Indexing Crop Diversification of Northwest Bangladesh : A GIS Approach

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Abstract

Northwest Bangladesh is an agrarian region of this country. People's main occupation is cropping up here. Multiple cropping is a common feature in this region. Though paddy is cultivated here in large volumes, other crops are also cultivated simultaneously. Accordingly, the diversification of crops is not satisfactory. The study units (Upazilla/thana) are distributed throughout the vast areas of the northwestern part of Bangladesh. Their physiographic and climatic conditions are different. The region is divided into 13 agroecological zones. So significant spatial variation in cropping and crop diversification is happening. An attempt is made to construct a crop diversification index of 125 upazillas/thanas in the study area and examine their spatial variation. For this purpose, Gibb's and Martin's index methods are followed. Secondary data are used in this study, and data are collected through the documentation method. The agricultural census report 2008 of the Bangladesh Bureau of Statistics (BBS) is the main data source. According to the index, the upazilas/thanas are categorized and mapped using the Geographic Information System (GIS) technique. A long range of diversity is seen in the study area. Most of the upazilas/thanas fall under the low (36.8%) and very low (37.6%) categories of crop diversification. As crop diversity is necessary for food as well as the nutrition security of the population in the study area, special attention should be given to enhancing it. Besides, attempts should be made to reduce regional disparity concerning the diversification of crops.

Keywords: *Crop Diversification, Spatial Variation, Northwest Bangladesh, GIS Approach*

Introduction

Bangladesh is an agrarian country. The development of this sector during the last couple of decades drew the attention of the global community and development partners. This sector contributed 11.50% of the total GDP of the country in the fiscal year 2021-2022 (GoB, 2022). According to the Labour Force Survey 2022, it is the most dependable sector to provide 45.33% of the total labor force (The Daily Star, March 30, 2023). Agriculture makes food available for a huge number of people and is responsible for offering food and

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nutrition security for them. This is why special attention is given here to the Millennium Development Goal (MDG), Sustainable Development Goals (SDG), Vision 2041, Delta Plan 2100, and other development plans, policies, and programs.

Crop diversification is an essential component of ensuring food security. It was adopted as a policy strategy in many Asian countries, including Bangladesh, in the 1960s. The process was geared up here in the 1980s to reduce the emphasis on rice and achieve self-sufficiency in food (Islam, 2016). In doing so, the Bangladesh government started pursuing crop diversification and incorporating it into national policy planning. Various projects were undertaken to promote crop diversification. The Crop Diversification Project (CDP), the Northwest Crop Diversification Project (NCDP), the Second Crop Diversification Project (SCDP), etc. are examples of those.

The government of Bangladesh (GoB) is committed to ensuring food security for the people of the country. To achieve this goal, the policy of increasing food production is followed in the spirit of 1996. It was declared at that summit that food security should be achieved through "access by all people at all times to the food needed for an active and healthy life." It is reflected in the policy documents of the government. Almost all the policy documents suggest food security through increasing production as well as diversifying crops.

In the present world, crop diversification is considered an important instrument for achieving food security both at the farm level and at the national level. This process is not only responsible for ensuring nutrition security but also for helping with income growth, poverty alleviation, employment generation, judicious use of natural resources, sustainable agricultural development, and environmental as well as ecological management. All of these phenomena have an important relationship with the issue of food security. Singh (2001) viewed the same importance of crop diversification relating to food security when he addressed "Crop Diversification in the Asia-Pacific Region" at the FAO-RAP seminar in Bangkok.

Upazilas are important administrative units in Bangladesh. Crop diversification at a greater level was seen previously in Bangladesh and abroad. However micro-level units like upazilas were not considered in this concern. It is important to know the picture of micro-level crop diversification so that more specific agrarian decisions can be adopted.

In this paper, an attempt is made to construct an upazila-level crop diversification index in the study area. It is constructed based on upazila-level crop data. The feature is then decorated on a choropleth map.

Crop Diversification

Crop diversification is the result of competition among crop varieties. It means the raising of crop varieties for arable land. It is, however, an indicator of the

multiplication of agricultural activities that include intense competition among various activities for space. The keener the competition, the higher the magnitude of diversification, and the lesser the competition, the greater the trend toward specialization or mono-cultural farming, where the emphasis is on one or two crops (Singh and Dhillon, 2005). To be specific, the greater the number of crops in a combination, the greater the degree of diversification (Hussain, 1979). Agricultural diversification is now obviously almost a normal feature of stable agriculture and progressive farm management in most of the extensive agricultural parts of the world (Singh and Dhillon, 2005).

Where the monoculture or specialization of some crops is practiced, the competition for land occupancy remains weak. The degree of diversification indicates the impact of physical, socio-economic, and techno-organizational influences. When physical, social, and economic settings encourage the growth of a variety of crops, farmers tend to diversify their agricultural patterns. According to Singh and Dhillon's (2005) comprehensive study of the agricultural geography of a region, the interpretation of its diversification is important. It is also important for geographers as it has direct relevance to agricultural land use planning.

Bhatia (1965) first attempted to measure crop diversification mathematically. Singh (1976) later modified his formula and used it for the investigation of crop diversification in Haryana, India. According to Bhatia's (1965) and Singh's (1976) suggested formula, the degree of diversification is normally measured by relating the number of agricultural elements in an established element combination in a regional unit to the total percentage occupied by those elements in the same unit. It is assumed for the formula that if arable land is occupied by ten elements of ten percent each, it would be an example of the extreme degree of diversification. In contrast, if a particular crop in that area occupies 100 percent of the total cropped area, there is no diversification at all. So, the lower the value of the index, the higher the degree of crop diversification (Singh and Dhillon, 2005). This study, however, followed the Gibbs-Martin index for measuring the extent of diversification in cropping patterns in different regions of the study area. The formula is given below (Gibbs and Martin, 1962):

$$CDI = 1 - \frac{\sum X^2}{(\sum X)^2}$$

Here, CDI = Crop Diversification Index, X = Percentage of total cropped area occupied by each crop.

According to this method, if the entire area of a region is devoted to a single crop (in the case of mono-cropping or specialization of cropping), the index value is zero (0). On the other hand, if the arable land is evenly distributed

among all crops, the index value stands at 0.9. Therefore, the index of diversification varies from 0.0 to 0.9.

In a broad sense, crop diversification is defined as the strategy of changing from less profitable to more profitable crops. It also means changing crop varieties and cropping systems, increasing exports and competitiveness in both domestic and international markets, protecting the environment, and making conditions favorable for combining Agriculture, Fishery, Forestry, and Livestock. Crop diversification can be a useful means to increase crop output in different situations. It can be approached in two different ways, viz., (a) horizontal crop diversification and (b) vertical crop diversification (Singh, 2000).

Horizontal crop diversification is its major form, and it is a normally understood concept. It means the addition of more crops to the existing cropping system. Through this type of crop diversification, more crops are added, utilizing techniques such as multiple cropping and other efficient management practices. (Singh, 2000).

Vertical crop diversification is another type of cropping system. In this process, various downstream activities are undertaken. In this way, any crop species can be refined to manufacture products such as fruits, which are canned or processed into juice or syrup. Vertical crop diversification is a reflection of the extent and stage of industrialization of the crops. In this type, crop diversification can provide more economic returns from different crops. This is very different from the concept of multiple cropping, in which the cropping of a given piece of land over a given period is taken into account (Singh, 2000).

In this study, crop diversification is mainly horizontal, and it is revealed by constructing an index using proper tools and techniques.

Review of concerned literature

Rahman (2009) examined the existence of economies of crop diversification, scale economies, and diversification efficiencies at the farm level using a stochastic input-distance function approach. The results of his work reveal strong evidence of diversification economies amongst most crop enterprises, except for the combination of modern rice and modern wheat enterprises.

Alam (2008) examined the extent of crop sector diversification in Bangladesh with the "Simpson index" of diversity. Using the data from different years, he showed that the extent of crop diversification has increased in the country slowly over time and the specialization of rice has declined. The study also showed that the diversity of crops was accompanied by diversity in the patterns of consumption of people, and it was promoted mainly through a steady increase in the intensity of cropping.

Malik and Kundu (2006) examined the changes in cropping patterns and measured the extent and nature of crop diversification in Haryana, India, based

on the Herfindahl, Entropy, and Simpson Index of Diversity. They observed that the cropping pattern in this state has substantially changed over the period 1971–2004.

Noman (2003) initiated the classification of transformation in agriculture in Bangladesh as from traditional subsistence to mixed commercial farming to diversified commercial farming to a limited degree.

Malik et al. (2000) showed with evidence from Haryana, India, in the years 1997–1998 that the area under paddy of different sizes of farms decreased and the area under high-value crops increased.

Rahman (2000) explored the spatial crop diversity of Bangladesh. He used some formulas and methods to mathematically calculate some indicators of crop diversification in Bangladesh. In his work, data from 1974, 1984, and 1996 from three decades were used. He showed that a wide range of diversification has occurred in Bangladesh.

Choudhury et al. (1996) show that the cropping pattern is more diversified in semi-commercial farming.

Singh and Dhillon (1984) attempted to describe some of the prime foundations of the agricultural methodology for identifying the diversity of crops. They used some formulas for the measurement of indicators of crop diversification. In this work, crop diversification in the Haryana state of India is analyzed.

Bhatia (1965) discussed the concentration and diversification of some selected main crops in India. He pointed out the regional imbalances of concentration and diversification of those crops.

Very few of the above-mentioned works calculated the diversification of crops mathematically. They used Simpson, Herfindahl, Entropy, and Gibbs-Martin Index. However, none of the works showed upazila-level CDI of northwest Bangladesh to understand the spatial variation of the diversity of this region. An effort is made in the present study to fill the research gap.

Research Method

The objective of the study is to construct a crop diversification index of 125 upazilas/thanas in the study area and examine their spatial variation. The north-western part of Bangladesh, consisting of two administrative divisions, Rajshahi and Rangpur, which are made up of 16 administrative districts, was selected as an area for this study. The work is mainly quantitative. Data are collected from secondary sources, mainly the Agricultural Survey Report 2008 by BBS. It is a government survey where steps concerning validity and authenticity are taken carefully. From that point of view, the data used in this work is reliable. The acreage of the twelve main crops of the area, which are rice, wheat, maize, jute, pulses, oilseeds, sugarcane, potato, cotton, vegetables, fruits, and spices, is

considered for this study. The collected data is then calculated in an Excel program to construct the CDI of twenty-five upazilas/ thanas of the study following the above-mentioned Gibbs-Martin formula. The constructed CDI is then processed and mapped using GIS (the ArcView program).

Result and Discussion

A series of regional CDIs is shown here to understand the spatial changes of this important phenomenon of agricultural development in the study area. In the present work, the upazila-wise crop diversification index (CDI) is made to reveal the upazila-wise distribution of crop diversification. It is mentionable that CDI is constructed considering the acreage of rice, wheat, maize, jute, pulses, oilseeds, sugarcane, potatoes, cotton, vegetables, fruits, and spices.

Figure 1 shows the distribution of a crop diversification index of 125 upazilas in the study area. 18 (14.4%) upazilas lie under high CDI, 14 (11.2%) upazilas lie under moderate CDI, 46 (36.8%) upazilas lie under low CDI, and 47 (37.6%) upazilas lie under very low CDI. Almost 75% of the total upazilas are under low or very low CDI, and their index value is below 0.75. Almost the entire area of the Rangpur division and the northeastern half of the Rajshahi division is covered by these two indexes.

The very low CDI upazilas create a large single cluster, including 47 upazilas from both the Rajshahi and Rangpur divisions. It is expanded from the northern border of the Nilphamary district to the southeastern edge of the Sirajganj district, expanding two branches, one towards the southern side of the Rangpur division and another towards the northwestern side of the Rajshahi division.

Besides, three distinct clusters of low-CDI upazilas are found. The first of them is identified in the western part of the Rangpur division, including the 14 upazilas of Panchagar, Thakurgaon, and Dinajpur districts. The second cluster extends from the middle of the Rangpur division to its northeastern part. This cluster includes 13 upazilas in Rangpur, Nilphamary, Lalmonirhat, and Kurigram districts. The third cluster is built up with 8 upazilas of Gaibandha, Bogura, and Sirajganj districts, creating a thin line starting from southern Gaibandha to northern Sirajganj.

Moderate and high CDI upazilas surround the study area by the Gangatic plains in the south and a thin part of the Old-Braminputra and the Tista plain in the east. 15 upazilas in Rajshahi, Natore, and Pabna districts create the only cluster of high CDI. The moderate CDI creates two clusters. The first of them is created by the six upazilas of Rajshahi, Chapainawabganj, and Naogaon districts on the southwest side of the Rajshahi division. The second cluster is found at the eastern border of the study area, with six upazilas of Sirajganj, Bogura, Gaibandha, and Kurigram districts closer to the river Jamuna.

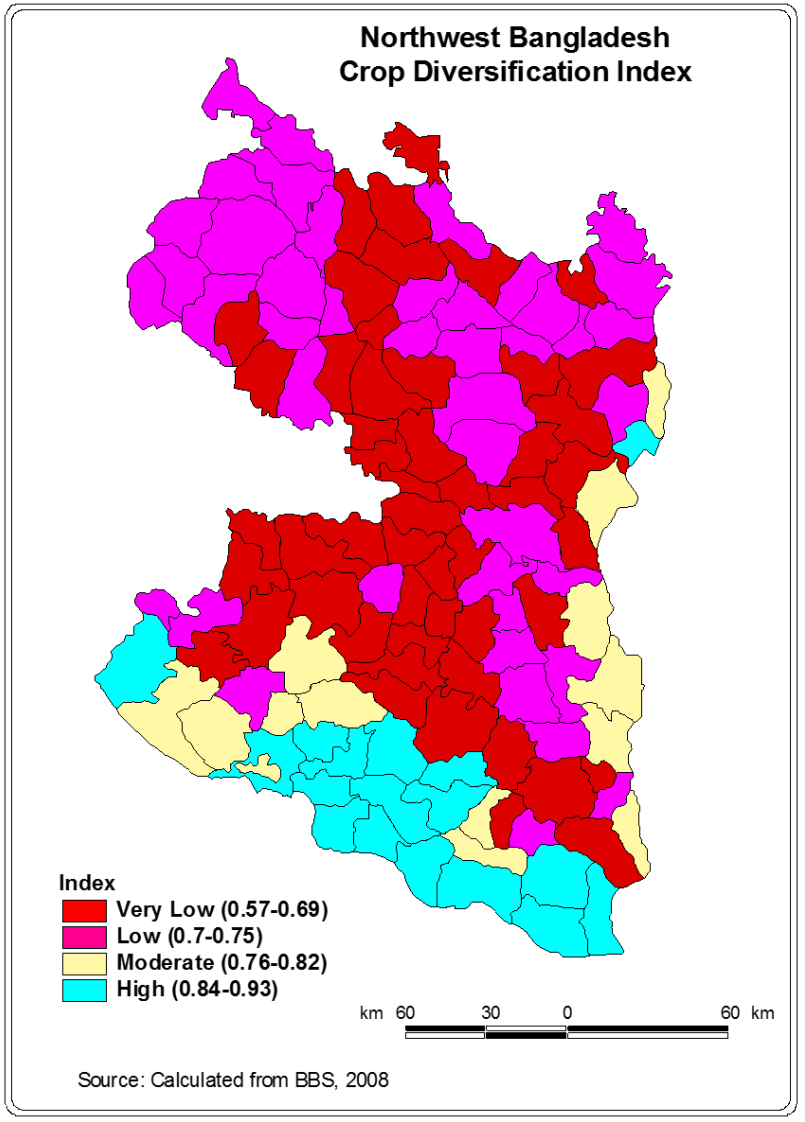

Figure-1: *Upazila-wise Crop Diversification Index of the Study Area*

Table-1: Distribution of Upazilas on the Basis of CDI

Name of the Districts	*Number of Upazilas on the basis of FSIs*				
	High CDI	*Moderate CDI*	*Low CDI*	*Very Low CDI*	*Total*
Panchagar	--	--	5	--	5
Thakurgaon	--	--	5	--	5
Dinajpur	--	--	5	8	13
Nilphamary	--	--	3	3	6
Lalmonirhat	--	--	4	1	5
Rangpur	--	--	6	2	8
Kurigram	1	1	5	2	9
Gaibandha	--	1	1	5	7
Joypurhat	--	--	1	4	5
Bogura	--	1	6	5	12
Naogaon	--	1	2	8	11
Chapainawabganj	1	2	1	1	5
Rajshahi	6	3	1	--	10
Natore	5	--	--	1	6
Pabna	5	2	1	1	9
Sirajganj	--	3	2	4	9
Total	**18**	**14**	**46**	**47**	**125**
Percentage	**14.4%**	**11.2%**	**36.8%**	**37.6%**	**100%**

Source: *Calculated from Bangladesh Agricultural Census Report 2008, BBS.*

A district-wise distribution of various types of CDI is also obtained from Figure 1, which is then decorated in Table table-1. Only five districts—four from the Rajshahi division and one from the Rangpur division—bear high CDI upazilas. Among them, Natore contains the highest percentage (83.33%) of upazilas. Eleven districts do not have such a rank of upazilas. Eight districts bear moderate CDI upazilas, seven from the Rajshahi division and one from the Rangpur division. Chapainawabganj has the highest percentage of upazilas of this type. Eight districts do not have upazilas of such rank. Low CDI upazilas are contained in fourteen districts: six from the Rajshahi division and eight from the Rangpur division. Thakurgaon and Panchagar districts bear the highest percentage (100%) of upazilas with low CDI. Two districts do not bear low CDI upazilas. Thirteen districts have very low CDI upazilas: six from the Rangpur division and seven from the Rajshahi division. The highest percentage of upazilas is contained in the Joypurhat district (80%). Three districts do not have such types of upazilas.

Conclusion

The study shows very interesting features of the spatial distribution of crop diversity. The high areas of the riverside of the Padma and the Jamuna contain high and moderate indexes of crop diversity. Water, both from the ground and underground sources is available here to grow high-value different crops. On the other hand, regions of water scarcity and water-logged areas show lower indexes of diversity. Favorable areas of diversity should be selected for high-value, diversified crops to ensure maximum crop culture. In this way, people can ensure the availability of diversified nutrition, and the government can fulfill the objectives of their highly ambitious projects. Besides, a series of studies should be conducted on this concern periodically to reveal the changing pattern of agricultural phenomena, especially the diversification of crops in the study area.

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