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Spatial inequality in Bangladesh: A geospatial analysis

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ABSTRACT

Spatial inequality of development is an important issue in Bangladesh. In this study a set of sectors-education, infrastructure, health, and economy-and sectoral components/indicators were selected aiming at investigating the spatial inequality scenario of Bangladesh. All components/indicators of each sector were weighted overlaid using ArcGIS tool. Finally, the overall spatial inequality of development was generated overlaying all the sectoral inequality maps. The spatial inequalities were revealed categorically from the highest overlaid cell value as the most lagged area to the lowest value as the most advance area. A serious centralized character towards the capital Dhaka was identified almost in all the sectors in spatial inequality maps of Bangladesh. The overall spatial inequality map identified a total of 16 districts in the comparatively 'lagged area' category; and 44 districts in the category of the 'moderate area'. Only one district (the capital Dhaka) was identified in the category of 'most advance area', while three districts (Chittagong, Gazipur, Narayanganj) found in the 'advance area' category. Most of the lagged districts were identified in the north-west and north-east parts of Bangladesh. Besides, the districts of Chittagong Hill Tracts (Bandarban, Khagrachari, Rangamati) were also found most lagged..

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1. INTRODUCTION

Spatial inequality in development is the inequality in economic and social pointers of wellbeing across geographical units within a country [1]. Globalization, privatization, and deregulation are frequently cited as the causes of the increasing spatial dissociation, social polarization, and spatial disparities that are occurring as a result of the global economic transformati [2] [3] [4] [5]There's a sense that spatial disparities in multidimensional socio-economic indicators are on the increase in most of the developing countries and transitional economies. The spatial dimensions of inequality have become a great attraction to the policy-makers of developing countries. In Bangladesh regional inequality is a growing conce [6]. There are very limited studies which have focused the regional disparity issue from both macro and micro perspective in Bangladesh [7]. Bangladesh has been successful in accomplishing a momentous reduction in poverty, but in terms of socioeconomic conditions there are big differences between regions, the facilities are very unequal [8]. Historically, there is discrimination in the socio-economic prosperity within the country. The term 'east-west division', which has been coined at the beginning of this century, indicates the difference between the progress of eastern and western districts of Bangladesh; where the east division which constitutes Dhaka, *Chittagong*, and *Sylhet* divisions, is thought to be the more progressive region than the west

division including *Barisal, Khulna, Rajshahi, and Rangpur* division [8] s. This present study analyzed the spatial inequality in Bangladesh comparing the district level data.

There are multiple dimensions of spatial inequality in Bangladesh. Therefore, several criteria are needed to evaluate and meet a specific objective of the study. [9] A single indicator can't explain the whole picture of spatial inequality within a country. Combinations of a multidimensional set of indicators give a composite measure of human welfare or development. This study examined four sectors particularly- education, infrastructure, health, and economy, to investigate the spatial inequality in Bangladesh. The sectors and their corresponding indicators were selected based on their importance.

Nowadays, GIS and Remote Sensing technology acted as an interactive decision-support and visualization tool that plays a principal role in regional economic development plans as well as conventional expository frameworks or approaches. GIS makes it suitable to study the spatial dimensions of inequalities [10]. A broad composite scenario of spatial inequalities can be extracted through multivariate analysis. Therefore, GIS and Remote Sensing tools and techniques are used to analyze the spatial integration of information and the overall spatial inequality scenario of Bangladesh. The purpose of this study is to find out the spatial inequality among the districts of Bangladesh through examining the status of education, infrastructure, health and economic condition of all districts. Finally, the magnitudes of the disparity between the most advance and most lagged have been identified. To determine the spatial inequality scenario of Bangladesh, this study mainly focused on integrating multiple sectors' data of all the districts. Considering these, this study aims at identifying the spatial inequality in Bangladesh in general and the specific objectives are:

1. To identify the spatial inequality of the education sector in Bangladesh
2. To identify the spatial inequality of the economic sector in Bangladesh
3. To identify the spatial inequality of the health sector in Bangladesh
4. To identify the spatial inequality of the infrastructure sector in Bangladesh
5. Finally, to identify the overall spatial inequality scenario of Bangladesh

2. MATERIALS AND METHOD

2.1. Study Area

Bangladesh is mostly a riverine, low-lying, and densely populated country. According to the 2011 census, Bangladesh has 142.3 million population[11] and in 2021, the population reaches to 166.3 million[12]. The country lies between 20°34'N to 26°38'N latitude and from 88°01'E to 92°41'E longitude (Figure 1).

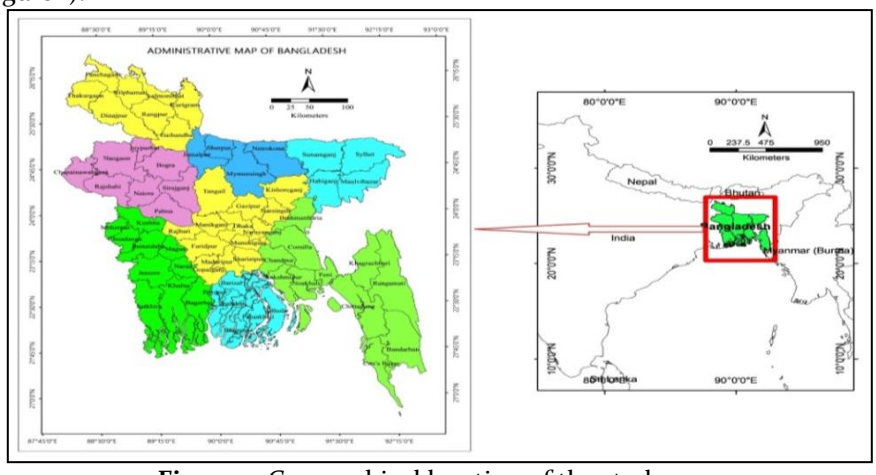

Figure 1. Geographical location of the study area

Administratively Bangladesh is divided into 8 divisions (Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Sylhet, and Rangpur) and 64 districts. It has 147,610 square kilometers of land

area. It has the longest bordering area with India on the west, north, and east; and in the southern part it is connected with Myanmar[13].

2.2. Data and Data Sources

To examine the spatial inequality in Bangladesh, four major sectors and their components/indicators were selected. The list of the data and their sources are described below:

Table 1. Sectors and selected indicators

Indicators	Data sources
Education Sector	
Literacy rate	BBS, 2011 [11]
Female literacy rate	BBS, 2011 [11]
Percentages of SSC/Equivalent passed population	BBS, 2011 [11]
Dropout rate in primary education	DPE, 2015 [14]
Infrastructure Sector	
Proportions of households having electricity connection	BBS, 2011 [11]
Proportions of households having sanitary latrine facilities	BBS, 2011 [11]
Household proportions living in pukka & semi-pukka houses	BBS, 2011 [11]
Proportions of metalled road length	BBS, 2011 [11]
Health Sector	
Infant Mortality Rate	BBS & UNICEF, 2009 [15]
National tetanus protection percent	BBS & INICEF, 2014 [16]
Prevalence of underweight children (under 5 years)	BBS & UNICEF, 2014 [16]
Number of hospital beds per 10,000 people	BBS, 2011 [11]
Economic Sector	
Employment rate	BBS, 2011 [11]
Number of manufacturing establishments	BBS, 2013 [17]
Proportions of persons engaged in non-farm activities	BBS, 2013 [17]
Poverty rate	BBS, WB, WFP, 2010 [18]

2.3. Conceptual Framework

In this study, the spatial inequality in Bangladesh was examined taking into consideration the conditions/quality of life and distribution of opportunities/accessibilities of physical facilities. The main conceptual framework of the data was organized as the following figure:

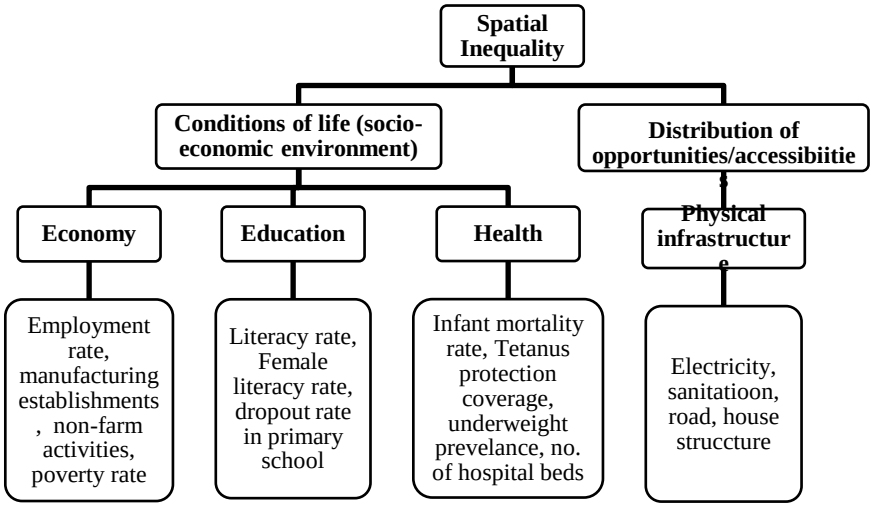

Figure 2. Conceptual framework of the study

The quality of life and distribution of accessibilities at all districts of the country were identified in this study through examining education, health, infrastructure and the basic economy of the country.

2.4. Method

To make an integrated analysis of multiple dissimilar indicators, the weighted overlay technique is used in GIS applying a common standard measurement scale of values to multiple inputs. Additionally, the indicators may have unequal importance of influences on their relevant sector. To determine the relative influence of each raster cell, each is categorized into a common measuring scale and multiplied by weight. The final output raster is created by adding the resultant cell values to get the weighted overlaid cell values for each point on the map. The weighted overlay process can be mathematically illustrated as:

$$WO = \sum w_i f_i \quad (1)$$

Where,
WO = Weighted Overlaid cell value
w_i = weight of each class range value of the individual indicator
f_i = influence of each indicator

In this study the thematic layers of all selected indicators of each sector were overlaid in ArcGIS 10.5 platform to see the spatial inequality in each sector. After getting weighted overlaid thematic layers of all sectors from the integration of all indicators' thematic layers of each sector, they were then finally overlaid to identify the overall spatial inequality scenario of Bangladesh. The weighted overlaid cell values reflected a spatial development index. The lowest overlaid cell value represented the worst-off areas/most lagged areas and the highest overlaid values represented the best-off areas/most advance areas.

2.5. Preparation and Manipulation of GIS Data

For performing the data preparation using ESRI ArcGIS 10.5, a common field ID was created between the excel data and the ArcGIS attribute table of the administrative boundary shapefile of Bangladesh. The excel data were combined with ArcGIS attribute tables based on the common field between the excel sheet and the ArcGIS layer attribute table of the administrative boundary shapefile of Bangladesh. Using the 'Conversion Tool' of ArcGIS 10.5, the data were then transferred to raster data. The data were converted to raster to enable the ArcGIS software to quantify the data into spatial values with gradient colors. The raster data classified in nine ranks/classes in the feature map were reclassified in 5 ranks/classes applying equal interval classification. In the cases of positive components (e.g. 'literacy rate') the class of the highest values was evaluated as the best status. On the other hand, the class of the highest values of negative components (e.g. the 'dropout rate in primary education) was evaluated as the worst status (Table 2).

2.6. Weighing Process

The major challenge of this study was to measure the proportionate weight effect/influence of each component on its sector and the assessment of the overall spatial disparity. Everybody has a varied set of circumstances and priorities in various areas of life and there are no standard references to quantify the weight influence of components/indicators (selected for each sector based on the availability of data) on their related sector. That's why a questionnaire was developed to measure the weight effect or influence of each component on its sector. In this study, a purposive sampling technic was used to compile 30 samples from experts in population sciences, regional planning, and development studies from various institutions and organizations. On the other hand, the ratio influence of every sector was set in an equal order (i.e. equal proportionate influence for every sector was settled). In all cases, the relative weight influence must add up to 100. To visualize the overall spatial inequality in one map, the sectors were treated as indicators to perform in a single map

overlaid in a weighted manner. A weighted indexing table, adopted in this study to examine the spatial inequality, has been shown in Table 2.

Table 2. Weighted indexing table

Indicators	Fields**	Scale values (Scale: 1 to 5 by 1)	Weight Influence* (%)
Education Sector			
Literacy rate	1 (worst) to 5 (best)	1 to 5 (worst to best)	25
Female literacy rate	1 (worst) to 5 (best)	1 to 5 (worst to best)	31
SSC/equivalent passed population rate	1 (worst) to 5 (best)	1 to 5 (worst to best)	18
Dropout rate in primary education	1 (best) to 5 (worst)	1 to 5 (worst to best)	26
Infrastructure Sector			
Electricity connectivity	1 (worst) to 5 (best)	1 to 5 (worst to best)	30
Sanitary latrine facilities	1 (worst) to 5 (best)	1 to 5 (worst to best)	23
Pukka and semi-pukka house structure	1 (worst) to 5 (best)	1 to 5 (worst to best)	22
Metalled road length	1 (worst) to 5 (best)	1 to 5 (worst to best)	25
Health Sector			
Infant Mortality Rate	1 (best) to 5 (worst)	1 to 5 (worst to best)	26
Tetanus protection coverage	1 (worst) to 5 (best)	1 to 5 (worst to best)	19
Prevalence of underweight children	1 (best) to 5 (worst)	1 to 5 (worst to best)	20
Hospital beds per 10000 people	1 (worst) to 5 (best)	1 to 5 (worst to best)	35
Economic Sector			
Employment rate	1 (worst) to 5 (best)	1 to 5 (worst to best)	23
Manufacturing establishments	1 (worst) to 5 (best)	1 to 5 (worst to best)	27
Persons engaged in non-farm activities	1 (worst) to 5 (best)	1 to 5 (worst to best)	20
Poverty rate	1 (best) to 5 (worst)	1 to 5 (worst to best)	30

Note. **In cases of negative indicators (Dropout rate in primary education, Infant Mortality Rate, Prevalence of underweight children, Poverty rate) the highest field values are evaluated as worst status, while in cases of all other positive indicators the opposite evaluations are made; *The proportionate weight influence is calculated from the questionnaire survey.

3. RESULTS AND DISCUSSIONS

The results are recapitulated in maps, tables and bars. The sectoral outcomes are discussed at first in this section before finally moving on to the overall spatial inequality finding.

3.1. Spatial Inequality in Infrastructure Sector

Five fields of overlaid cell values are found after integrating the four indicators of infrastructure (Figure 3).

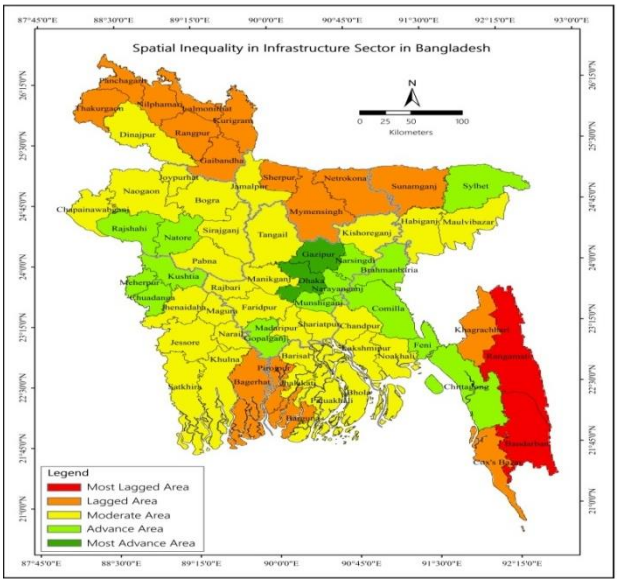

Figure 3. Spatial inequality scenario in the infrastructure sector in Bangladesh

As a whole it is obtained that most of the lagged districts in infrastructure are identified in the hilly districts in south-eastern parts of the country and in the northern parts of the country. The districts in between capital *Dhaka* and the port city *Chittagong* are identified advance in infrastructure. Besides, the *Sylhet* district and some districts in the mid-western parts of the country are obtained comparatively advance in infrastructure.

Most of the districts (30 districts) were identified in the 'moderate area' category of the infrastructure sector, while 16 districts were found in the 'lagged area' category and 14 districts found in the 'advance area' category (Table 3).

Table 3. Spatial inequality scenario among the districts of Bangladesh in the infrastructure sector

Status	Total number of districts	Percentages of districts	Area coverage (%)	Percentages of populations
Most Lagged	2	3.12	7.16	0.68
Lagged	16	25.00	25.25	21.07
Moderate	30	46.88	47.38	42.16
Advance	14	21.88	18.00	25.37
Most Advance	2	3.12	2.21	10.72

Note. Data in columns were adapted and calculated from "Population and Housing Census" by Bangladesh Bureau of Statistics, 2011 [11]

The percentages of populations are much greater than the percentages of the area covered in the advanced districts in the infrastructure sector, while the inverse scenario is located in the case of districts of the worst status in the infrastructure sector (Table 3). It indicates the more dense population of the infrastructural advanced areas than the lagged areas.

3.2. Spatial Inequality in Education Sector

Five fields of spatial inequality are identified in the overlaid spatial inequality map of the education sector (Figure 4).

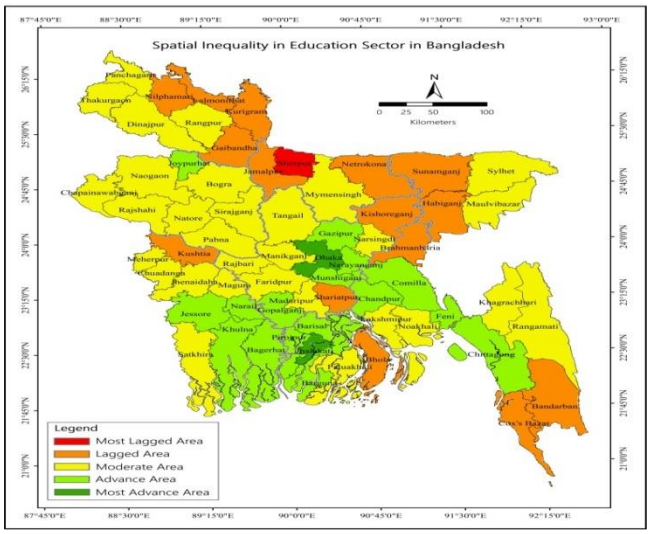

Figure 4. Spatial inequality scenario in the education sector in Bangladesh

As a whole, it is identified from the spatial inequality map of the education sector that most of the advanced districts in the education sector lay in the southwest and southeast parts of the country, while most of the lagged districts are identified in the north-west and north-east parts of the country.

Most of the districts (30 districts) are identified in the 'moderate area' category of the infrastructure sector, while 16 districts are found in the 'advance area' category and 15 districts are found in the 'lagged area' category in the education sector (Table 4). It is also found that the districts of the best status in education are much more densely populated area than the districts of worst status (Table 4).

Table 4. Spatial inequality scenario among the districts of Bangladesh in the education sector

Status	Total number of districts	Percentages of districts	Area coverage	Percentages of populations
Most Lagged	1	1.56	0.92	0.94
Legged	15	23.44	24.47	20.78
Moderate	30	46.88	49.60	42.82
Advance	16	25.00	23.51	26.63
Most Advance	2	3.12	1.50	8.84

Note. Data in columns were adapted and calculated from "Population and Housing Census" by BBS, 2011 [11]; "Annual Primary School Census 2015" by DPE, 2015 [14].

3.3. Spatial Inequality in Health Sector

The spatial inequality map of the health sector (Figure 5) built through weighted overlay shows that Netrokona district is the 'most lagged area' in the health sector and Dhaka is comparatively 'most advance area' in the health sector amongst the 64 districts of Bangladesh.

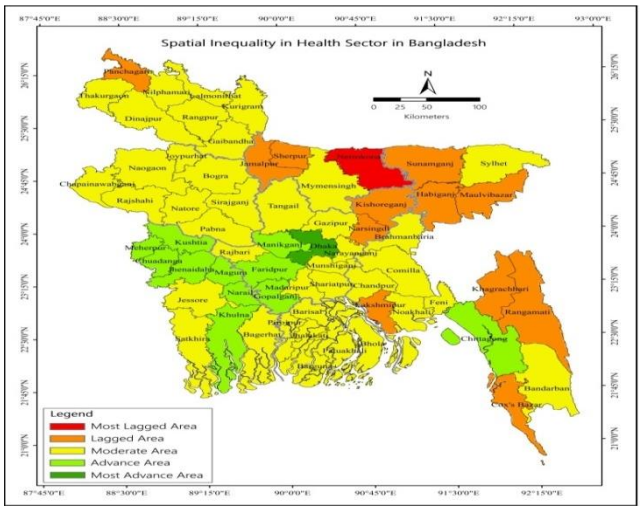

Figure 5. Spatial inequality scenario in the health sector in Bangladesh

Recapitulating the overall scenario of the health sector, it is found that the districts of the north-east part of Bangladesh and some hilly districts of the south-east part of the country are lagged in the health sector. As only 1 district is identified in the 'most advance area' category of health sector, it can be said that there is a centralized characteristic in the health sector where people depend on the capital *Dhaka* for getting better health services. It is found that the population proportion is much higher than the proportion of area in the most advanced area in the health sector. The reverse condition is obtained from the lagged portions (Table 5).

Table 5. Spatial inequality scenario among the districts of Bangladesh in the health sector

Status	Total number of districts	Percentages of districts	Area coverage	Percentages of populations
Most Lagged	1	1.56	1.89	1.56
Lagged	12	18.75	20.61	14.91
Moderate	39	60.94	61.71	60.21
Advance	11	17.19	14.80	14.96
Most Advance	1	1.56	0.99	8.36

Note. Data in columns were adapted and calculated from "Population and Housing Census" by BBS, 2011 [11]; "Multiple Indicator Cluster Survey 2012-13" by BBS and UNICEF, 2014 [16]; "Multiple Indicator Cluster Survey 2009" by BBS and UNICEF, 2009[15].

3.4. Spatial Inequality in Economic Sector

A serious centralized characteristic is identified from the spatial inequality map of the economic sector in Bangladesh (Figure 6).

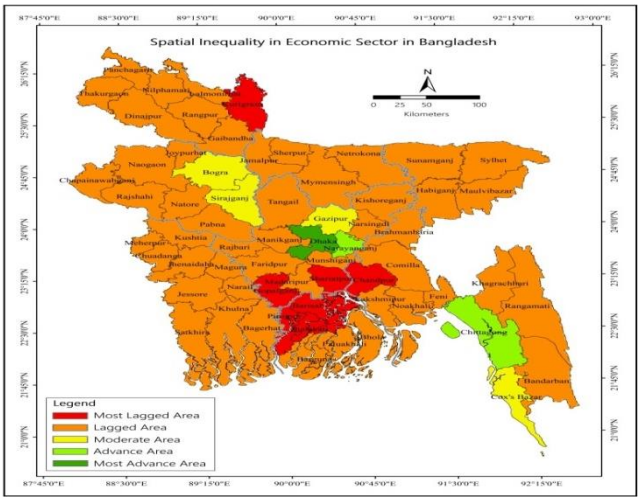

Figure 6. Spatial inequality scenario in the economic sector in Bangladesh

Only 1 district (*Dhaka*) is found in 'most advance area' category and 2 districts (*Chittagong* & *Narayanganj*) are in the 'advance area' category, while 50 districts (covering 80.59% area and 68.25% population of the whole country) are identified as 'lagged area' and 7 districts (covering 7.79% area and 7.59% population of the whole country) are identified as 'most lagged area' in the economic sector (Table 6).

Amongst the three districts of 'most advance area' and the 'advance area' category in the economic sector, *Dhaka* and *Chittagong* are the principal financial centers of the country, and the remaining one (*Narayanganj*) is the oldest industrial district in Bangladesh. The percentages of populations are much greater than the percentages of the area covered in the advanced districts in the economic sector, while the inverse scenario is located in the case of districts of the worst status in the economic sector (Table 6).

Table 6. Spatial inequality scenario among the districts of Bangladesh in the economic sector

Status	Total number of districts	Percentages of districts	Area coverage	Percentages of populations
Most Lagged	7	10.94	7.79	7.59
Lagged	50	78.13	80.59	68.25
Moderate	4	6.25	6.56	8.46
Advance	2	3.12	4.08	7.33
Most Advance	1	1.56	0.99	8.36

Note. Data in columns were adapted and calculated from "Population and Housing Census" by Bangladesh Bureau of Statistics, 2011[19]; "Economic Census 2013" by Bangladesh Bureau of Statistics, 2013[17]; "Poverty Maps of Bangladesh 2010" by WB, WFP and BBS, 2014[18].

3.5. Spatial Inequality in Bangladesh: An Overall Integrated Scenario

The integration of all sectors' thematic layers through weighted overlay results in four raster cell values (2 to 5) which are termed from the lowest value to the highest value as- lagged area, moderate area, advance area, and the most advance area (Figure 7).

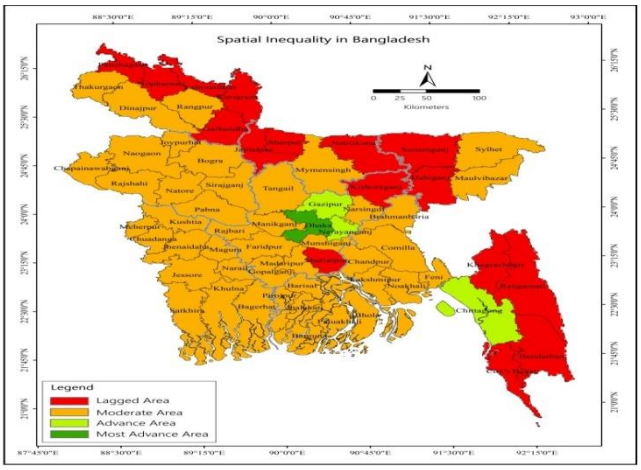

Figure 7. Overall spatial inequality scenario in Bangladesh in all aspects

16 lagged districts are identified having the lowest overlaid raster cell value 2, revealed as lagged area in the map. Most of these 16 districts (covering 27.61% area and 18.69% population of Bangladesh) are identified in the north-west and northeast parts of the country (Table 7), while some of them are also identified in the hilly and coastal region in the southeast part of the country. Only one district- the capital *Dhaka* is identified 'most advance district' amongst all the districts in all aspects, and three districts- *Gazipur*, *Narayanganj*, and *Chittagong*- are identified 'advance area' in Bangladesh in all aspects; this spatial inequality scenario reflects a centralized character in Bangladesh. Most of the districts (44 districts) are identified as the comparatively moderate developed area covering 66.10% area of the whole country and 63.25% population of the country (Table 7).

The proportional comparison of the population and area coverage of Bangladesh based on the spatial inequality status in all aspects suggested that the advance districts in education, infrastructure, health and economic sector are more densely populated than lagged districts (Table 7).

Table 7. Spatial inequality scenario among the districts of Bangladesh in all aspects

Status	Total number of districts	Percentages of districts	Area coverage	Percentages of populations
Lagged	16	25.00	27.61	18.69
Moderate	44	68.75	66.10	63.25
Advance	3	4.69	5.30	9.70
Most Advance	1	1.56	0.99	8.36

Note. Data in columns were adapted and calculated from "Population and Housing Census" by Bangladesh Bureau of Statistics, 2011 [11].

4. CONCLUSIONS

This research developed a methodology, in which GIS was used as an effective and valid diagnostic tool to determine complex and multidimensional aspects of spatial inequality. The multidimensional characteristics of spatial inequalities among the districts of Bangladesh were examined in this study.

Most of the lagging districts were identified in the northwest and northeast parts of Bangladesh, while some of them were also of the southwest and southeast region of Bangladesh. So, it would not be ideal to see the spatial inequality in Bangladesh only from the traditional 'east-west division' point of view, where the west division is thought to be less developed than the east division. This study suggests that the comparison between east and west divisions or among the eight divisions of Bangladesh doesn't reveal the relative micro picture of the spatial inequality in Bangladesh. That's why this study revealed the spatial inequality of Bangladesh making comparison among the 64 districts of the country.

In the comparatively 'advance areas', there were found noticeable differences between the area coverage and the population coverage in all cases. The proportions of populations were found much greater than the proportions of the area in the 'advance areas' in all cases, where the opposite scenario was noticed in the cases of the 'lagged areas'. It can be said that better education, infrastructure, health and economic opportunities and facilities attract people to migrate districts of best status in all aspects.

In the final spatial inequality map built through integration of all sector maps, the capital Dhaka was only found in the comparatively 'most advance area' category which represented centralization in the country. A dominant centralized characteristic in Bangladesh was identified in the economic sector. In this regard, this study suggests that Bangladesh has the right conditions for the dispersal of administration and governance in all sectors to be useful and to take place. To ensure a sustainable development in Bangladesh, it should be ensured first that no one is left behind, reducing spatial inequalities.

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