Agricultural Regionalization of Bangladesh Based on Productivity and Analysis of Spatial Dependencies of for Productivity Between the Districts of Bangladesh

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Abstract

Agricultural productivity of the Bangladesh are not equal all districts, some are in very in worse condition. This creates a dependency tendency for the low productive districts To identify the low productive districts for their agricultural development plan it is necessary to identify them through agricultural regionalization. The purpose of this study is to make agricultural regionalization of the 64 districts of the Bangladesh based on agricultural productivity and lists out probable hindrance causing low productivity. Productivity index was used as a parameter of agricultural productivity. Moran-I concept has been used to identify spatial dependencies between different regions. Scatter plot and Percentile value has been used to identify the outlier districts with extremely low and high productivity. The study has divided the whole country into four regions which will be helpful for taking policy for the agricultural development on basis their production level. From the analysis of degree of agricultural productivity dependencies between districts can be helpful for setting up agricultural development priority. The study also suggests possible initiatives for agricultural development on the basis of the study.

Introduction

Bangladesh is an agricultural country. Agriculture sector contributes 29% of the Gross Domestic Product of the Country and generates employment opportunity for 63% people of the total labour force of the country (WFP, 2013). Due to predominance of agriculture sector in the national economy, agriculture sector should be given top priority while planning for the national development. Although a wide variety of crop grows in Bangladesh, there is a spatial variation of production of these crops. Different regions or districts of Bangladesh have specialized in growing different crop (Faroque, M.A.A. *et al* 2011). While planning for the agricultural development, focus should be given on the variation in pattern of crop production. One of the effective tools to incorporate agro-spatial variation in establishing agricultural development policy and program is agricultural regionalization (Sharma, S.P. 1973, Singh, J. and Dhilon, S.S. 2004).

Agricultural regions are the territorial unit for formulating short and long term agricultural plans. Agricultural regionalization helps to identify the backward regions so that regional imbalances can be diminished. If proper agricultural development policy is undertaken, then agricultural regionalization can assist to achieve the goal of regional self sufficiency by proper utilization of agricultural potentials and local resources and infrastructure (Singh, J. and Dhilon, S.S. 2004).

There is functional relationship between agricultural productivity of the regions. This relationship should also be taken into consideration so that appropriate development measure can be taken (Anselin, 2003).

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Agricultural regionalization is necessary for an agro –based country like Bangladesh so that appropriate agricultural development policy and strategy can be on the basis regional condition by utilizing local resources. The study also uses Moran I to determine the degree spatial dependencies between regions so that they can be integrated policy measure.

Methodology and Study Design

Agricultural regionalization has been done on the basis of productivity in this study for year 2010. Necessary data were collected from the website of BBS. Different types of Rice, Wheat, Jute, Potato were only considered for this study as production data for all crops was not available. 64 districts of Bangladesh have been divided into four categories. The range of productivity was determined such that regions are found clusters.

Crop productivity index which a widely used for agricultural regionalization is used determine the individual and composite productivity condition of the district. The individual productivity condition of each crop in a district is determined by the productivity index.

Productivity index = (Y / Yn) / (T / Tn)

Where,

Y is the total production of selected crops in an area

Yn is the total production of the same crop on national scale

T is the total cropped area of the unit area

And Tn is the total cropped area for the national scale.

And combined productivity index for all crops in a regions are found by

$$\text{Combined productivity index} = \frac{\sum (y1/ t1) + (y2 / t2) + \ldots\ldots + n}{\sum (Y1/ T1) + (Y2/T2) + \ldots\ldots\ldots + n}$$

Where,

y1, y2……. n= total production of the selected crops in the unit area.

t1, t2……n = Total cropped area of those crops in the unit area

Y1, Y2…..n= total production of the selected crops in national scale

T1, T2……n= Total cropped area of those crops in national scale (Singh, J. and Dhilon,S.S. 2004).

This combined productivity index is used to determine the regions of relative agricultural productivity   from lowest to highest productivity.

Spatial Auto correlation Analysis

Spatial autocorrelation can be defined as the coincidence between value similarity and locational similarity on the basis of functional relationship and spatial dependence (Anselin, 2003). Therefore, there is positive spatial autocorrelation when high or low values of a random variable tend to cluster in space and there is negative spatial autocorrelation when geographical areas tend to be surrounded by neighbors with very dissimilar values. The measurement is usually based on Moran's I statistics (Cliff and Ord, 1981).

$$I = \frac{n}{S} \frac{\sum_i \sum_j w_{ij} z_i z_j}{\sum z_i^2}$$

N is then number of regions, z_i and z_j are log of percentage of electricity connection of each district, w_{ij} are the elements of weight matrix $W(n \times n)$ and it is equal to one if i and j are neighbors and zero if they are not. S is the sum of all elements of W (spatial weights). A binary contiguity matrix was used adopting the familiar rules. There are two constructions of used for the binary spatial weight matrix, namely rook and queen. Rook computes only common boundaries and nodes. Here the weight matrix has been constructed using rook contiguity.

Instead of Moran's I, Moran scatter plot is used to determine the local spatial cluster or statistically significant high outlier values as The Moran's I is useful to detect global spatial auto correlation, but it is not able to identify local patterns of spatial association.

The Moran scatter plot is divided into four different quadrants corresponding to the four types of local spatial association between a region and its neighbors. Quadrant 1 (on the top right corner) displays the regions with a high value surrounded by regions with high value (above the average).Quadrant 2 (on the top left corner) shows the regions with low value surrounded by regions with high values. Quadrant 3 (on bottom left) displays the regions with low value surrounded by regions with low values. Quadrant 4 (on bottom right) shows the regions with high value surrounded by regions with low values (Anselin, 2003).

Data Analysis

Total 64 districts of Bangladesh were divided into four agricultural region in this study on the basis combined productivity index and composite score. The considered four classes have been grouped as highly productivity, moderately high productive, moderately low productive, low productive regions. Table 1 shows a detailing of the agricultural regions.

Table 1: Agricultural Regionalization Based on Productivity for Bangladesh

Range of Productivity Index	Attribute	Frequency	Percentage	District
1.68-3.00	Low Productive	11	17.11%	Bhola,Patuakhali, Barguna, Laxmipur, Noakhali, Feni, Khagrhachari, Chittagong, Rangamati, Bandarban , Cosxbazaar.
3.00-3.40	Moderately Low Productive	14	21.87%	Panchghar, Nilphamari, Lalmonirhat, Kurigram, Rangpur, Sherpur, Jamalpur, Tangail, Mymensingh, Netrokona, Sunamganj, Sylhet, Habiganj, Maulivibazar.
3.40-3.70	Moderately High Productive	22	34.22%	Sirajganj, Pabna, Gazipur, Manikganj,Dhaka, Nayanganj, Faridpur, Kishorganj, Narsingdi, Brahmanbaria, Comilla, Chandpur, Shariatpur, Munshiganj, Shariatpur, Barisal, Gopalganj,Narail, Khulna, Bagherhat, Perojpur, Jhalkahti,Madaripur.
3.70-4.94	Highly Productivity	17	26.56%	Thakurgaon, Dinajpur, Joypurhat, Bagura, Naogaon, Nawabganj, Rajshahi, Natore, Kushtia, Meherpur, Chuadanga, Jhenaidahi, Magura, Jessore, Sathkhira.Rajbari, Gaibanda

Source: Authors Calculation

Low Productive Region

Around 17.11% districts are in low productive regions. This region covers mostly south-east part of the Bangladesh. Agricultural productivity of this region is relatively low because of most the districts are vulnerable to the natural disasters. All the districts in these regions are on the surrounded by Bay of Bengal in the south. Due to proximity to Bay of Bengal, these districts are the worst victim of the hurricane, typhoon, cyclone etc. These natural disasters have a negative impact on local agriculture. Government low expenditure in the agriculture sector in east is another reason for low productivity in this region (World Bank, 2013). Besides, Chittagong, Khanghrachari, Bandarban, Rangamati etc are hilly areas which is unsuitable for agricultural production (LGED, 2013). Among these hilly areas, Chittagong has relatively better productivity because of low labour cost and technological innovation (Quddus, M.A. 2009).

Bandarban has the lowest productivity index in the region which is lowest of the Bangladesh as well. Due to hilly topography and natural disaster proneness, Bandarban has a very low potentiality of agricultural production (National Web Portal Bangladesh, 2013).For this, crop production very low in this district.

Feni, Laxmipur, Chittagong, Bhola has relatively better productive index for rice than other district in this region. Due to relatively better production of rice in these four regions they have relatively higher combined productivity index than other districts of this region.
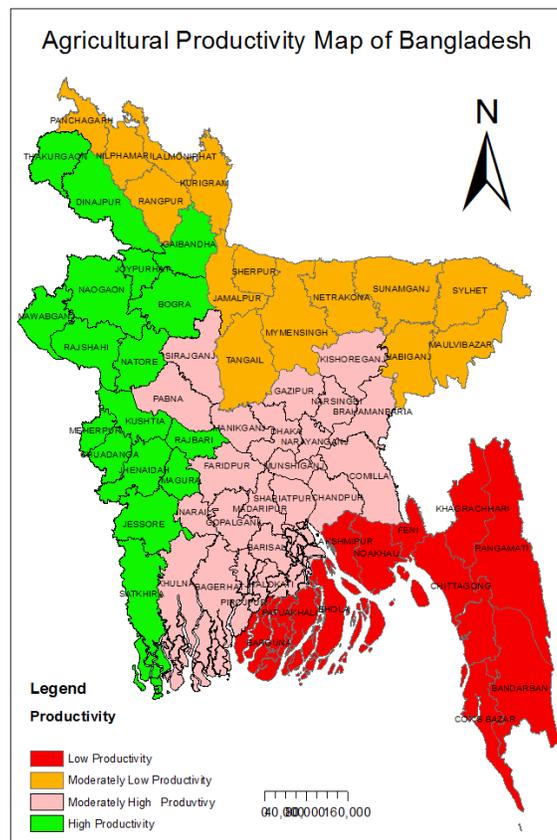

Fig 1: Agricultural productivity Map of Bangladesh; *Source: Prepared by Authors*

Moderately Low Productive Region

Within this region 21.87% percentage districts are located. The districts under this region clusters in the northern part of the Bangladesh.

Most of the districts of this region have a flat terrain which is suitable for agricultural production of rice, jute, wheat etc. However, Sylhet has relatively low crop productivity in respect of other district in this region as it has dominancy of hilly topography. Maulavibazar, Kurigarm, Jamalpur and Sunamganj have the lowest productivity index in this region because production of jute, potato is very poor in this district. These four districts have a better rice production which has made them moderately low productive district (National Web Portal Bangladesh, 2013).

Rangpur has the higher productivity in this region. Rice, jute, wheat grows well in these regions because of alluvial soil characteristics (LGED, 2013, Annexure A).

Moderately High Productive Region

Total number of districts in this region is 22 which are 34.22% of total number of districts in Bangladesh. Most of the districts of the country in located in this moderately high productive region.

Bagherhat and Khulna, in spite of being prone to salinity intrusion and natural disaster, they have moderately high level of production. It is because both these districts Ganges Tidal Flood Plain Agroecological zone which moderate to higher level of fertility due to alluvial characteristics of land which is suitable for agricultural production (Quddus, M.A. 2009).

The nature of terrain in these districts of this region is predominantly flat. Districts like Dhaka, Comilla, Barisal, Khulna which are divisional headquarters. They have better infrastructure and communication system which are a catalyst for agricultural improvement (LGED, 2013). For this, they have moderately higher level of production.

Highly Productive Region

In the highly productive region, 26.56% districts of Bangladesh are situated. This region mostly ranges in the western part of the county.

Due to high agricultural productivity of the district of the western part of the country has always received a priority for expenditure on agricultural sector of the government. Using this investment, these districts have made greater agricultural productions than other districts (World Bank,2008).

Flat topography of this region is suitable for production rice, jute, wheat etc. Kustia has the highest combined productivity index of Bangladesh. Rice, wheat, jute grows abundantly in Kustia but rice has the best potentiality (Annexure A). Presence of rice mill is a key factor that encourages farmer in rice production. High productivity of Naogaon, Dinajpur, Jessore can also be attributed by presence of rice mill encouraging farmers rice production (The Daily Star, 2011).

Thankurgaon has the second highest combined productivity index of Bangladesh because of high productivity of rice, wheat, jute, particularly rice which has the highest productivity index of Bangladesh (Annexure A). Clay, silt clay, silt clay loam, textures of soil are best for Paddy crop which matches with the soil type of the district (AGRISNET, 2013, Quddus, M.A. 2009). Hence, contributes to higher rice production.

Spatial Autocorrelation and Trend Analysis

Productivity index has been used as base for spatial auto correlation analysis. Low productive districts are likely to depend highly productive districts. Moran's *I* value from fig 2 shows the slope of the regression line. From the Moran scatter plotting of the Moran I value is 0.283147.

Now whether the geo-graphic location of these districts have been maintaining spatial dependence the confidence level of their probability to make cluster has been revealed by Randomization process using Geoda. Monte Carlo (random) permutation for Moran's *I*

> ➢ Randomly arrange the values among the space and calculate *I* each time (e.g., 999 times)
> ➢ Comparing the actual *I* with the 999 randomly gained *I*s
> ➢ If the actual *I* falls into area of either more than 95% or less than 5%, it is said the *I* is pseudo significant at 5% level (positive/negative)
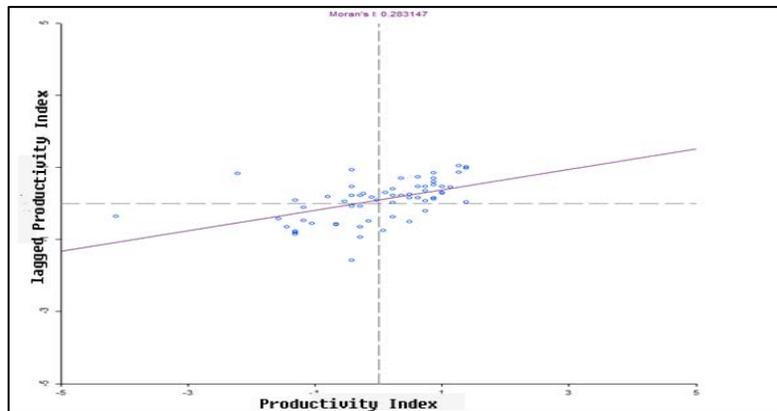

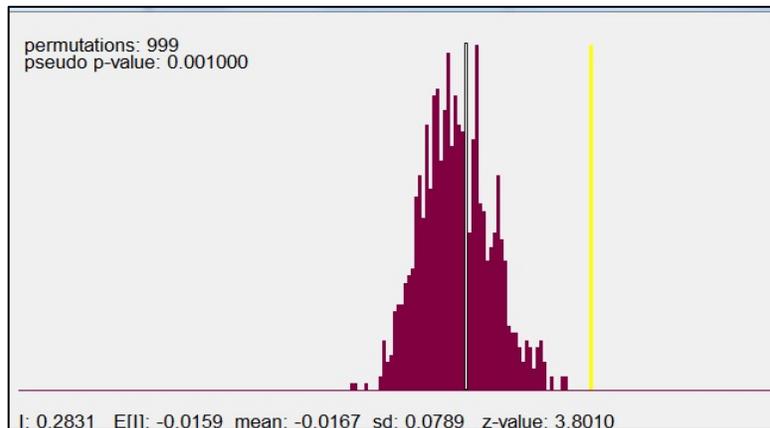Fig 2: Scatter Plot of Productivity Index; *Source: Prepared by Authors*

Fig 3: Randomization of Productivity Index; *Source: Prepared by Authors*

From the figure 3, Randomization on the Moran's *I* values has been done. It shows that the p-value falls in 5% significance level as the value is 0.001 which is less than 0.025. Therefore, cluster maps will show the clustered districts which are significant at 95% confidence level.

The LISA map (even after 999 permutations) identifies a few clusters, which is a reminder to be cautious in the interpretation of statistically significant clusters (especially at a 0.05 level) since they can occur under random conditions (stricter significance tests can be applied in *GeoDa* to test the sensitivity of the LISA results).

Based on the effect of spatial lag and spatial weights of the neighboring districts, the significant districts having spatial weighted homogeneity at 95% confidence level has been shown in Cluster Map in fig 4.

The cluster map of Moran's *I* at 95% confidence interval is a special Choropleth map showing those locations with a significant Local Moran statistic classified by type of spatial correlation: bright red for the High-High association, bright blue for Low-Low, light blue for Low-High, and light red for High-Low. The High-High and Low-Low locations suggest clustering of similar values, whereas the High-Low and Low-High locations indicate spatial outliers. Cluster map is drawn for the visualization of spatial association in geographic location. The map illustrates that that Noagoan, Rajshahi, Jhenaidah, Magura, Jessor, Faridpur and Madaripur districts are in High-High and Panchagor, dinajpur, Borguna, Khagrachhari Districts falls in Low-Low. It also shows that Meherpur and Pabna Districts falls in Low-High.
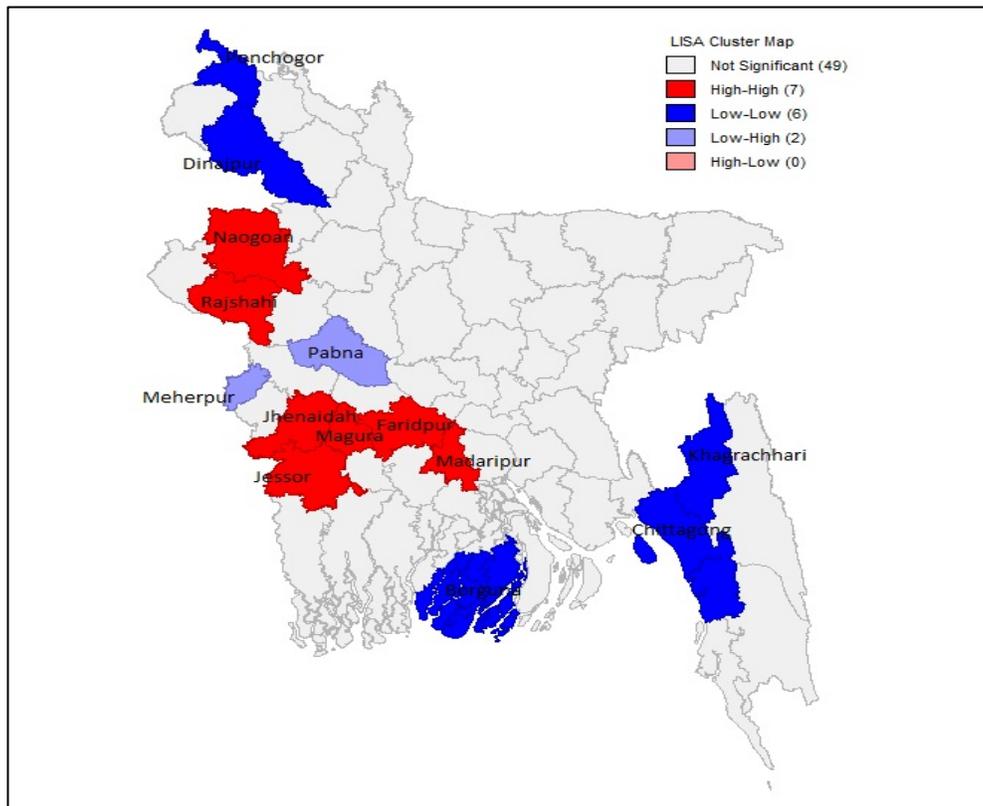

Fig 4: Cluster Map of Productivity of Bangladesh; *Source: Prepared by Authors*

The cluster map of Moran's *I* at 95% confidence interval is a special Choropleth map showing those locations with a significant Local Moran statistic classified by type of spatial correlation: bright red for the High-High association, bright blue for Low-Low, light blue for Low-High, and light red for High-Low. The High-High and Low-Low locations suggest clustering of similar values, whereas the High-Low and Low-High locations indicate spatial outliers. Cluster map is drawn for the visualization of spatial association in geographic location. The map illustrates that that Noagoan, Rajshahi, Jhenaidah, Magura, Jessor, Faridpur and Madaripur districts are in High-High and Panchagor, Dinajpur, Barguna, Khagrachhari Districts falls in Low-Low.

GeoDa percentile test shows that only one district Bandarban is below 1% percentile and only one district Kustia is above 99% percentile. These are the spatial outlier. Bandarbar and Kustia has respectively highest and lowest combined productivity index which has established them as spatial outlier.

Conclusion and Recommendation

From the agricultural regionalization it is clear that all districts are not equally well off. The prime reasons behind the disparity is the lack of fertility of land, topographic variation, inadequate infrastructure facility etc. Due to unequal distribution of crop production, ultimate result is dependency of the low productive districts on the higher productive districts. With the passage of time population will increase, if any initiative is not taken now the then dependency between regions are likely to increase. For this focus is to be given on the increase of agricultural production. Like HYV rice, others crops should be encouraged to cultivation as they grow well in land with poor fertility (Karmokar, P.M. *et al.* 2012). While investing on agricultural sector focus should be given on low productive area. Better infrastructure facilities like agriculture dependent industry establishment and communication development can play a vital role in agricultural development. In order to provide access to the farmers' modern technology, high quality fertilizers and credit, they should not be concentrated in particular region rather should get scatter throughout the country particularly to low agricultural production yielding area so that crop intensity can be increased (Begum, S.F. *et al*, 2004) .Farmers should be encouraged to grow crops all over the rather than in any particular seasonal crop. This will lead to crop diversification as well as save the cultivable land from getting barren due to cultivating one crop again and again.

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