple regression of the form $L_nHI = \beta_1 + \beta_2 \sum L_nX_i + U_i$ is performed. Here, HI is the Herfindahl Index and X_is are various infrastructures, technology and farm size related explanatory variables. The goodness of fit was, however, very poor, which is due to the fact that HI takes values only between zero and one. Hence, the logit transformation of the dependent variable was tried out and that also, did not yield good results. Finally, with the robust regression method by applying weighted median least squares on the logit *HI* and the three explanatory variables as described for the state as a whole throughout all the years, we obtained some reasonable results. However, for the case of inter-district variations in *HI*, it could not yield good results due to very small degrees of freedom.

Among the several competing crops, allocation of area under three major crops (viz., paddy, potato and mustard) received high

[3] Here, the calculations are made for the composite districts of 24 Paraganas, Midnapore and West Dinajpur. These districts were divided a few years back and the data on divided districts were not available separately for the early years of discussion. For the systematic analysis thus the combined figures for these composite districts have been calculated to make those comparable with their previous figures.

[4] Primary statistics of production, acreage and yield of various crops are collected from different districts of West Bengal and compiled and published by these departments on a regular basis.

priority among the farmers over the years in West Bengal. This may be due to the farmers' expecting profit from these crops relative to the other competitive crops and that has been guided by the expansion of several infrastructural and other factors. In order to examine the impact of different factors on the level of diversification over time in West Bengal, here the proportion of area under these three major growing crops, which have been responsible for changing the diversification indices, are regressed on three variables like rainfall, proportion of GCA under canal irrigation and use of chemical fertiliser per unit of cropped area. These are the variables on which time series for the whole period are available at the district level as well as for the state as a whole. Here, log-linear specification, that is, Cobb-Douglas specification was adopted for the state as a whole. Using Dickey-Fuller test, we found that dependent variables in all the cases follow stationary autoregressive process of order one and thus lagged (one period) endogenous variable was introduced as explanatory variable (Green, 2003). As time series information on other important explanatory infrastructure variables were not available for all the years under study, these could not be included in the regression. Thus finally, district-wise growth of area under three fast growing crops during 1970 - 1973 to 2002 - 2005 (towards which high concentration was observed over time but at differential rates) was regressed on the growth of some selected explanatory variables for the same period. The similar log linear form was adopted for running the regression.

RESULTS

Indices of crop diversification are presented in Table 1. The district-wise variation in values of 'Herfindahl, Simpson, Entropy and Modified Entropy indices' show a similar pattern for all the chosen years. The districts, which were earlier at top in terms of these indices remained at the top in the later years also. Nadia, Murshidabad and Malda have always been within the top five and Purulia, Birbhum, Bankura and 24Paraganas have always been within the bottom five districts in terms of diversification of crops. Here, the rank correlations of district-wise indices between any two years are found to be significantly positive, which is an indication that the districts where the levels of diversification in the early stage were high, maintained the same position over the later years. As HI represents the extent of concentration of crops, SI is calculated by deducting the HI from unity, we find similar correlations between any two chosen years for both the HI and SI.

Similar is the case for entropy and modified entropy indices where the values are calculated only with different base values. But there is hardly any change in the number of crops cultivated except tea in a few northern districts of West Bengal and hence, the ranking in terms of both these measures are found to be the same. Actually, the concentration towards a few crops has emerged over the years as this particular crop cycle yields maximum possible annual return from a particular plot of land (De, 2003). Area under aman and boro paddy, potato and mustard together increased from about 64% of GCA in 1970 - 1973 to about 77% in 2002 – 2005 despite some inter-district variations, which might important factors like use of chemical fertiliser, irrigation, be presumed to be due to variation in growth of some agro-implements, electricity, land under different size-classes of holding etc (Table 1).

We, however, notice that the coefficient of variation in the indices is very high due to the variation in number of crops cultivated in some districts owing to the specific agro-climatic conditions. For example, tea is cultivated extensively in three northern West Bengal districts; Darjeeling, Jalpaiguri and Cooch Behar. While the southern districts like Burdwan, Hooghly, Howrah and Nadia concentrate more on three specific crops, namely aman paddy followed by potato or mustard in winter and then boro paddy during the summer in a yearly crop cycle, which has been possible, particularly, due to the availability of minor irrigation in the off monsoon seasons and growing availability of technologically improved inputs, implements and other infrastructure. The relatively backward districts like Bankura and Purulia in terms of irrigation and other land improvement measures, follow a different cropping pattern suitable to the specific condition. However, majority of the farmers in different districts of West Bengal choose the cropping cycle in such a fashion that they can maximise their expected profit, given the agro-climatic and other farming conditions including marketing facilities. If we look at the changes in coefficient of variations of the indices across the districts, it is observed to be on the decline for the indices *SI, EI* and *MEI* over time, but not statistically significant. It indicates that the laggard districts are gradually catching up with the developed districts in terms of diversification. In fact, the laggard districts gradually started getting benefit from several irrigation projects undertaken by the government, and also of the development of other infrastructures, while the early advanced districts have been recording deceleration in the growth of those facilities as they have already reached the saturation level.

The same indices have been computed by including the horticultural crops for the triennia year (2002 - 2005) and are presented in Table 2. As expected, the level of diversification based on different indices for these crops has increased across all the districts. However, the inter-district variations in the diversification indices also increased several times with the incorporation of horticultural crops due to its wide variations in proportion of GCA across the districts. This is due to the fact that the importance of horticultural crops varies across districts because of non-availability of irrigation or non-favourable geographical conditions in some specific districts for some specific crops. For example, the percentage of area under horticultural crops is high in Darjeeling (30%), but relatively low in Burdwan (7%), which is one of the advanced agricultural districts of the state and known as the granary of Bengal (Table 2). In order to examine the impact of different factors on the level of diversification over time in West Bengal, the results of robust

Table 1a. Crop diversification indices in West Bengal for various years between 1970 - 1973 to 2002 - 2005.

	Herfindahl Index				Simpson Index			
0	1	2	3	4	5	6	7	8
District	**1970 - 1973**	**1979 - 1982**	**1989 - 1992**	**2002 - 2005**	**1970 - 1973**	**1979 - 1982**	**1989 - 1992**	**2002 - 2005**
Burdwan	0.5278 (5)	0.4839(7)	0.4013(6)	0.3734 (7)	0.4722(11)	0.5161(9)	0.5987(10)	0.6266 (9)
Birbhum	0.4027 (8)	0.5594(4)	0.5014(3)	0.4378 (3)	0.5973 (8)	0.4406(12)	0.4986(13)	0.5622(13)
Bankura	0.6261 (2)	0.6388(2)	0.5171(2)	0.4862 (2)	0.3739(14)	0.3612(14)	0.4829(14)	0.5138(14)
Midnapore	0.5821 (4)	0.6156(3)	0.4811(5)	0.4017 (5)	0.4179(12)	0.3844(13)	0.5189(11)	0.5983(11)
Howrah	0.4515 (6)	0.4915(6)	0.3318(9)	0.3841 (6)	0.5485(10)	0.5085(10)	0.6682(7)	0.6159(10)
Hooghly	0.3119 (11)	0.3277(8)	0.2888(11)	0.2771 (12)	0.6881 (5)	0.6723(7)	0.7112(5)	0.7229 (4)
24 Paraganas	0.5829 (3)	0.5550(5)	0.4836(4)	0.4153 (4)	0.4171(13)	0.4450(11)	0.5164(12)	0.5847(12)
Nadia	0.1666 (15)	0.1642(15)	0.1502(15)	0.1476 (15)	0.8334 (1)	0.8358(1)	0.8498(1)	0.8524 (1)
Murshidabad	0.1766 (14)	0.1763(14)	0.1772(14)	0.1686 (14)	0.8234 (2)	0.8237(2)	0.8228(2)	0.8314 (2)
West Dinajpur	0.3095 (12)	0.2985(12)	0.3711(8)	0.2825 (11)	0.6905 (4)	0.7015(4)	0.6289(8)	0.7175 (5)
Malda	0.1769 (13)	0.1825(13)	0.2194(13)	0.2094 (13)	0.8231 (3)	0.8175(3)	0.7806(3)	0.7906 (3)
Jalpaiguri	0.4160 (7)	0.3557(9)	0.3964(7)	0.3654 (8)	0.5840 (9)	0.6443(8)	0.6036(9)	0.6346 (8)
Darjeeling	0.3541 (9)	0.3262(10)	0.2838(12)	0.3283 (10)	0.6459 (7)	0.6738(6)	0.7162(4)	0.6717 (6)
Cooch Behar	0.3328 (10)	0.3003(11)	0.3255(10)	0.3310 (9)	0.6672 (6)	0.6997(5)	0.6745(6)	0.6690 (7)
Purulia	0.7035 (1)	0.7665(1)	0.6916(1)	0.7791 (1)	0.2965(15)	0.2335(15)	0.3084(15)	02209(15)
W B	0.3593	0.3698	0.3398	0.2966	0.6407	0.6302	0.6602	0.7034
CV of index	41.67	44.71	38.71	42.25	28.72	31.86	23.20	23.68
Rank correlation	R_{12} = 0.943, R_{13} = 0.889, R_{14} =0.936, R_{23} = 0.925, R_{24} = 0.964, R_{34} = 0.954				R_{56} =0.943, R_{57} = 0.889, R_{58} = 0.936,		R_{67} = 0.925, R_{68} = 0.964, R_{78} = 0.954	

Notes: (i) R_{ij} is the rank correlation between i^{th} and j^{th} column. All the correlation coefficients are significant at 1 per cent level of significance by two tailed test. (ii) Figures in the parentheses represent ranking of the district.

weighted median least squares regression of Logit of HI on rainfall, chemical fertiliser per hectare of GCA and proportion of area under canal irrigation are presented as follow:

$$\text{Logit}HI_t = \underset{(1.19)}{12.526^*} - \underset{(0.0897)}{0.6279}\, L_nI_t^* + \underset{(0.01416)}{0.038}\, L_nCF_t^* - \underset{(0.03414)}{0.0548}\, L_nR_t^*$$

Weighted R^2= 0.8146, $F_{3, 29}$ = 32.21, n = 33.....(1)

where R_t, CF_t and I_t represent rainfall, use of chemical fertilizer per hectare of GCA and percentage of GCA under canal irrigation, respectively. Figures within the parentheses represent standard error of the corresponding coefficient. Here, * and ** indicate that the coefficient is significant at one and five percent level of significance by two tailed test.

It shows a significantly positive impact of chemical fertiliser on the probability of concentration index, while the canal irrigation and rainfall have negative impact on the same. Actually, availability and utilisation of chemical fertiliser made the cultivation remunerative for some fertilizer intensive crops such as boro paddy and potato, but rainfall (on which also the irrigation is partly dependent) and irrigation especially in the off-monsoon season is essential for the expansion of diverse crop activities.

Now, the log linear regression of proportion of GCA under boro paddy, potato and mustard on the factors like rainfall, chemical fertiliser per hectare of GC and proportion of area under canal irrigation are presented as follows: For boro paddy:

$$L_nAB_t = \underset{(3.067)}{-0.406} - \underset{(0.235)}{0.0695}\, L_nR_t + \underset{(0.05)}{0.059}\, L_nCF_t + \underset{(0.10)}{0.183}\, L_nI_t^{**} + \underset{(0.07)}{0.0899}\, L_nAB_{(t-1)}^*$$

R^2= 0.989, R_{bar}^2 = 0.986, F = 583.88, D=1.55, n = 33 ... . (2)

Table 1b. Crop diversification indices in West Bengal for various years between 1970 - 1973 to 2002 - 2005.

	Entropy index				Modified entropy index			
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
District	**1970 - 1973**	**1979 - 1982**	**1989 - 1992**	**2002 - 2005**	**1970 - 1973**	**1979 - 1982**	**1989 - 1092**	**2002 - 2005**
Burdwan	1.1395(11)	1.2695(9)	1.3242(9)	1.3119(11)	-0.4586(11)	-0.5109(9)	-0.5329(9)	-0.5279(10)
Birbhum	1.3069(7)	1.0816(11)	1.1655(12)	1.2430(13)	-0.5260(7)	-0.4353(11)	-0.4690(12)	-0.5002(12)
Bankura	0.8743(14)	0.9120(14)	1.1478(14)	1.1848(15)	-0.3518(14)	-0.3670(14)	-0.4619(13)	-0.4768(14)
Midnapore	0.9935(13)	0.9507(13)	1.1811(11)	1.3143(10)	-0.3998(13)	-0.3826(13)	-0.4753(11)	-0.5289(9)
Howrah	1.2992(9)	1.1799(10)	1.1553(13)	1.2224(14)	-0.5228(9)	-0.4748(10)	-0.4649(14)	-0.4919(13)
Hooghly	1.5309(5)	1.5542(5)	1.5858(4)	1.5114(9)	-0.6161(5)	-0.6255(5)	-0.6382(4)	-0.6082(8)
24Paraganas	1.0154(12)	1.0692(12)	1.1865(10)	1.3094(12)	-0.4086(12)	-0.4303(12)	-0.4775(10)	-0.5269(11)
Nadia	1.9683(1)	1.9683(1)	2.0225(2)	2.0243(1)	-0.7921(1)	-0.7921(1)	-0.8139(1)	-0.8146(1)
Murshidabad	1.9409(3)	1.9641(2)	1.9503(3)	1.9523(2)	-0.7811(3)	-0.7904(2)	-0.7848(3)	-0.7857(2)
West Dinajpur	1.6066(4)	1.6506(4)	1.5021(6)	1.7509(4)	-0.6465(4)	-0.6642(4)	-0.6045(6)	-0.7046(4)
Malda	1.9494(2)	1.8897(3)	2.0180(1)	1.8444(3)	-0.7845(2)	-0.7605(3)	-0.8121(2)	-0.7423(3)
Jalpaiguri	1.2010(10)	1.4044(8)	1.3451(7)	1.6494(5)	-0.4833(10)	-0.5652(8)	-0.5413(8)	-0.6638(5)
Darjeeling	1.3007(8)	1.4416(7)	1.5226(5)	1.5735(7)	-0.5235(8)	-0.5801(7)	-0.6127(5)	-0.6332(6)
Cooch Behar	1.3903(6)	1.4957(6)	1.4874(8)	1.5570(8)	-0.5595(6)	-0.6019(6)	-0.5986(7)	-0.6266(7)
Purulia	0.7265(15)	0.5814(15)	0.7210(15)	0.5748(6)	-0.2924(15)	-0.2340(15)	-0.2901(15)	-0.2313(15)
W. B.	1.5503	1.5390	1.5947	1.6719	-0.6239	-0.6193	-0.6418	-0.6728
CV of Index	28.82	30.05	25.75	24.97	28.82	30.05	25.75	24.97
Rank correlation	R_{12} =0.95, R_{13} = 0.871, R_{14} =0.821, R_{23} = 0.946, R_{24} = 0.914, R_{34} =0.932				R_{56} =0.95, R_{57} = 0.871, R_{58} = 0.821, R_{67} = 0.946, R_{68} = 0.914, R_{78} = 0.932			

Note: All the correlation coefficients are significant at 1 per cent level of significance by two tailed test.

For mustard:

$$L_nAM_t = -1.397 - \underset{(2.085)}{0.238}\, L_nR_t^{*} + \underset{(0.076)}{0.169}\, L_nCF_t^{*} + \underset{(0.062)}{0.189}\, L_nI_t^{**} + \underset{(0.16)}{0.674}\, L_nAM_{(t-1)}^{*} \quad (0.11)$$

R^2= 0.99, R_{bar}^2 = 0.989, F = 703.27, D=1.43, n = 33 ... . (3)

For potato:

$$L_nAP_t = -0.219 - \underset{(2.96)}{0.166}\, L_nR_t + \underset{(0.222)}{0.133}\, L_nCF_t^{*} + \underset{(0.052)}{0.28}\, L_nI_t^{*} + \underset{(0.099)}{0.785} L_nAP_{(t-1)}^{*} \quad (0.064)$$

R^2= 0.988, R_{bar}^2 = 0.987, F = 568.98, D=1.02, n = 33 ... . (4)

In all the three cases (2, 3 and 4), availability and utilisation of chemical fertiliser and expansion of irrigation in general are found to have significant positive impact on the area under these crops. Both potato and boro paddy are highly irrigation and fertiliser intensive without which cultivation of these crops is almost impossible. Mustard as cultivated in winter season also depends, to some extent, on irrigation. Also, the demonstration effect generated for each year by the existing farmers on the decision to expand cultivation of these crops are also found significant as exhibited through the positive coefficient of the lagged value of the dependent variables. In fact, diversification of crops towards boro paddy, potato and mustard depends on minor irrigation, which has been clearly indicated in Table 3.

Information on some of the important infrastructure variables are available only for some specific years such as 1970, 1990 and 2005 at the district level. The role of these variables certainly has significant impact on the diversification as discussed. Now, to examine the inter- district variations of these crops, the percentage variations in area under these three crops for the whole

Table 2. Crop diversification indices in West Bengal during 2002 - 2005 with horticultural crops.

District	HI	SI	EI	MEI	Percentage of GCA			
					Flowers	Fruits	Vegetables	Horticulture total
Burdwan	0.3260(5)	0.6740(11)	1.5016(12)	-0.5545(13)	0.005	0.829	6.314	7.149
Birbhum	0.3701 (3)	0.6299(13)	1.4554(13)	-0.5374(14)	0.004	0.609	8.314	8.927
Bankura	0.3863 (2)	0.6137(14)	1.4398(14)	-0.5613(12)	0.000	0.679	11.817	12.496
Midnapore	0.3424(4)	0.6576(12)	1.5368(10)	-0.5675(11)	0.468	0.839	7.060	8.367
Howrah	0.3075(7)	0.6925(9)	1.5212(11)	-0.5764(10)	0.885	1.788	9.130	11.802
Hooghly	0.2234(11)	0.7766(5)	1.7589(8)	-0.6665(8)	0.006	2.318	10.064	12.388
24Paraganas	0.3163(6)	0.6837(10)	1.6086(9)	-0.5940(9)	0.131	2.379	12.473	14.983
Nadia	0.1250(15)	0.8750(1)	2.2076(1)	-0.8152(1)	0.400	1.355	10.253	12.007
Murshidabad	0.1440(14)	0.8560(2)	2.1309(2)	-0.7869(2)	0.002	2.062	7.481	9.545
West Dinajpur	0.2354(10)	0.7646(6)	1.9463(4)	-0.7187(5)	0.006	1.372	8.933	10.311
Malda	0.1597(13)	0.8403(3)	2.0987(3)	-0.7750(3)	0.011	6.079	11.053	17.143
Jalpaiguri	0.2836 (8)	0.7164(8)	1.8874(6)	-0.7152(6)	0.000	2.343	11.869	14.212
Darjeeling	0.2067(12)	0.7933(4)	1.9457(5)	-0.7586(4)	1.210	9.663	19.502	30.375
Cooch Behar	0.2700 (9)	0.7300(7)	1.7683(7)	-0.6894(7)	0.000	0.946	10.688	11.634
Purulia	0.6290 (1)	0.3710(15)	0.8847(15)	-0.3427(15)	0.000	0.776	10.112	10.888
W. B.	0.2425	0.7575	1.8921	-0.6987	0.151	1.738	9.436	11.325
CV of Index	229.879	575.348	500.243	-512.743	180.86	108.27	30.20	42.98
Rank Corr. of Different Indices with and without Horticulture				R_{HI} =0.971, R_{SI} =0.97, R_{EI} = 0.95, R_{MEI} =0.93				

Notes: (i) All the correlation coefficients are significant at 1% level of significance by two tailed test. (ii) Figures in parentheses represent ranking of the district.

period are separately regressed on the percentage growth of some infrastructural variables across the districts in West Bengal. After thorough examination, only the relevant variables are included in the analysis to avoid the problem of degrees of freedom and multi-collinearity. The estimated results are presented in Tables 3 and 4.

Table 3 shows that the growth of irrigation (both minor and major), use of electricity in agriculture measured by a proxy variable namely, number of electric pump-sets and storage facility have significant positive impact on the inter-district variations in growth of proportion of area under boro paddy in West Bengal during 1970 - 1973 to 2002 - 2005. Also, percentage of agricultural labour force to total working force and proportion of area under small and marginal farms have significant positive impact on inter-district variations.

It indicates that the small and marginal farmers having limited cultivable land and with no other sources of income try to adopt more and more multiple cropping, and diversify land towards the cultivation of boro paddy instead of til, jute or other competing crops for their survival. This is supported by some infrastructural variables such as irrigation, electricity, availability of fertiliser, road density etc. The variations in growth of these factors across the districts are also evident. Though the small farmers do not own tractor, deep tube well, they try to avail the facilities of such technology from local informal markets. The impact of use of some machines such as tractor and tiller do not give any significant result because of the existence of multi-collinearity. However, use of power tiller is seen to be more prevalent in case of boro cultivation than the tractor owing to some user convenience in the fragmented plots of smaller holdings.

In case of potato as shown in Table 4, it was observed that the variations in availability and intensity of chemical fertiliser used, storage capacity, intensity of minor irrigation had strong positive impact, while tractor and power tiller, had positive, but not highly significant impact on the growth of proportion of area under potato. As expected, market played a negative role in explaining the inter-district variations in diversification towards potato cultivation. However, the growth of proportion of area under small and marginal farms showed a significant positive impact on the diversification towards potato, the fastest growing winter crop in the state of West Bengal (Table 4).

Table 4 also reveals that in the variations in expansion of market, the densities of road are responsible for significant inter- district variations in diversification towards mustard over the years. Use of fertiliser and minor irrigation show significant inverse relation in the context of inter-district variations in the growth of mustard cultivation. However, the growth of tractor and power tiller, storage facilities and proportion of cropped

Table 3. Regression coefficients of percentage growth of proportion of GCA under Boro Paddy on explanatory variables with varied specifications (n = 15).

Explanatory variable	Dependent variable: Ln ∆boro(Log-log Model)	Dependent variable: Ln ∆boro (Excluding some explanatory variables)	Dependent variable: ∆boro (Line-log Model)
	R^2 = 0.847, Adj. R^2 = 0.643, F = 4.146	R^2 = 0.765, Adj. R^2 = 0.671, F = 8.15	R^2 = 0.963, Adj. R^2 = 0.896, F = 14.34
Constant	-1.857	-1.872***	-216.040*
Ln ∆fertilizer	0.036	0.528	-0.524
Ln ∆market	0.261	---	---
Ln ∆store	0.252*	0.271*	13.946*
Ln ∆sf	0.629**	0.875*	20.761*
Ln ∆epump	-0.194	---	7.582*
Ln ∆AL	0.380	---	41.285
Ln ∆minorIrri	0.478**	0.515*	2.883
Ln∆ roadacity	0.171	---	5.234
Ln ∆canalirri	---	---	16.157
Ln ∆tractill	---	---	-3.01

Notes: (1) Here fertiliser indicates consumption of chemical fertiliser per hectare of GCA in the district, market = number of market per thousand Sq. Km., store = number of storage per thousand Sq. Km., sf = percentage of GCA under small and marginal farm, epump= number of electric pump set per hectare of GCA, AL=agricultural labourer as percentage of total working force, minorIrri= number of minor irrigation set up, roadacity= road density per thousand Sq. Km., tractill= total number of tractor and power tiller per hectare of GCA, canalirri= percentage of GCA under canal irrigation. Here ∆ indicates percentage change of the variable during the whole period.
(2) *, ** and *** indicate that the coefficient is significant at five, ten and twenty per cent level of significance by two tailed test.

Table 4. Regression coefficients of log of percentage growth of proportion of GCA under potato and mustard, (n = 15).

Explanatory variable	Dependent variable: Ln ∆Potato	Dependent variable: Ln ∆Mustard
	R^2 =0 .818, Adj. R^2 = .491, F = 2.50	R^2 =0 .830, Adj. R^2 = 0.702, F = 6.51
Constant	-5.208*	4.759*
Ln ∆fertiliser	0.810**	-0.655**
Ln ∆market	-0.388*	0.268**
Ln ∆store	0.214*	0.073***
Ln ∆sf	0.487*	0.136
Ln ∆epump	0.102	---
Ln ∆AL	0.170	---
Ln ∆minorIrri	0.208***	-0.275*
Ln∆roadacity	-0.263	0.362**
Ln ∆tractill	0.178	0.160

Note: Same as Table 3.

area under small and marginal farms has positive impact on mustard cultivation though not highly significant. Thus, the statistical results relating to mustard do not permit us to arrive at a firm conclusion regarding the factors responsible for diversification.

It is clear from the aforementioned results that size of holdings is one of the important factors explaining the extent of diversification at any rate in different districts of West Bengal. This is in conformity with the results obtained by some other researchers not only for India, but for some other countries as well (Chand and Chauhan, 2002; Pingali et al., 1997; Wehbe et al., 2006; Joshi et al,. 2007; IDRC, 2008). The other infrastructural variables like irrigation, use of chemical fertiliser etc., are also important, but the nature and extent of variations of these variables for different crops in different districts of West Bengal do not follow any rigid pattern. Hence, it would be misleading to assume that they contribute in the same way for everywhere in the state. Existing studies, however, have failed to depict such reality.

Concluding observations

The empirical results as presented reveal that crop diversification in West Bengal have been persisting since 1970. The value of diversification index has increased though not at a very faster rate, but reallocation of land towards a few crops has been taking place continuously. Among the varieties of crops, the growth of summer or boro paddy, potato and mustard cultivation has been accelerating over the past three decades whereas, the cultivation of wheat, other cereals, pulses, jute, sugarcane etc have been declining over the years. Data analysed separately for different sub-periods also confirm this phenomenon. The level of diversification has also been associated with the large scale inter- district variations. Interestingly, the level of diversification in the relatively backward agricultural districts like Bankura, Midnapore has taken place at relatively faster pace than the other advanced districts such as Burdwan, Hooghly etc. This is reflected through the decline in coefficient of inter-district variations in diversification indices over the years. However, it may be noted that the relatively advanced districts always maintained their relative positions in terms of diversification, due to the better availability of agricultural and supporting infrastructure. Decline in coefficient of variation with respect to diversification indices over the years is an indication that the laggard districts where irrigation and other infrastructure have increased at relatively faster rate, could diversify at relatively faster pace than the hitherto advanced districts.

Minor irrigation facilities supported by the electricity, storage and marketing facilities etc have played important roles with varied degrees for the diversification of crops. Also, availability of fertiliser along with expansion of irrigation and agro-implements through raising yield of crops, helped in many cases to diversify the selected crops. Therefore, agricultural infrastructures are found to be crucial in promoting diversification of crops and ensure sustainable income and employment of the farmers. This explains why small and marginal farmers who have limited land resources for maintaining minimum living standard, diversify their crop cultivation. Though, growth of infrastructures has significant impact on the diversification, disparities in growth of such infrastructure lead to differences in diversification of crops towards boro paddy, potato and mustard. However, the so-called political stability since the inception of Marxist government in West Bengal in 1977 and the new economic reforms in the 1990s, have not been that helpful to alter the scenario of selective agricultural diversification in West Bengal.

In conclusion, therefore, it can be said that policies towards the expansion of infrastructure like road network, irrigation facilities through different modes wherever possible, marketing and storage facilities, power supply especially to the minor irrigation setups, availability of fertiliser, and facilitating or empowering those especially the poor farmers are the important preconditions for the diversification of crops across the districts. As the poor farmers take the leading role here in diversification, markets and other infrastructure should be fair and competitive for their rational use by them. However, many of the poor farmers suffer from lack of capital, and thus provision of capital through cooperative and regional rural banks need to be well warranted.

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