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Research Article

IMPLICATIONS OF THE METHODS OF AGRICULTURAL DIVERSIFICATION IN REFERENCE WITH MALDA DISTRICT: DRAWBACK AND RATIONALE

Swades Pal[1] and *Shyamal Kar[2]
[1]Department of Geography, University of Gour Banga, Malda, West Bengal
[2]Department of Geography, Visva-Bharati, Santiniketan
**Author for Correspondence*

ABSTRACT
This paper aims to implement different measures of crop diversification for a uniform data set of Malda district. At the same time it focuses on status and changing pattern of crop diversification in different blocks of Malda district with a comparative outlook of District and State level status. Herfindahl index and Simpson index are widely used measures of crop diversification but as per the output scale of resolution, Gini's Coefficient and Entropy Measures are to be considered as better. As per the way of calculation Entropy index, Modified entropy index and Ogive index are more effective. District level status is far ahead the state level and blocks level status good. Monotonization in crop diversification is going on which is reflected through forward and backward shifting crop diversification into a single class in between 2001 to 2008. Peasants are still addicted with cereals instead of high value crops.

Key Words: *Methods of Diversifications, Problems and Justification, Horizontal Diversification, Vertical Diversification*

INTRODUCTION
Crop diversification in the Third World Countries like India is a pungent applied concept to remove the plight of subsistence agricultural economy and to ensure diversified nutrition status of the poor countrymen. Crop diversification means raising of a variety of crops involving intensity of competition amongst field crops for arable or cultivable land. "The keener the competition, the higher the magnitude of the crop diversification and lesser the competition the greater will the trend toward specialization or monoculture farming where emphasis is on one or two crops" (Jasbir Singh 1976).
The main advantage of the study of diversification in a region lies in the fact that it enables us to understand the impact of physical and socio-economic conditions on the agriculture. Moreover, it helps us in knowing the contemporary competition among crop for area, for rotation and effect on double cropping, total production and per hectare productivity (Bhalsing, 2009).
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. Attention on high value crops with available modern farm inputs may provide a stable economic base of the poor peasants (De and Chattopadhyay, 2010).
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). In contrary of this result, technology in shape of ground water based irrigation facilities in some districts like, Nadia, Murshidabad, Burdwan etc. have ensured more crop concentration. Most of the cases selection of crop is mainly boro paddy crop (Pal, 2010).

This paper has stressed on proper selection of crop diversification methods with field implication, finding out associated parameters of crop diversification in this regional level.

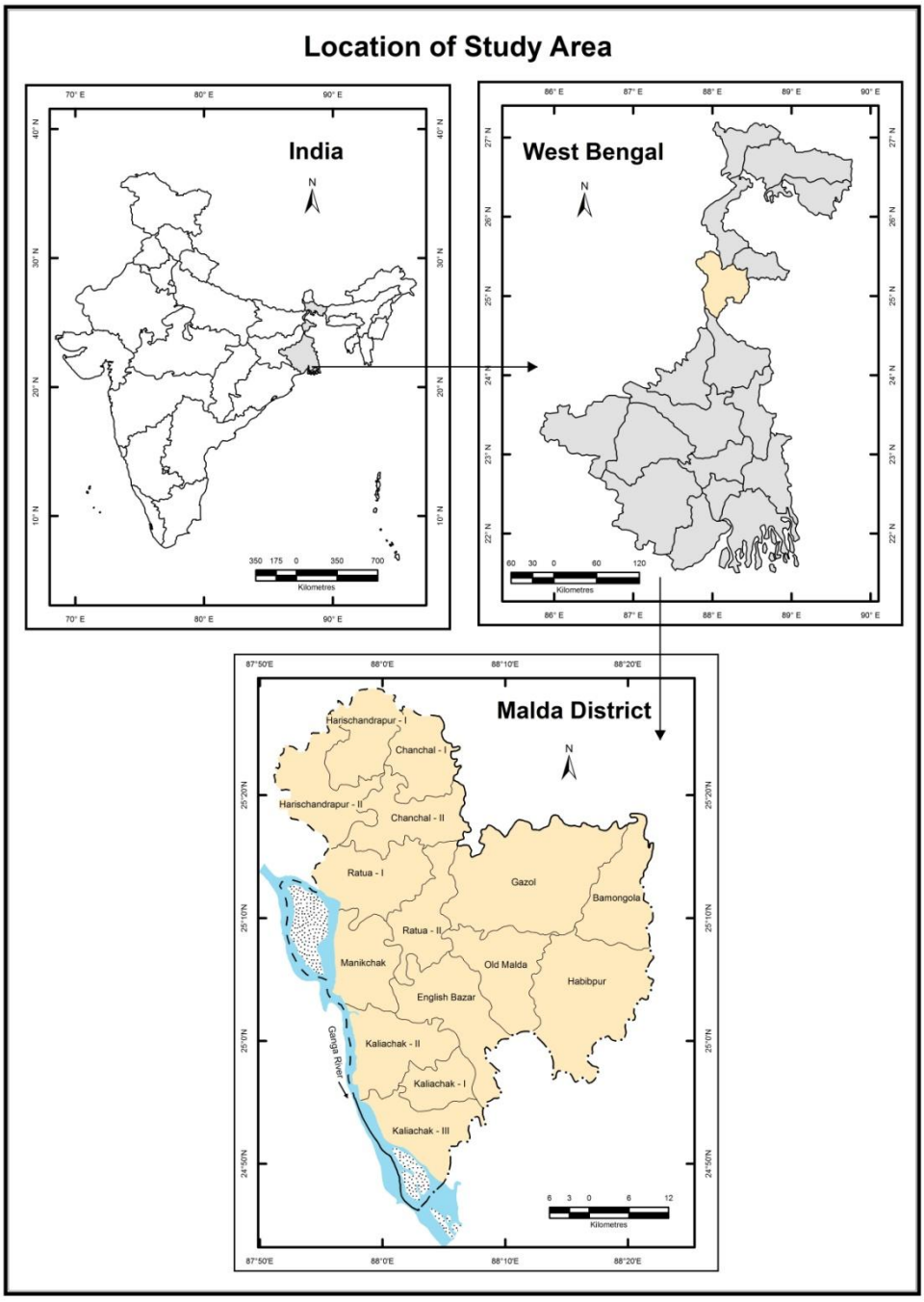

Figure 1: Reference Map
Source: Prepared by the Authors from the Base Map of DST

Study Area

Malda district is a low-lying plain, through which flow a number of rivers. On the basis of topography and drainage pattern, the district can physiographically be divided into Barind region (eastern part of Mahanada) and Rarh (Western part of Mahananda). The Rarh region again is subdivided into (a) Tal

Region in northern portion (1,32,761 hectare), (b) Diara in southern portion (1,12,186 hectare). Tal region is very famous for wetland. Climatically, this area is under the influence of subtropical monsoon flow. Average annual rainfall of this area is 1453.10mm. Maximum rainfall is happened during June to October. Hydrological conditions of the wetland are directly linked with meteorological dynamics.

MATERIALS AND METHODS

The approach used in this study involves utilization of a variety of measures of crop diversification which indicate the extent of dispersion and concentration of activities in a given time and space by a single quantitative indicator. The extent of crop diversification at a given point in time may be examined by using several indices namely

a) Bhatia's Method
b) Jashbir Singh's Method
c) Herfindahl Index (HI)
d) Transformed Herfindahl Index (THI)
e) Ogive Index (OI)
f) Entropy Index (EI)
g) Modified Entropy Index (MEI)
h) Composite Entropy Index (CEI)
i) Gini's Coefficient (Gi)
j) Simpson Index(SI)

Among these indices, the THI, 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.

Bhatia's Method

Crop diversification index (Icd) is inversely proportional to the degree of diversification i.e. higher is the value of the index, lower will be the degree of diversification and vice versa. Here those n crops are identified whose proportion is more than 10%.

$$\text{Icd}=\frac{\text{Percentage of total cropped area under 'n' crops}}{\text{Number of 'n' crops}}$$

Jasbir Singh's Method

In this equation, the notion is similar to Bhatia but here those crops are considered whose proportion is 5%. So, more number of crops are probably included in this second equation.

$$\text{Icd}=\frac{\text{Percentage of total cropped area under 'n' crops}}{\text{Number of 'n' crops}}$$

Herfindahl Index (HI)

Herfindahl Index (Pattayanayak, 2006) given below is computed by taking sum of squares of acreage proportion of each crop in the total cropped area. Mathematically, the index is given as below.

$$\text{HI} = \sum_{i=1}^{N} P_i^2$$

Where N is the total number of crops and Pi represents area proportion of the i-th crop in total cropped area. The index was first used to measure the regional concentration of industries (Theil, 1967). With the increase in diversification, the Herfindahl Index would decrease. This index takes a value one when there is complete concentration and approaches zero when diversification is 'perfect'. Thus the Herfindahl Index is bounded by Zero and one.

Transformed Herfindahl Index

Since the Herfindahl Index is a measure of concentration, it was transformed by subtracting it from one, i.e. (THI= 1-HI or THI= (1- $\sum_{i=1}^{N} P_i^2$). The transformed value of HI will avoid confusion to compare it with other indices. The value of transformed Herfindahl Index (1-HI) increases with the increase in diversification and assumes 0 (zero) value in case of perfect concentration i.e. when only one crop is cultivated.

Ogive Index (OI)

This index is used to measure industrial diversity. It measures deviations from benchmark given by equal proportion of each crop. For example, if there are N crops, the norm used for measuring deviations is I/N. The formula of computing Ogive Index is as follows.

$$OI = \frac{\sum_{i=1}^{N} \{P_i - (1/N)\}^2}{(1/N)}$$

Like HI the Ogive Index is also a measure of concentration. Hence it was transformed as (1 – O.I.). Thus it implies that the index approaches zero in extreme cases of perfect concentration as well as perfect diversification.

Entropy and Berry's Measures for Crop Diversification

Entropy Index is regarded as an inverse measure of concentration having logarithmic character. This index has been widely used to measure diversification (Shiyani and Pandya, 1998).

To estimate the level of crop diversification Hart's Entropy Index and Berry's Index have been used. Two indices have been computed to measure the extent of diversification, viz.

i) Berry's Index (DI_B) based on Berry (1971) and

ii) Entropy Index (DI_E) as suggested by Hart (1971).

DI_B is computed by using the equation DIB = $1–\sum P^2it$

DIE is computed using the formula $DI_E = \sum [P^2_{it} \times In (1/P_{it})]$

Or $$EI = \sum_{i=1}^{N} P_i * \log P_i$$

Where, Pi stands for proportion of area under the i^{th} crop at time point DI_B or DI_E is expected to increase with increase in the extent of diversification and vice-versa.

Actual degree of diversification to maximum diversification possible for a given number of crops is measured for Berry's Index as $DI_B/[1–(1/n)]$, while for Entropy Index as $DI_E/In(n)$ More the Entropy or Berry's measures value expected is the result or otherwise.

The index would increase with the increase in diversification and it approaches zero when there is perfect concentration, i.e., when Pi equals 1. The upper value of the index can exceeded one, when the number of total crops is higher than the value of the index can exceed one, when the number of total crops is higher than the value of logarithm's base, and it can be less than one when the number of crops is lower than the base of logarithm.

Modified Entropy Index (MEI)

Modified Entropy Index is used to overcome the limitation of Entropy Index by using variable base of logarithm instead of fixed based logarithm. It can be computed as :

$$MEI = \sum_{i=1}^{N} \{P_i * \log_N P_i\}$$

The MEI, however, is equal to EI/log N

It is worth mentioning that the base of logarithm is shifted to 'N' number of crops. This index has a lower limit equal to zero when there is complete concentration, and it assumes upper limit of one in case of perfect dispersion, i.e. it is bounded by zero and one.

Maximum MEI (when Pi approaches 1/N)

= å 1/N* $\log_N$N = å 1/N = 1

This index is quite useful as compared to the Entropy Index which does not have a fixed upper value. This index is a measure of diversification in terms of the number of crops.

Gini's Coefficient

Gini's coefficient is used to measure the inequality. It can be useful to measure crop diversification.

$$Gi = \sum_{i=1}^{n} P_i^2$$

Pi = Proportion of area under i-th crop

Gi value ranges from 0 – 1, higher the values of Gi higher is the specialization of crop and vice-versa.

Composite Entropy Index (CEI):

This index possesses all desirable properties of Modified Entropy Index and is used to compare diversification across situations having different and large number of crops since it gives due weightage to the number of crops. The formula of C.E.I. is given by :

$$CEI = -\left(\sum_{i=1}^{N} P_i * \log_N P_i \right) * \{1 - (1/N)\}$$

The CEI has two components viz. distribution and number of crops, or diversity. The value of Composite Entropy Index increases with the decrease in concentration and rises with the number of crops. The value of C.E.I. ranges between zero to one.

Simpson Index

Horizontal diversification is the increase in the number of crops grown given the economical rationality of this expansion. The extent of horizontal diversification has been gauged empirically through another index termed Simpson's index of diversification (SI)

SI = 1-(proportionate area of food grains in the gross cropped area)

Limitations of Diversification Indices

The major limitation of Herfindahl Index is that it cannot assume theoretical minimum, i.e., zero for smaller values of N. In case of Ogive Index the major limitation is that the upper bound tends to approach zero in case of perfect concentration. Similarly Entropy Index does not give standard scale for assessing the degree of diversification. Though modified Entropy Index is superior to Entropy Index, its limitation is that it measures the deviation from equal distribution among existing activities in number of crops only and does not incorporate the number of activities in it. The composite Entropy Index use $-\log_N P$ as weights, it assigns more weight to lower quantity and less weight to higher quantity. In addition to the above limitations none of these measures is however, designed to capture the dynamic aspect of diversification or change in production choices over time as is generally implied in the popular uses.

Ramesh Chand *et al.* (2002) for the first time measured diversification in terms of change in level of resource (land) allocated to different production activities as a proportion of total resource (land) used for the purpose using following measures :

DIV_{mk} = ½ Σ|(A_{im} – A_{ik})|/TCA

Where; DIV_{mk} refers to diversification in crop pattern between the year m and k.

A_{im} and Aik refer to area under i^{th} crop in m^{th} year and k^{th} year respectively, and TCA is total crop area.

RESULTS AND DISCUSSION

State Level vs. District Level Status of Crop Diversification:

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 fertilizer, irrigation, be presumed to be due to variation in growth of some agro-implements, electricity, land under different size classes of holding etc. Indices of crop diversification both for district and state level do not provide any clear cut trend of change but Malda district always far ahead state level (vide table 1).

Block Level Crop Diversification

Most of the agricultural scientists have established the fact that in the Third World Countries like India, crop diversification is necessary for the poor peasants to self harness of domestic needs of nutrient requirements. But result shows that the blocks have urban or rurban tendencies register good level of crop diversification as per all the indices. So, rural poor farmers are still addicted on mono cropping or duo cropping cycle. Nearness of market and other infrastructural supply encourage people to cultivate

Table 1: Crop Diversification Indices in District and State Level in Different Years

Indices	Malda District				West Bengal			
	1970 - 1973	1979 - 1982	1989 - 1992	2002 - 2005	1970 - 1973	1979 - 1982	1989 - 1992	2002 - 2005
Herfindahl Index	0.1769 (13)	0.1825(13)	0.2194(13)	0.2094 (13)	0.6407	0.6302	0.6602	0.7034
Simpson Index	0.8231 (3)	0.8175(3)	0.7806(3)	0.7906 (3)	0.3593	0.3698	0.3398	0.2966
Entropy index	1.9494(2)	1.8897(3)	2.0180(1)	1.8444(3)	1.5503	1.5390	1.5947	1.6719
Modified entropy index	-0.7845(2)	-0.7605(3)	-0.8121(2)	-0.7423(3)	-0.6239	-0.6193	-0.6418	-0.6728

Table 2: Comparative Status of Crop Diversification Indices, 2001

Block	Jasbir	GI	HI	Block	Jasbir	GI	HI
Harish chandrapur-I	30.47	0.33	0.67	Habibpur	45.11	0.63	0.36
Harish chandrapur-II	24.63	0.37	0.63	Old Malda	19.20	0.24	0.76
Chanchal-I	24.03	0.34	0.66	English Bazar	13.52	0.17	0.83
Chanchal-II	23.49	0.30	0.70	Manikchak	17.21	0.22	0.78
Ratua -I	16.06	0.25	0.76	Kalichak-I	15.86	0.19	0.81
Ratua -II	15.41	0.19	0.81	Kalichak-II	15.47	0.16	0.84
Gazole	24.11	0.44	0.56	Kalichak-III	9.94	0.14	0.86
Bamongola	23.49	0.33	0.67				

SD of HI=0.129

varieties of crops. Horticulture in the urban surrounding area is one of the major vectors of greater crop diversification in the block like English Bazar.

Comparative pattern of crop diversification between 2001 and 2008 shows that the degree of crop diversification has to some extent increased in the later period. There is forward shift of diversification i.e. from moderate to high since 2001-2008 but at the same time backward shifting for two blocks

(English Bazar and Kaliachak III) from excellent level to good is also noticed. It means diversification of inter block crop diversification is minimized in effect of monotonization of crop culture. Standard deviation value for all the blocks in 2001 is 0.129 and it is 0.059 in 2008 indicate that monotoniztion effect on crop diversification is superfluously running on. It means people of all blocks are going to select

Table 3: Comparative Status of Crop Diversification Indices, 2008-09

Block	Bhatia	Jasbir	HI	OI	EI	BI	GI	MEI
Harish chandrapur-I	23.22	23.21	0.73	0.80	0.66	0.73	0.27	0.63
Harish chandrapur-II	21.91	19.42	0.76	0.83	0.70	0.76	0.24	0.67
Chanchal-I	27.25	22.76	0.74	0.82	0.69	0.74	0.26	0.67
Chanchal-II	23.64	19.90	0.72	0.79	0.65	0.72	0.28	0.62
Ratua -I	22.54	22.54	0.77	0.84	0.73	0.77	0.23	0.65
Ratua -II	21.01	21.00	0.80	0.88	0.79	0.80	0.20	0.70
Gazole	23.72	23.72	0.75	0.83	0.66	0.75	0.25	0.62
Bamongola	30.63	30.62	0.71	0.79	0.59	0.71	0.29	0.57
Habibpur	31.80	31.80	0.63	0.70	0.52	0.63	0.37	0.50
Old Malda	26.99	19.26	0.76	0.83	0.69	0.76	0.24	0.64
English Bazar	21.03	21.03	0.81	0.88	0.78	0.81	0.19	0.73
Manikchak	38.90	28.53	0.64	0.72	0.60	0.64	0.36	0.54
Kalichak-I	23.00	22.99	0.68	0.75	0.64	0.68	0.32	0.64
Kalichak-II	21.35	15.36	0.83	0.90	0.74	0.83	0.17	0.68
Kalichak-III	17.90	13.16	0.81	0.88	0.77	0.81	0.19	0.69

SD of HI = 0.059

only some crops as their interest of cultivation. Peasants are mainly concentrated on aman paddy, boro paddy, wheat and mustard crops both during 2001 and 2008. Actually, they are still interested on cereals crops rather than any other high value crops. Mustard as a sole representative of high value crops which is cultivated in this district. Moreover, mustard has been losing its priority which is reflected in the areal shrinkage of its coverage since 2001 to 2008. Uniform type of crop cultivation in every year also focuses on very close crop rotation practices in this area.

Table 4: Categorization of Herfindal Values (2001 to 2008)

Crop Diversification Class	Value	Name of the Blocks, 2001	Name of the Blocks, 2008
Low	0.34-0.50	Habibpur	
Moderate	0.50-0.66	Harish chandrapur-II, Gazole, Chanchal-I	Habibpur, Manikchak
High	0.66-0.82	Harish chandrapur-I, Chanchal-II, Ratua –I, Ratua –II, Bamongola, Old Malda, Manikchak, Kalichak-I	Kalichak-I, Harish chandrapur-I, Harish chandrapur-II, Chanchal-I, Chanchal-II, Ratua –I, Ratua –II, Gazole, Bamongola, Old Malda, English Bazar, Kalichak-I, Kalichak-III
Excellent	0.82-0.98	English Bazar, Kalichak-II, Kalichak-III	Kalichak-II

According to Ramesh Chand *et al.* (2002), the change of crop diversification between two times is the gross departure of area under different crops. Less departure value indicates marginal change of crop diversification and vice versa. Here the departure value is 0.3272 indicates the change of crop diversification is not dominantly and expectedly high.

Explanatory Resolution Scale of the Crop Diversification Indices

Standard deviation and coefficient of variation is a good measure to identify the degree of internal dispersion. A set of methods are available for measuring the degree of crop diversification. If the range of diversification value is more for the indices, explanatory power of that index is good. All those indices have calculated for the same data set. So, the index possesses good range of maximum minimum difference or standard deviation or co efficient of variation should be accepted as better fitted. In case of Bhatia and Jasbir Singh's method CV is high but these are not widely accepted in contemporary period because here there are not any definite upper or lower threshold limits. Out of other methods, Gini's Coefficient and Entropy indices are good measures as per their better scale of resolution (vide table 5).

Herfindahl index and Simpson index are widely used measures of crop diversification but as per the output scale of resolution, Gini's Coefficient and Entropy Measures are to be considered as better. As per the way of calculation Entropy index, Modified entropy index and Ogive index are more effective. District level status is far ahead the state level and blocks level status good. In fine it be said that crop diversification in this study area is controlled by many a local traditional factors. Obviously, some external factors control the level of crop diversification and nature of change. Poverty of the farmers is one of the major withstand against crop diversification. Most the predecessors they suggested that in the poor regions implementation of crop diversification is necessary to support nutrient to the local people. But in this study area where the intensity of poverty stricken area is more the rate of crop diversification is low.

Table 5: Degree of Resolution for Different Indices

	Bhatia	**Jasbir**	**HI**	**OI**	**EI**	**BI**	**GI**	**MEI**
SD	5.35	5.07	0.06	0.06	0.08	0.06	0.06	0.06
Mean	23.76	21.27	0.70	0.77	0.68	0.74	0.26	0.64
CV	22.51	23.83	8.59	7.67	11.03	8.01	22.95	9.73

So, paradox is prevailing regarding legal support in favour of crop diversification in the economically poor region and ongoing status of crop diversification in this area. It is a good sign that peasants are now using their land in some diversified purposes and if government strategy encourages their motivation it will be great breakthrough in the course of agricultural development and allied economy.

REFERENCES

De UK (2000). Diversification of Crop in West Bengal: A Spatio-Temporal Analysis. *Artha Vijnana* **XLII** (2) 170-182.

Government of India (1997). Operational Land Holdings in India, 1991-92: Sailent Features NSS 48th round Report **407** Department of Statistics.

Anonymous (2001). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (2002). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (2003). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (2004). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (2005). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (2006). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (2008). Statistical Hand Book Malda Govt. of West Bengal.

Anonymous (1971 to 2005). Economic Review West Bengal Govt. of West Bengal.

Hart PE (1971). Entropy and other Measures of Concentration. *Journal of Royal Statistical Society Series* **A** 134.

Joshi PK, Birthal PS and Minot N (2006). Sources of Agricultural Growth in India: Role of Diversification towards High Value Crops. *MTID* Discussion Paper No. 98. IFPRI Markets Trade and Institutions Division.

Bhalsing RR (2009). Impact of Irrigation on Crop Diversification In: Ahmed Nagar District (Maharashtra) Shodh, Samiksha aur Mulyankan. *International Research Journal* **II (**7**).**

Sau, Sachinandan, Pathak and Sarat (2007). Diversification of agricultural- Rationale and Determinants- A Study with special reference to West Bengal. *Indian Journal of Regional Science* **39**(1) 140-149.

Sing J and Dhillon SS (2002). Agricultural Geography. Tata Mac Graw Hill Publishing Company Ltd New Delhi (Second Edition).

Utpal Kumar De UK and Chattopadhyay M (2010). Crop diversification by poor peasants and role of infrastructure: Evidence from West Bengal. *Journal of Development and Agricultural Economics* **2**(10) 340-350.