Agricultural Regionalization in relation to Irrigation and Crop Diversification: A Case Study of Paschim Medinipur District, West Bengal

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Abstract: Agricultural regionalization is a process of delineating an area into territorial units of complexes of uniformities on the basis of physical, social, economic and agricultural parameters. It has a significant bearing on the development of agriculture and regional planning in developing countries. Agricultural development depends on efficiency of an agricultural system in terms of productivity, diversification, commercialisation and ecological balance etc. Irrigation plays a significant role in crop diversification of a region along with other physical and socio-economic determinants. The present study analyzes the impact of irrigation on crop diversification and makes an attempt to delineate agricultural regions on the basis of relationship between these two components. Pearson’s Product Moment Co-relation Co-efficient has been used to find out the relation between irrigation and crop diversification. Gibb’s method of crop diversification has been used to find out crop diversification. Cluster analysis method has been applied to demarcate agricultural regions of the district. The study concludes that six distinct agricultural regions may be identified on the basis of irrigation intensity and crop diversification.

Key Words: Irrigation, Crop Diversification, Agricultural Regionalization.

1. Introduction: Agricultural regionalization is one of the oldest concepts in agricultural classification and has a significant bearing on regional planning and development of agriculture in developing countries. It is a tool to identify the regions based on agricultural criteria which could be descriptive or analytic, divisive or aggregative, qualitative or quantitative. Further, it is a process of delineating an area into territorial units of complexes of uniformities on the basis of physical, social, economic and agricultural parameters in a composite form and is a result of a set of agricultural processes. The task of agricultural regionalization is a complex one because characteristics of agriculture vary from country to country and region to region. Selection of criteria and indicators of regionalization are the key steps in delineation of an agricultural region. For instance, percentage of land under individual crops, percentage of NCA to the total area, association of crops, intensity of land use and organization of agricultural production are one of the common indicators considered by the agricultural geographers. Various techniques for the delineation of agricultural regions are cropping intensity, crop combination, crop sequence, crop diversification, crop concentration, cropping yield, agricultural productivity and agricultural efficiency (Williams, et. al., 2008; Ghodke, 2010; Khan, 2012 and Razzaq, 2014).

Studies on agricultural regionalization date back to 18th and 19th centuries. From the very beginning, however, divergent views have been held about the very meaning of an agricultural region and methods of regional delimitation. Major studies have included natural conditions and agricultural activities are the sole basis of agricultural regionalization. However, the use of purely physical criterion is both dangerous and unfruitful as agricultural activity is independent of the natural conditions (Birch, 1954). Marshall (1787) put forward his views regarding agricultural regionalization for the first time in Russia. Arsenev (1818) divided Russia into ten regions based on climate and soil conditions. Agricultural regionalization continued to arouse interest in Russia with the thrust having been directed towards the mapping of agricultural zones (Raktinika, 1959, 1971, 1973, 1975, 1979). Enyedi (1961) attempted agricultural regionalization based on a number of scores representing values of crop and animal production per unit area multiplied by correlation co-efficient expressing the ratio of given crop or of animal production in given unit area. Others have attempted to demarcate regions
by aggregation of basic areal units based on agriculture with the help of quantitative taxonomic methods (Hartshorne and Dicken 1935, Nordgard 1974). In United States, a series of relatively simple studies on cropping and livestock raising regions, explained in terms of environmental factors (Smith & Baker, 1915). The most important step towards agricultural classification on a world scale was made by Derwent Whittlesey (1936) who identified thirteen major agricultural regions based on crop and livestock combination, method of employed, intensity of application, methods of disposal and farm building. Barer (1922, 1926) provided a sound agricultural regionalization of the USA addressing “a large (sub-continental) area of the land characterized by homogeneity of agricultural conditions especially crops grown and sufficient dissimilarity from conditions in the adjacent territory as to be clearly recognizable”. Grigg (1969) published a comprehensive analysis based on modification of the previous works as proposed by Whittlesey and concluded that the typologies arrived at in these different schemes show considerable similarity which is not as surprising as they most appear to be derived from Whittlesey’s work. In India, much more attention has been paid to agricultural regionalization based on natural conditions and agricultural activities or on grouping crop combination, crop diversification, crop concentration, productivity (Sen Gupta 1968; Kulkarni 1968; P.S. Sharma 1971; Roy 1972; Singh, 1975; Mukhopadhyay, 1981 and Singh & Dhillon, 1984).

2. Irrigation and Agricultural Diversification- A Conceptual Framework: Irrigation is an important agricultural strategy designed to reduce moisture deficiency, i.e., the imbalance between the moisture supplied by rainfall and the evapo-transpiratory demand of crops (McKnight, 1992). This makes irrigation an important determinant for the cropping pattern of an area and overall development of agriculture. Additional area can be brought under crops with the application of irrigated water. Traditionally, irrigation was recognised only for its protective role of insurance against the vagaries of rainfall and drought. However, in present times, with adoption of high yielding varieties and chemical fertilisers, controlled irrigation has become a key factor in increasing productivity as well as diversifying cropping patterns (Sengupta, 2002).

Irrigation and Agricultural Diversification has been supported as a multifaceted approach to escape the crises of productivist model of agriculture, where the focus is on raising farm output (Finocchio, 2008). But from the social point of view, diversification of agriculture can be seen as a strategy to reduce the risks resulting from an especially risky environment and marketing (Mishra, et. al., 2004). Presently, diversification is a characteristic feature of stable agriculture and progressive farm management in the dominant agricultural regions of the world. In fact, this has been made possible by modern irrigation and liberal use of fertilizers, high-yielding varieties, pesticides and mechanical technologies (Meraner, et.al, 2015). Besides, there are other correlates of agricultural diversification. For instance, the vagaries of weather may compel a farmer to sow a number of crops or practice animal husbandry as an insurance against crop failure. Second, rural life and the orthodox farm practices force them to obtain most of their domestic requirements from their holdings. Third, the agricultural experts lay more emphasis on crop diversification for agricultural sustainability, maintaining soil fertility and gainful employment at farm throughout the year, etc. Index of diversification provides a sound method for generalizing the relationship between the relative strength and the number of crops grown. The regional dominance of some crops in an area has an important relationship with other crops, indicating a strong bearing on the degree of crop diversification or specialization. The present study focuses upon the role of irrigation on crop diversification in the study area.

3. Study Area: Located in the southern part of West Bengal, Paschim Medinipur has been carved from the erstwhile Medinipur district, the then largest district of India and came into existence in the present form on the 1st January 2002. Paschim Medinipur district is the southernmost district of the Burdwan Division, is situated between 21°36’ 35” and 22°57’ 10” North latitudes and between 86° 33’ 50” and 88° 12’ 40” East longitudes (Figure-1). Its boundary lies in Bankura and Purulia districts in the north, Mayurbhanj and Balasore districts of Odisha in the south, Hugli and Purba Medinipur districts in the east and Singbhum district of Jharkhand and part of Odisha in the west. The total geographical area of Paschim Medinipur district is 9345.00 sq. Km and contains twenty nine blocks. Net cropped area of
the district is about of 5, 73,575 ha. Major crops grown in the district are paddy (Aus, Aman and Boro), wheat, potato, vegetables, oilseeds, pulses, sugarcane, jute, maize, betel vine, mat-stick etc. The district is surplus in production of cereals, potato and vegetable crops.

4. Objectives: The present study aims at the following objectives:
   i) To analyze spatial variations in the intensity of irrigation and crop diversification in the blocks of Paschim Medinipur district.
   ii) To delineate agricultural regions of Paschim Medinipur district on the basis of irrigation and crop diversification.

5. Data Base & Methodology: The present study is based on secondary data like Total Irrigated Area, Net Cropped Area and Crop Production which have been taken from District Statistical Handbook (DSHB), Paschim Medinipur, 2011 and District Human Development Report (DHDR), Paschim Medinipur, 2011. Two key indicators, namely, irrigation intensity and crop diversification have been selected. Irrigation intensity denotes the percentage of net irrigated area to total cropped area. To study the levels of irrigation, Irrigation Intensity has been calculated by the following method:

\[ \text{Irrigation Intensity} = \frac{\text{Total Irrigated Area}}{\text{Net cropped Area}} \times 100 \]

In order to examine the spatial patterns of crop diversification, the present study adopts Gibb Martin’s Index of Diversification (1962). The formula for calculating this index is as follows:

\[ \text{Index of Crop Diversification} = 1 - \frac{\sum x^2}{(\sum x)^2} \]

Where, X is the percentage of total cropped area occupied by each crop or hectare under an individual crop.

Pearson’s Product Moment Correlation has been applied to find out degree of correlation between irrigation intensity and crop diversification. Agricultural regions on the basis of irrigation intensity and crop diversification have been delineated with the help of cluster analysis.

6. Analysis:

6.1 Irrigation Intensity: Out of total irrigated area in Paschim Medinipur district, 80.31 percent is contributed by ground water and 19.69 percent by surface water. The shallow tube wells (STW) account for major source of irrigation of about 1, 31,103 hectares against total irrigated area of 2,54,050 hectares (CGWB, 2011). This is followed by canal irrigation and tank irrigation accounting for 66,105 ha and 24,698 ha respectively. The major deep tube wells, medium high density deep tube wells and minor deep tube wells irrigate 8,585 hectares, 22,969 hectares and 590 hectares respectively(C-DAP, 2010). Of the various sources, canal irrigation is the most uncertain as the Kansabati reservoir does not always have adequate water. Other sources of irrigation are assured and dependable.

Therefore, it is obvious that irrigation remains a key determinant of agricultural development. The inter-block variability in total irrigated area to net cropped area is very high. Percentage of irrigated area is the highest in Sabong block (93.57 per cent) while the lowest is found in Binpur-II block (8.09 per cent). Table No-1 & Figure No-1 presents spatial variations in the percentage of net irrigated area across various blocks in Paschim Medinipur district. Five distinct categories of blocks with very high, high, medium, low and very low irrigation intensity may be identified. High ground water potential along with presence of canal and tank irrigation is the key determinant of very high and high irrigation intensity in certain blocks. On the contrary, the blocks with low and very low irrigation intensity display adverse geological conditions in terms of water bearing layers and lack of different sources of irrigation. In both the cases climate also plays a significant role in recharging the ground
water and maintaining the soil moisture. Blocks situated in the western parts receive lower amount of precipitation in comparison to the eastern part of the district. Besides, overutilization of ground water resources has aggravated the problems in relation to irrigation.

6.2 Crop Diversification:
Crop diversification in the blocks of Paschim Medinipur district is depicted in Table No-1. Maximum crop diversification occurs in Garbeta-II block whereas Binpur-II remains the block with minimum crop diversification (Table No-1 & Figure No-2). Various blocks of the district may be divided into five categories according to magnitude of crop diversification i.e. very high, high, moderate, low and very low.

Highly diversified agriculture in some of the blocks has resulted from a combination of favourable physiography and fertile alluvial soil along with application of high yielding varieties of rice and wheat, availability of better irrigation facilities and better accessibility to the market and storage facilities (DHDR, 2010). On the other hand, rugged topography, infertile laterite soil, low groundwater potential (CGWB, 2011), low levels of education (DSHB, 2011) and conventional methods of agriculture and inadequate market facilities have continued to hamper the requisite growth of the agricultural sector in rest of the blocks. Many blocks with low level of agricultural diversification fall under drought-prone regions of Paschim Medinipur (DHDR, 2010). Besides this, other constraints are weak infrastructure for agricultural extension and lesser scope for farm training and capacity building (DHDR, 2010). Inadequate irrigation facility in these blocks further reinforces agricultural backwardness.

6.3 Relationship between irrigation on crop diversification: The magnitude of impact of irrigation on crop diversification may be gauged by the correlation between the two indicators. The correlation between irrigation intensity and crop diversification has been established according to co-efficient value. Degree of correlation according to Pearson’s Product Moment is 0.64 which signifies a strong positive relation between irrigation and crop diversification in twenty nine blocks of Paschim Medinipur district. Correlation coefficient value indicates that irrigation plays dominant role in not only crop diversification but also overall development of agriculture.

6.4 Delineation of Agricultural Regions: Agricultural regionalisation is a task of dividing the region into number of units on the basis of a number of agricultural indicators like cropping intensity, crop combination, crop diversification etc. This technique has attracted the attention of many scholars in the field of agricultural geography (Whittlessey, 1936 and Singh, 1985). This study considers irrigation intensity and crop diversification for the regionalisation of Paschim Medinipur district. Cluster analysis has been done to delineate agricultural regions which have been shown in Figure-3.

Zone-I: Sabong is the only block which falls in this category. Correlation between level of irrigation intensity and crop diversification is very high. There is significant water available for the irrigation. Consequently, farmers grow multiple crops and high- water requirement crops in the field rather than single crop.

Zone-II: Salboni, Keshpur, Garbeta-I, Chandrakona-I, Chandrakona-II, Ghatal, Debra, Pingla, Daspur-I and Daspur-II blocks belong to this zone. Irrigation intensity is very high to high and level of crop diversification is also higher. Riverine alluvial plains, favourable climate and good soil conditions allow multiple cropping. Besides, ground water potential is also high, allowing better accessibility to irrigation facilities. Along with rainfed crops, various rabi crops like boro-paddy, wheat, mustard, seasame and potato are also cultivated. Some horticulture along with plantation agriculture is too practised throughout the year.

Zone-III: In two blocks, namely, Medinipur and Dantan-I a moderate correlation between irrigation intensity and crop diversification was found. Low water-requirement crops like wheat, mustard,
seasame and sugarcane are the dominant crops in these blocks. Dantan-I is the only block where sugarcane is cultivated at significant level.

**Zone-IV:** Dantan-II, Garbeta-II, Garbeta-III, Binpur-I, Jamboni and Gopiballavpur-II blocks show negative correlation between irrigation intensity and crop diversification. In these blocks, irrigation plays an insignificant role in agricultural development. There is scanty water available for irrigation and agriculture is totally dependent upon rainfall. Low water requirement crops like sugarcane, wheat, mustard, seasame and pulses are the main crops. Low groundwater potential in these blocks means the farmers depend upon river and canal irrigation.

**Zone-V:** Gopiballavpur-I, Jhargram, Sankrail, Keshiary, Narayangarh and Mohanpur blocks show moderate to low development in both irrigation intensity and crop diversification. Less fertile soils and droughts coupled with poor quality seeds in remote parts of the blocks are the key factors responsible for low agricultural development.

**Zone-VI:** Binpur-II, Kharagpur-I, Kharagpur-II and Nayagram show low to very low development in both level of irrigation and crop diversification. This is primarily due to physical constraints like rugged topography, coarse, infertile soil and lower ground water potential. Besides, these blocks are dominated by fragmented land holdings belonging to small and marginal farmers, which leads to low levels of agricultural development.

7. **Findings:** Following are main findings of the present study:

i) Disparity in irrigation intensity among twenty nine blocks of Paschim Medinipur is very much prominent. Except Sabong block, other blocks like Binpur –II, Jamboni, Nayagram, Sankrail, Gopiballavpur-I, Keshiary and Kharagpur-I do not have considerable irrigation facilities.

ii) Farmers of these blocks mainly grow paddy, vegetables and potato large in quantities and other crops are negligible.

iii) Overall, correlation between irrigation intensity and crop diversification in twenty nine blocks of Paschim Medinipur is highly positive. Only Dantan-II, Garbeta-II, Garbeta-III, Binpur-I, Jamboni and Gopiballavpur-II blocks show negative correlation contrary to the hypothesis. This means not only irrigation but other physical and socio-economic factors like cost-benefit, risk-profit, demand of new crops too are key determinants of agricultural development.

iv) Six agricultural regions emerge in Paschim Medinipur and each assumes a differential combination of irrigation intensity and crop diversification.

8. **Concluding Remarks:** Paschim Medinipur district is one of the agro-based districts of West Bengal. The present study delineates six agricultural regions in Paschim Medinipur district based on agricultural diversification and irrigation intensity. Except Dantan-II, Garbeta-II, Garbeta-III, Binpur-I, Jamboni and Gopiballavpur-II blocks, other twenty three blocks show a positive relationship between agricultural diversification and irrigation intensity. Even these six blocks display high crop diversification in spite of poor irrigation facilities. Therefore, the strategy for each of the emerging agricultural region needs to be different. In blocks with low crop diversification, less water requirement crops can be introduced. Paschim Medinipur district has a wide scope and opportunity for horticulture, animal husbandry, dairy and poultry besides the cereal crops which needs to explore for overcoming regional imbalances based upon agriculture and allied activities.
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