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Research Article

Assessment of Industrial Interdependence in the Southern Region of Bangladesh: A Functional Regionalization-Based Analysis Towards a Comprehensive Development in the Economy

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Abstract

Despite the growing progression of regional economic integration as a driving factor for national development, the spatial dynamics of industrial interdependence in Bangladesh's southern coastal zone remain insufficiently theorized and empirically underexplored. The research addresses this gap by examining the functional correlation, dependable characteristics, and structural linkages among industries across four strategically significant districts (Khulna, Satkhira, Bagerhat, and Narail) through an integrated spatial-analytical framework. Employing a composite weighted index for formal regionalization alongside Reilly's Law of Retail Gravitation, the research delineates influence areas (IA) and unserved areas (UA) at the upazila level to assess intra-regional economic reach and service accessibility differentials. Input-output interdependence is contextualized within a GIS-based spatial representation, while Local Indicators of Spatial Association (LISA) and Moran's I statistic are applied to detect local clustering patterns, spatial outliers, and distributional asymmetries in industrial concentration. The findings reveal considerable spatial heterogeneity: Koyra (Khulna) and Shyamnagar (Satkhira) exhibit the highest influence areas, whereas Daulatpur registers the lowest, reflecting structural deficits in transport connectivity and economic infrastructure. At the district level, Narail records the lowest unserved area share (0.96%), attributable in part to its favourable positioning along the Padma Bridge corridor. LISA analysis identifies the absence of significant high-high clusters, indicating a fragmented rather than cohesive pattern of industrial development, with Khulna emerging as a high-influence, high-unserved-area outlier characterized by disproportionately low industrial concentration relative to its functional importance. These spatial imbalances are further explained through a multi-factor analysis encompassing transport networks, vocational infrastructure, agricultural land use, and market density. The research concludes that targeted policy interventions, including upazila-scale industrial decentralization, infrastructure investment, and skills development, are necessary to foster inter-regional industrial interdependence and mitigate spatial disparities in southern Bangladesh.

Keywords

Functional Regionalization, Industrial Interdependence, Reilly's Gravitational Law, Influence Area, Unserved Area, LISA Analysis, Southern Bangladesh, Spatial Inequality, Regional Economic Development.

1. Introduction

Bangladesh, a densely populated country in South Asia, has been experiencing rapid economic growth over the last few decades. Bangladesh's economy is moving from the agricultural and service sectors toward the industrial sector, with the manufacturing subsector contributing the most and growing the fastest (Manik, 2023). The southern part of Bangladesh has significantly boosted the nation's economy.

According to the Analysis, industrial growth has been uneven in the southern region, with some sectors, like textiles and apparel, playing a more prominent role in the local economy than others. There is a significant interconnection among businesses, with sectors like textiles and chemicals serving as significant input suppliers to other sectors in the area. Industrial interdependence is rooted in the idea that industries are not independent entities but interconnected through input-output linkages (Sayedur et al., 2026). Economic growth is fundamentally analysed not only by examining industrial growth but also by examining how they are interconnected. According to the findings, governments should prioritise encouraging industry interdependence to support long-term economic growth in the region.

This paper aims to assess the interdependence among industries in the southern region of Bangladesh through a functionally regionalized analysis. The research uses quantitative methods, including input-output analysis, to identify the level of interdependence among different industries in the region. By analysing the interdependence of industries, the study aims to provide insights into the region’s economic development and suggest policy recommendations for a comprehensive and sustainable development strategy. The Seventh Five-Year Plan for Bangladesh, which emphasises the need for sustainable economic growth and balanced regional development, is consistent with the study's recommendations. Most studies have focused on a specific region, such as Khulna-Jessore or Chittagong, rather than comprehensively analysing the entire southern region.

The analysis focuses on the southern region of Bangladesh, which is significant because this region has been a catalyst for the country's overall economic growth. Bagerhat, Narail, Khulna, and Satkhira are examples of economic development and transformation dynamics in the southern area, where the framework for economic planning may be designed to ensure the prosperity of the entire economy. The districts in the southern region are being chosen as regions based on formal regionalization and the transportation linkage of the most recent transboundary connection, which runs from Dhaka to Narail, Khulna, Satkhira, and Bagherhat. This connection can potentially develop into an international freight transit network that includes Bangladesh, India, and Myanmar with the development of the Padma Bridge and highway construction (Chackroborty et al., 2024). As a result, Bangladesh seeks economic development by preserving harmonious ties with its neighbors, emphasizing the connection between China and India for regional harmony (Lutfa & Shanto, 2023). However, in Khulna and the southern region of Bangladesh, the industrial sector faces obstacles from high land costs, inadequate institutional administration, unclear national land policy, and disarray among government institutions (Mallick et al., 2022). These findings help in designing targeted interventions that can promote the interdependence of industries, reduce regional disparities, and foster sustainable economic growth. The prime objectives are to determine the influence and UA of the upazilas of Shatkhira, Bagerhat, Narail, and Khulna districts by functional regionalization and to assess the reasons behind having the most IA based on some factors. The depth interpretation based on IA, UA, and one of the key factors delineates the industrial domination, spatial imbalance, and regional integration by LISA analysis. LISA analysis, which is used to track absolute distribution dynamics, is crucial for understanding spatial process evolution across time at the local level (Tao & Chen, 2022).

Overall, this study is essential for policymakers, researchers, and practitioners interested in understanding the economic dynamics of the southern region of Bangladesh and developing effective strategies for comprehensive and sustainable development.

2. Methodology

The methodological framework first identifies industrialized districts using formal regionalization. It then applies functional regionalization to examine industrial interdependence in greater detail.

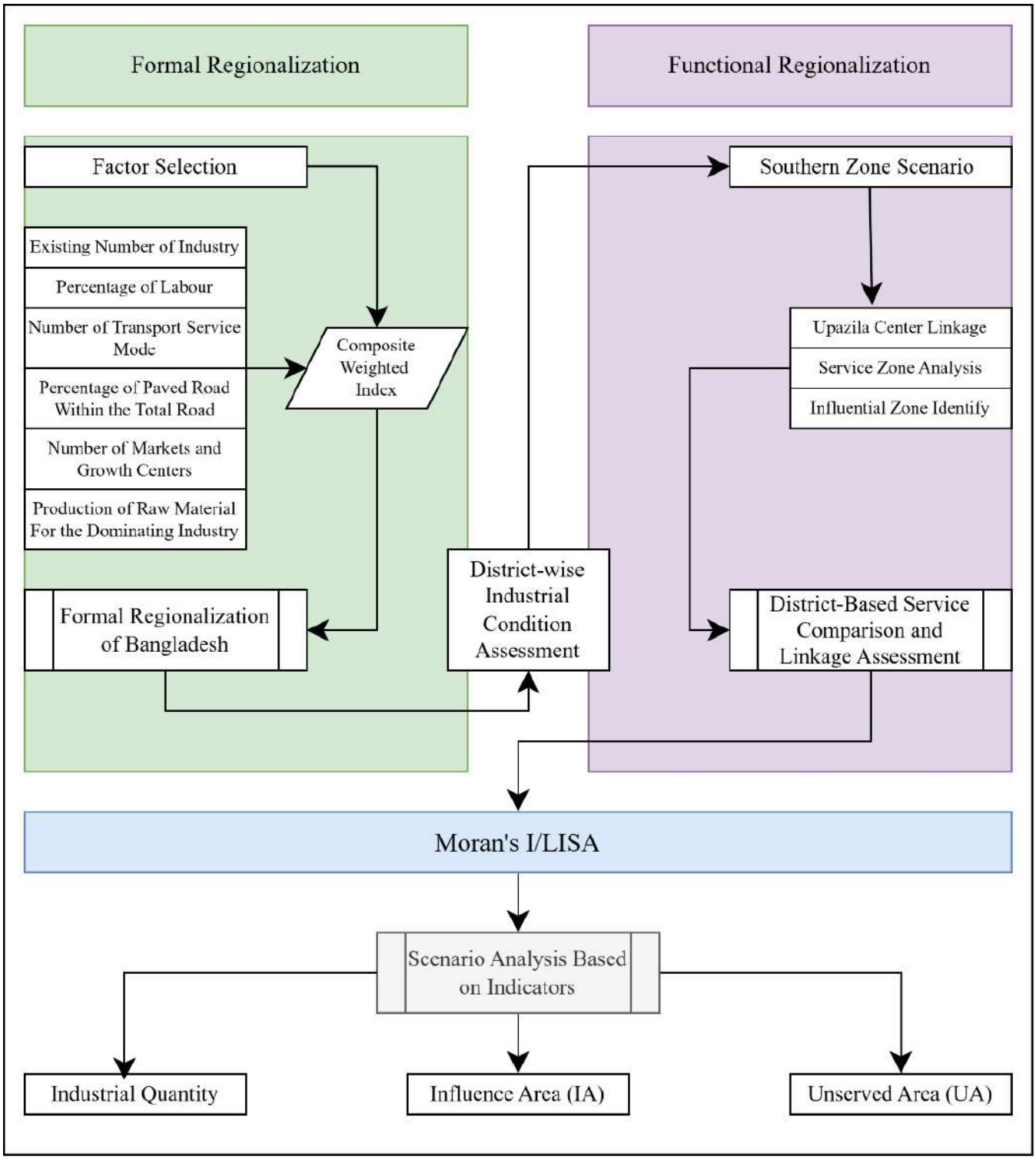


Figure 2-1: Methodological Framework

2.1 Method of Formal Regionalization

I. Selection of Factors and Justification

The study uses indicators such as the existing number of industries, percentage of labour, number of transport service modes, percentage of paved roads within the total road, number of markets and growth centers, and production of raw materials for the dominating industry.

II. Data Collection & Analysis

The secondary data on which this study is based. Data on 64 districts for these five criteria were taken from a 2011 publication by the Bangladesh Bureau of Statistics. Due to the unavailability of more recent datasets, this study relies on the 2011 data published by the Bangladesh Bureau of Statistics. After that, SPSS was used to evaluate the data using various statistical techniques.

III. Composite Weighted Index Method

Step 1: Weight Calculation of Individual Factors

W(n)= Mean of Log10 (X_n)/Standard Deviation of Log10 (x_n) [n=1,2,3,4]

W_1(Existing number of industry) = 11.14175377

W_2(Percentage of labour) = 17.3078502

W_3(number of transport services modes) = 1.23498448

W_4(percent of the paved road within the total road) = 4.853893131

W_5(number of markets and growth center) = 6.177714727

W_6(production of raw materials for the dominating industry) = 10.3266588

Step 2: Composite Weight Calculation of Each District

W=[log10(x1) *w1+log10(x2) *w2+log10(x3) *w3+log10(x4) *w4+log10(x5) *w5] /(w1+w2+w3+w4+w5)

Step 3: Selection of Class Interval

The preferred number of classes is 5. Three methods are used to select the class interval: Equal Class Interval Method, Mean Standard Deviation Method, and Arithmetic Mean Method. The suitable one is selected based on the graph, Skewness, and Kurtosis. For the selected factors, the Mean Standard deviation is the most suitable for forming a formally regionalised map of Bangladesh, as shown in **Figure 2-2.**

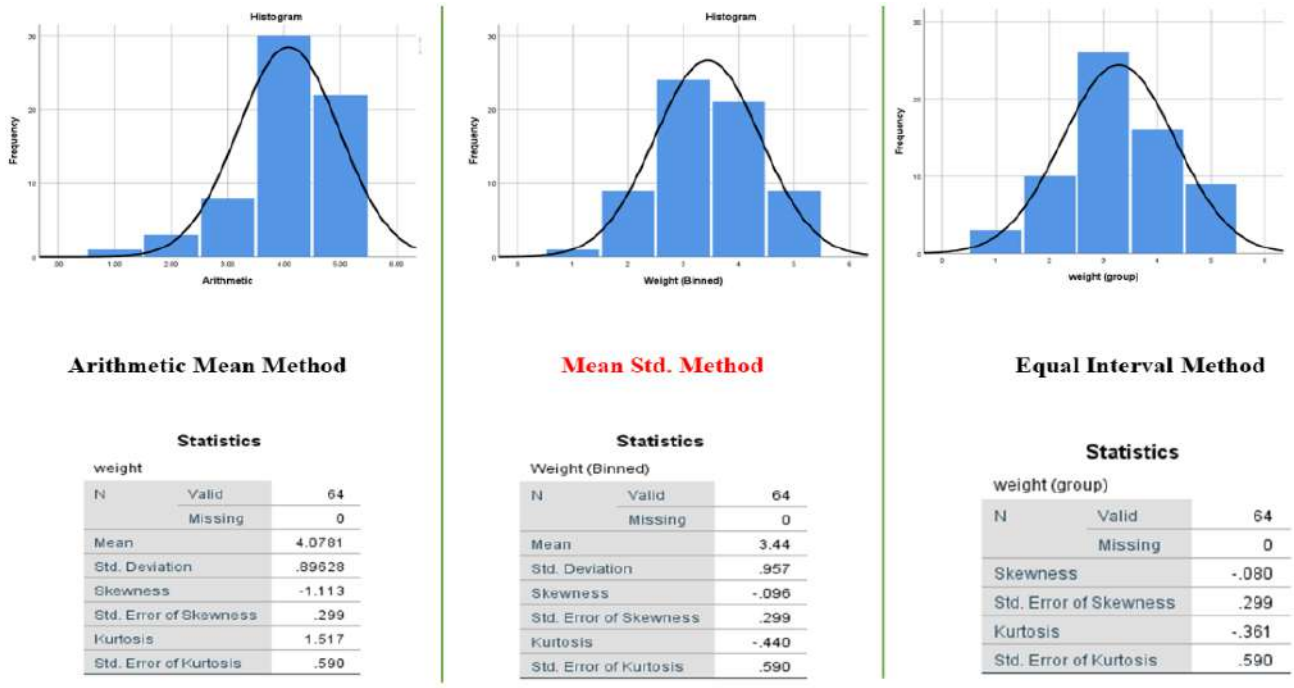


Figure 2-2: Histogram of Normal Distribution of Arithmetic, Mean Std., and Equal Interval Method for the classification of formal regionalization

After determining the most influential districts of the southern regions, a functional regionalization approach is initiated for further analysis. This study identifies the Khulna, Satkhira, Narail, and Bagerhat districts as the regional centres for the upazilas.

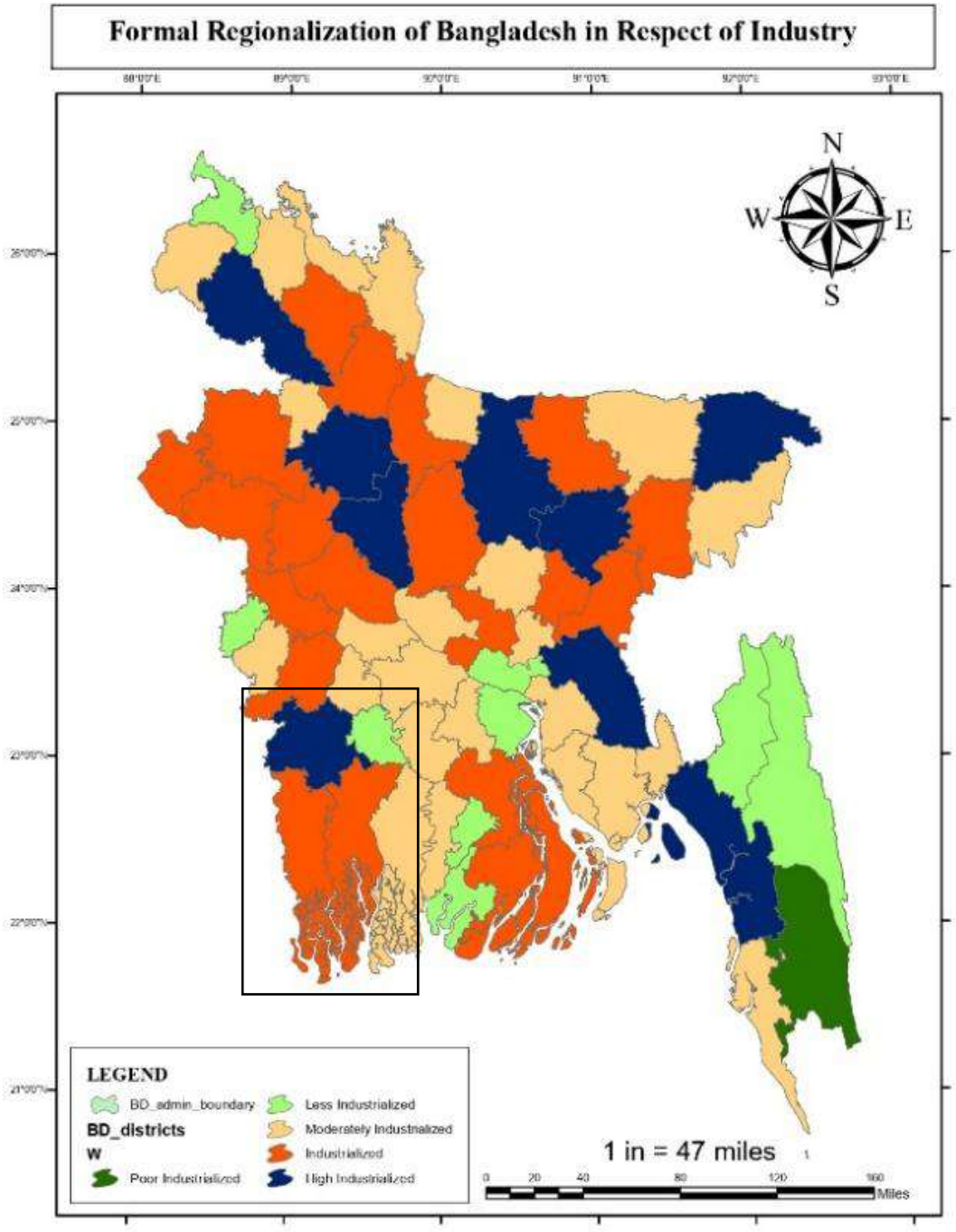


Figure 2-3: Formal Regionalization of Bangladesh with respect to Industry

2.2. Method of Functional Regionalization

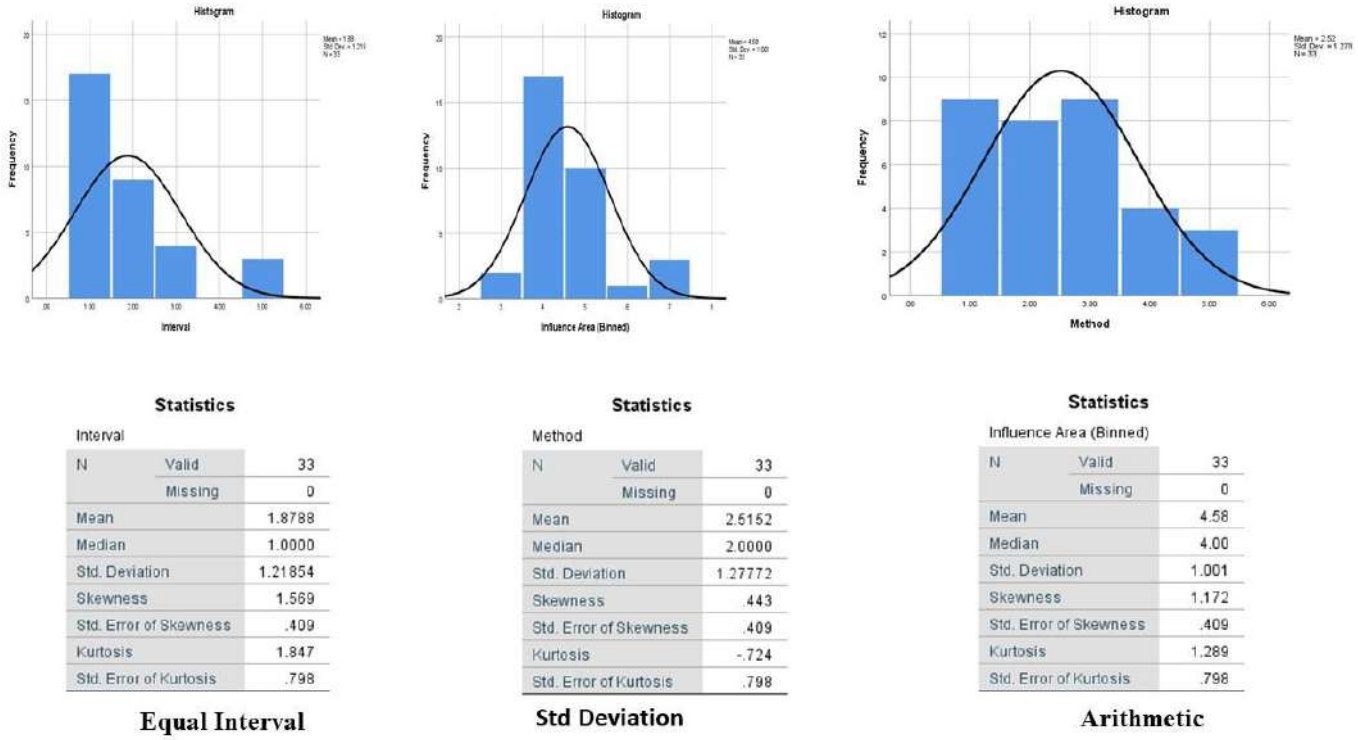
The Bangladesh Bureau of Statistics (BBS) was consulted for the names of the upazilas and population statistics. The BBS shapefile also provides the upazila headquarters' location, region, and boundary.

The map of the current geographical boundaries has been created using a Geographical Information System (GIS). The analysis mostly adhered to Reilly's Retail Gravitational Theory. The equation followed for determining the breaking point is,

Influential distance from A: $\frac{Distance\ between\ A\ to\ B}{1+\sqrt{Population\ of\ A}/{Population\ of\ B}}$

Equation 1: Reiley's law ["The law of Retail Gravitation" by William J. Reilly]

Where adjacent upazilas A and B are. The breaking point for every upazila was found using GIS to calculate the distance between two upazila headquarters. The IA for each upazila was found by connecting the breaking point for each upazila. The delimited effect region and the UA between the polygons were shown on a GIS map (version 10.8).



Statistics

Interval

N	Valid	33
	Missing	0
Mean		1.8788
Median		1.0000
Std. Deviation		1.21854
Skewness		1.569
Std. Error of Skewness		.409
Kurtosis		1.847
Std. Error of Kurtosis		.798

Equal Interval

Statistics

Method

N	Valid	33
	Missing	0
Mean		2.5152
Median		2.0000
Std. Deviation		1.27772
Skewness		.443
Std. Error of Skewness		.409
Kurtosis		-.724
Std. Error of Kurtosis		.798

Std Deviation

Statistics

Influence Area (Binned)

N	Valid	33
	Missing	0
Mean		4.58
Median		4.00
Std. Deviation		1.001
Skewness		1.172
Std. Error of Skewness		.409
Kurtosis		1.289
Std. Error of Kurtosis		.798

Arithmetic

Figure 2-4: Method Comparison for served area Analysis in functional Regionalization

After determining served and unserved areas, based on the served area through SPSS analysis, three classes are selected for in-depth analysis. Three methods are used to select the class interval. These are Equal Class Interval, Mean Standard Deviation, and Arithmetic Mean Method. The suitable one is selected based on the graph, Skewness, and Kartosis. For the selected factors, the Arithmetic Mean Method is the most suitable.

SPSS uses the BBS data to rank geographic regions, population IA, and the percentage of IA to present the factors most effectively. Secondary sources were used to cross-check the results of the analysis.

Local indicators of spatial association (LISA) can identify local patterns of spatial association and influence individual locations in global statistics, such as Moran's I (Anselin,2010). To identify local spatial cluster patterns, local indicators of spatial association (LISA) are applied in ArcGIS software. A spatial weights matrix was built considering queen contiguity to determine neighbourhood relationships among spatial indicators. The Moran's I statistic is calculated to identify the existence of a significant level.

The results are classified into high-high (HH), low-low (LL), low-high (LH), and high-low (HL) clusters on the basis of statistical significance at the 95% confidence level ($p<0.05$). The study considers three local indicators, such as influence area (IA), unserved area (UA), and number of industries. To understand industrial independence, inequity, and industrial strength, these factors have been selected.

If Moran's I value $P < 0.05$, then statistically significant, the cluster high-high (HH), low-low (LL), low-high (LH), and high-low (HL) can be determined at that time. If $p>0.05$, it is not statistically significant.

Moran's, I index value is positive (+), which means similar neighbours, and a negative (-) value expresses dissimilar neighbours.

Moran's I Z value is highly positive; it shows strong clustering, and a low negative defines strong outlier.

3. Data Analysis and Discussion

According to formal regionalization, the southern region has the highest industrialised area. Following the procedures outlined in the methodology, the BBS data were processed using GIS software. Then, a map of the Satkhira, Khulna, Narail, and Bagerhat districts is created, showing the affected region and UA as they hold the most influence in the industrial segment of Bangladesh. More importantly, they have one of the highest potentialities of growth, incorporating the transboundary linkage and development of railway construction with the Padma Bridge. The adjacent network with the southern region helps identify the industrial and economic interdependence. Jessore, Magura, Faridpur, Gopalganj, Pirojpur, and Borguna have several impacts on the trade and service providers in the southern region, significantly demonstrating the industrial linkages and facility distribution.

3.1. Functional Gap (FG) Analysis

Table 3-1 is formed based on affected and undercounted area coverage, created in **Figure 3-2**, to investigate the (FG). To achieve spatial equilibrium, functional zones should be formed that facilitate the closing of regional gaps and permit unrestricted resource movement between areas (Fan & Li, 2009). With the investigation of the FG, it will be possible to attain strategies for the different districts in the southern region based on their influence and unserved percentage.

Table 3-1: FG Analysis of Adjacent Districts of Southern Region, Bangladesh

District	Population	Area	Influence Area	Ranking
Jessore	2764547	2583.6	3184.1	2
Jhenaidhah	1771304	1954.45	1765.7	6
Magura	98355	1048.32	817.54	11
Faridpur	1912969	2042.3	2091	5
Gopalganj	1172415	1474.4	1576	7
Pirojpur	1113257	1268.76	1114.4	9
Barguna	892781	1344.5	1365.2	8
Satkhira	1985959	3388.3	2286.5	4
Narail	721868	994.9	876.85	10
Khulna	2318527	3622.5	3544.3	1
Bagerhat	1476090	3643.3	2577.9	3

(Source: Author's Preparation, 2024)

The gap analysis helps to identify the influence of one district over another. Jessore district has the highest percentage of industrialisation because of the Indian border and better road connections due to its influence. Satkhira, Khulna, and Bagerhat rank higher than other geographic areas, primarily due to the transportation network provided by National Highway 112 (NH112), making a significant impact on the southern region's economy. The border and international trade are highly emerging with the impact of the 6-lane highway construction. The primary cause for selecting the southern region is to identify the potential of different places for future industrialisation. Narail has the highest percentage of influential areas that can be increased with proper strategies.

3.2. Functional Regionalization Approach Over the Southern Region

Functional regionalization is a spatial optimization approach that restricts spatial contiguity and clusters various units according to shared features. The spatial distribution is formed using ArcGIS, further connecting the Upazila centers to identify the Upazila centers, as shown in **Figure 3-1**, and connecting them with the adjacent Upazilas to estimate served and unserved zones for different districts.

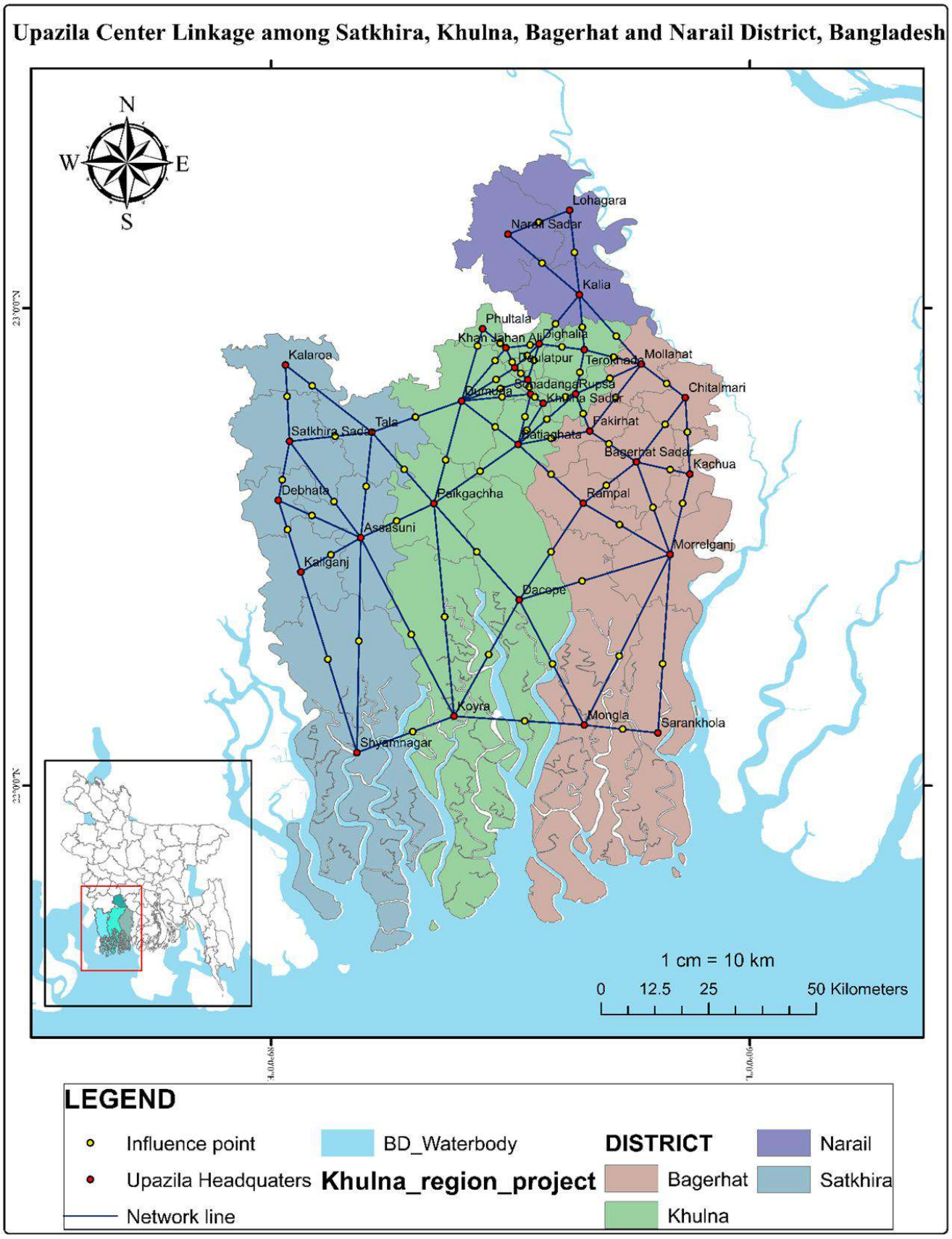


Figure 3-1: Upazila Center Linkage of Khulna, Satkhira, Bagerhat, and Narail

After forming line graphs, the influence points are identified using equation 1 of the gravitational law, which helps form a regionalised zone with served and unserved zones, as shown in **Figure 3-2**.

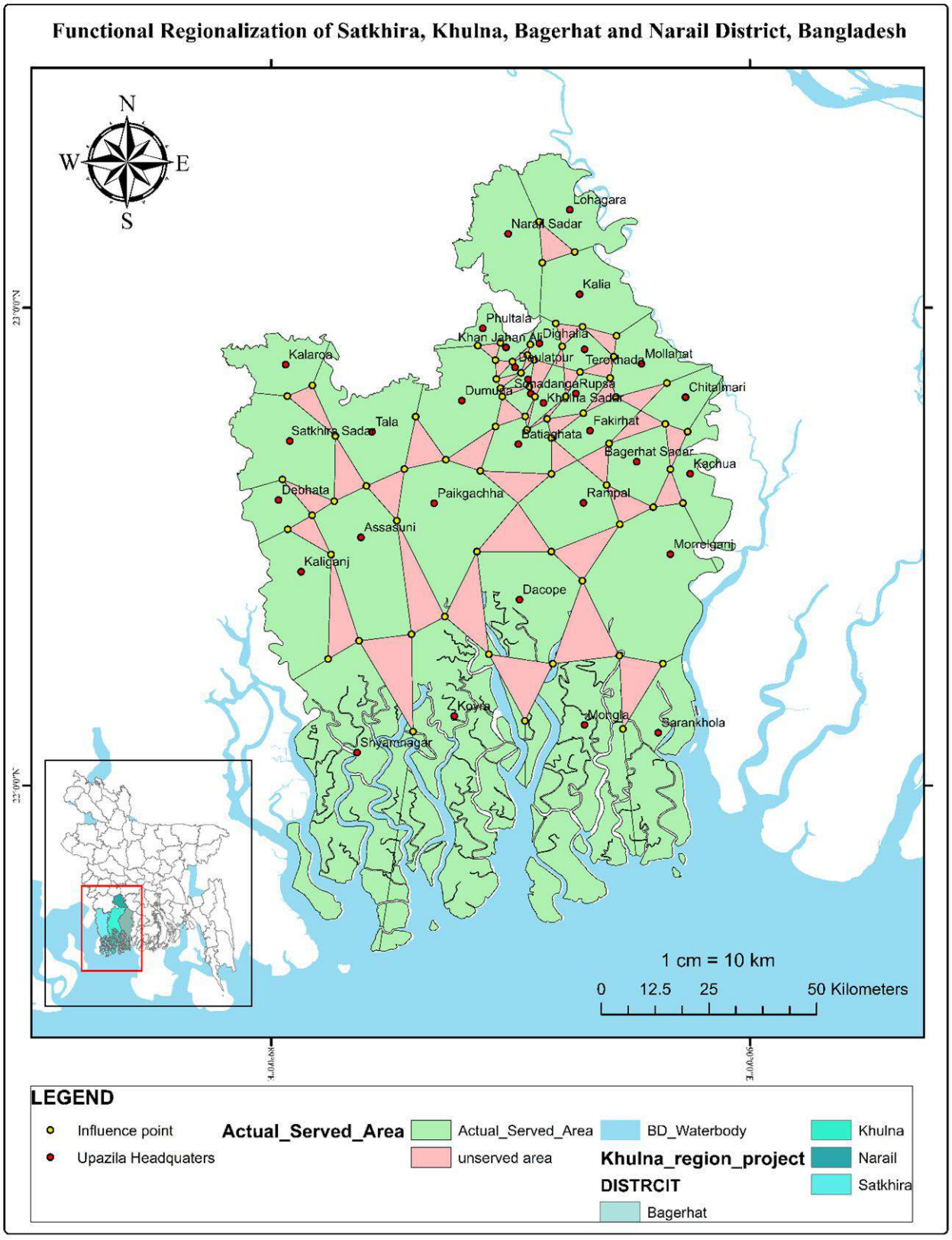


Figure 3-2: Functional Regionalization of Khulna, Satkhira, Bagerhat, and Narail

After the regionalization map preparation, the function gap is calculated to form a comparative analysis among the upazilas shown in **Table 3-2**.

Table 3-2: FG Analysis Upazila of the Regional Districts

District	Upazila	Population	Area	Ranking	Influence Area	Ranking
Satkhira	Assasuni	268754	378	11	467.66	7
	Debhata	125358	175.3	23	129.27	24
	Kalaroa	237992	232.8	19	205.18	18
	Kaliganj	274889	326.1	13	394.48	9
	Satkhira	460892	397.7	8	386.82	11
	Shyamnagar	318254	1543	1	954.92	2
	Tala	299820	334.9	12	365.54	12
Khulna	Batiaghata	172000	234.7	18	154.68	21
	Dacope	152000	784.5	4	424.53	8
	Dighalia	115000	77.16	27	54.46	29
	Dumuria	301000	456.1	6	324.77	13
	Khulna City	751003	12.37	32	57.60	28
	Koyra	194000	1254	3	1133.55	1
	Pakiagacha	248000	381.4	10	512.44	5
	Phultala	83000	56.42	28	68.76	25
	Rupsa	179000	119.6	26	64.46	27
	Sonadanga	167739	8.722	33	24.12	31
	Daulatpur	112442	14.86	30	13.77	33
	Khalispur	173255	12.5	31	17.44	32
	Khan Jahan Ali	36853	25.81	29	30.58	30
	Terokhada	117000	184	21	67.00	26
Bagerhat	Bagerhat	266000	310.4	15	184.20	20
	Kachua	97000	128.4	25	216.68	17
	Sarankhola	119000	680.1	5	477.11	6
	Chitalmari	139000	197.3	20	134.67	22
	Rampal	178503	278.5	17	272.91	16
	Morrelgonj	295003	443.8	7	684.05	4
	Mongla	137000	1276	2	924.46	3
	Mollahat	131000	176.5	22	203.21	19
	Fakirhat	138000	160.9	24	133.76	23
Narail	Kalia	220202	311.2	14	315.49	14
	Lohagara	228504	298.7	16	278.47	15
	Narail	272872	385.1	9	391.47	10

(Source: Author's Preparation, 2024)

In the detailed Analysis, it is found that Assasuni, Kaliganj, Tala, Khulna City, Pakiagacha, Phultala, Sonadanga, Khalispur, Khan Jahan Ali, Kachua, Morrelgonj, Mollahat, Kalia, and Narail upazilas have more IA than the geographical area. On the contrary, areas like Debhata, Kalaroa, Satkhira, Shyamnagar, Rampal, Batiaghata, Dacope, Dighalia, Dumuria, Koyra, Daulatpur, Terokhada, Bagerhat, Sarankhola, Chitalmari, Mongla, Fakirhat, and Lohagara have less IA.

Furthermore, as seen in Table 3-3, the changes in geographical ranking demonstrate the better-conditioned upazilas of the regions where areas like Lohagara, Khulna, Kaliganj, Mongla, and Fakirhat have a better influential rhythm in the industrial aspects. Considering their potentiality, Kaliganj from Satkhira and Fakirhat from Bagerhat are taken under the Upazila Masterplan Project by the Government of Bangladesh under the project of UTMIDP.

Table 3-3: Change in Geographical Ranking of Upazila

Change in Geographical Ranking	Upazilas
Upgraded	Assasuni, Kalaroa, Kaliganj, Rampal, Khulna City, Koyra, Pakiagacha, Phultala, Sonadanga, Kachua, Morrelgonj, Mongla, Mollahat, Fakirhat, Lohagara.
Remain in the same position.	Tala, Kalia.
Degraded	Debhata, Satkhira, Shyamnagar, Batiaghata, Dacope, Dighalia, Dumuria, Rupsa, Daulatpur, Khalispur, Khan Jahan Ali, Terokhada, Bagerhat, Sarankhola, Chitalmari, Narail.

Source: Author's Preparation, 2024

The comparative analysis among the districts in Table 3-4 shows that Narail has the lowest percentage of unserved areas for facility distribution. The newest railway and 6-lane road construction will surely change the region's population attraction, ultimately causing drastic growth in service areas.

Table 3-4: Comparison Among the Districts of the Southern Region

District	Area	Influence Area	Unserved Area	% Unserved
Khulna	3622.142	2948.16	673.98	18.61%
Satkhira	3666.3	3176.77	489.53	13.35%
Bagerhat	3373.4	2958.13	415.27	12.31%
Narail	995	985.42	9.58	0.96%

Source: Author's Preparation, 2024

The attributes and various characteristics delineate a proper view of the interconnectedness within the southern region. Bagerhat and Satkhira also have better conditions, covering the most influential areas. The different districts require different development strategies for better responsibilities and industrial growth.

Table 3-5: Upazila Attributes According to the IA

Classification According to Area	Upazilas
Highly Influential	Kaliganj, Assauni, Paikgacha, Dacop, Morrelganj, Sarankhola, Mongla, Koyra, Shyamnagar, Satkhira Sadar, Tala, Narail.
Moderately Influential	Debhata, Kalaroa, Dumuria, Batiaghata, Rampal, Fakirhat, Bagerhat Sadar, Kachua, Mollahat, Kalia, Lohagara.
Low Influential	Khan Jahan Ali, Phultala, Dighalia, Daulatpur, Sonadanga, Rupsha, Khulna Sadar, Tarekhoda.

Source: Author's Preparation, 2024

The map analysis describes the most influential areas from different districts: Koyra from Khulna, Mongla from Bagerhat, Shyamnagar from Satkhira, and Narail Sadar from Narail district. The coastal areas have the highest number of service areas. Having a colossal labour and industry force is a blessing for the growth of the southern region in Bangladesh. Mongla has one of the largest seaports in the country. Shyamnagar and Kaliganj have international boundaries with West Bengal that have a massive influence on the economic transition in the southern region.

The recent mega projects will quickly enhance the region's growth chances and service range. Recently, Narail Sadar, Mongla, and Khulna Bypass have been under construction, which will enhance the region's growth.

3.3. Detailed Classification of the Southern Region of Bangladesh

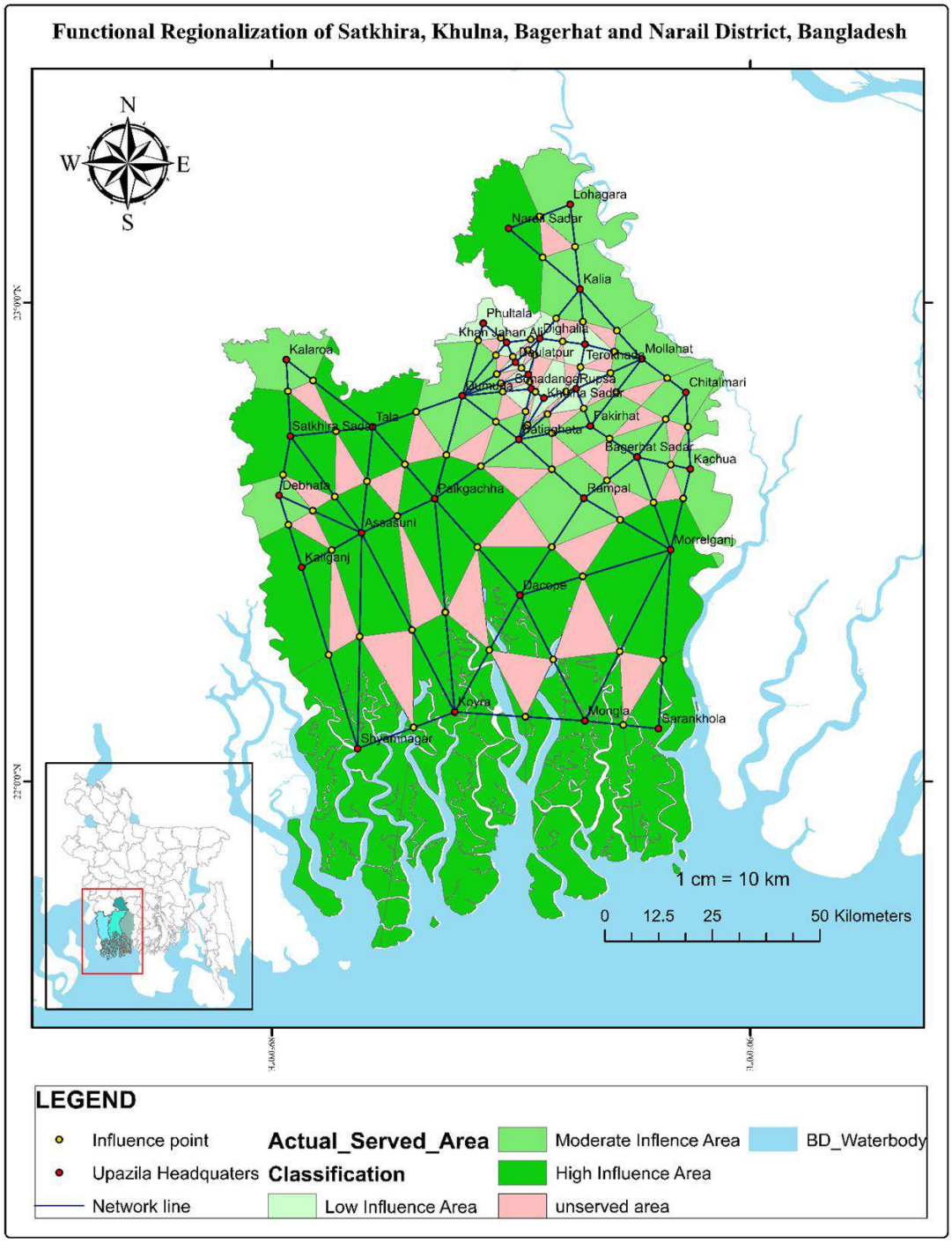


Figure 3-3: Classification of IA of the Upazilas

The classified map in **Figure 3-3** is prepared using the classification method shown in **Figure 3-2**. It describes major influential upazilas in the districts and lagging areas concerning industrial growth, as tabulated in **Table 3-5**.

3.4. Factor Selection and Analysis

A factor-based analysis is an effective method to delineate the regional impacts and the reasons behind the influential characteristics of a site. Industrial influence is more of an addition of different facilities and a trained population. After the map preparation, about six factors are considered to cross-check the function gap and identify suitable actions to deal with the gap based on the significant challenges faced in the industrial sector.

The industrial sector in Bangladesh is confronted with five primary obstacles, including inadequate infrastructure, lower labour costs, costly technology installation, insufficient government backing, and inadequate expertise (Islam et al., 2018).

Consequently, factors considered for the in-depth influence analysis are the number of industries, vocational institutions, and growth centers.

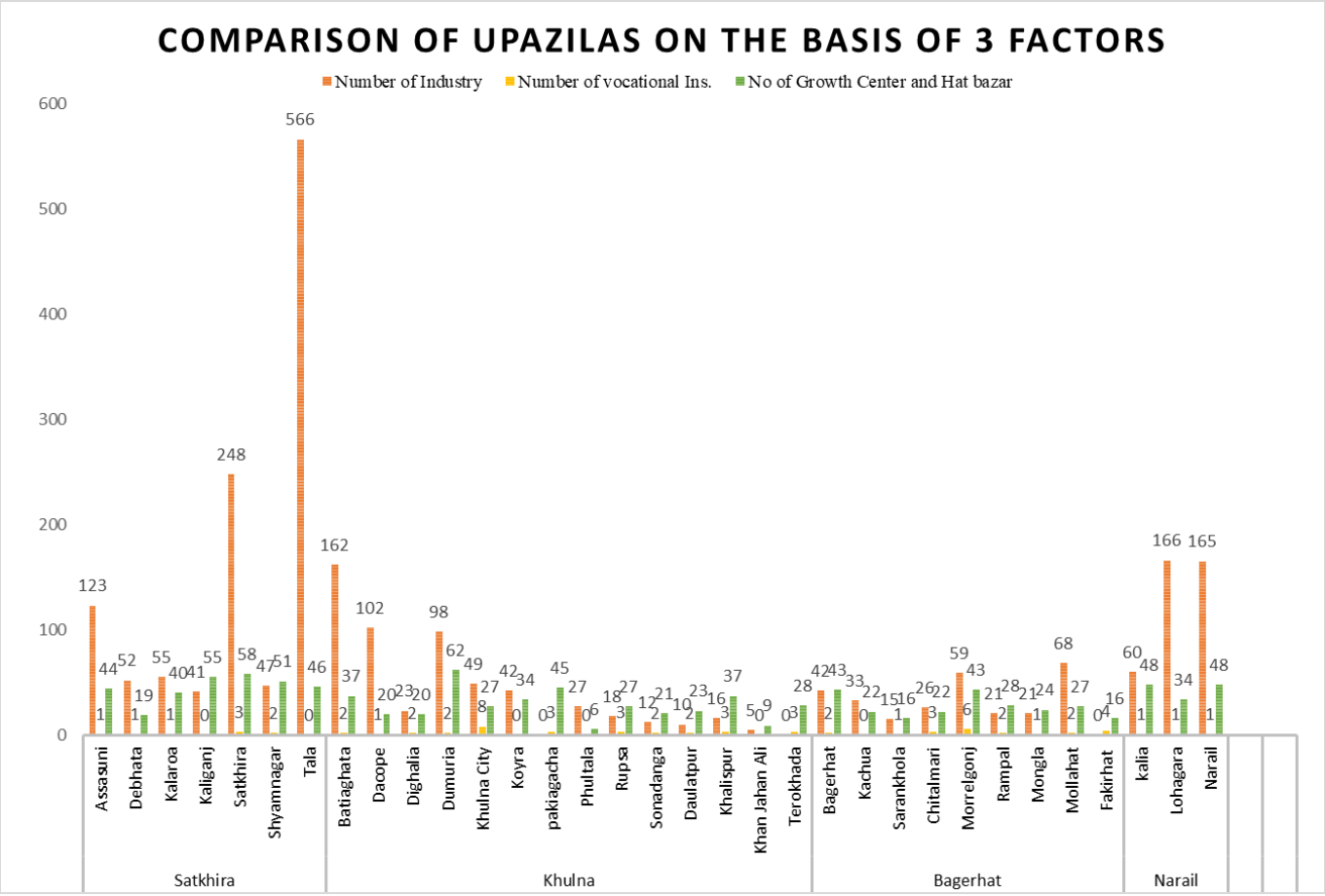


Figure 3-4: Comparison of Upazilas Based on No. Of Industry, Vocational Institutions, and Growth Center Factors

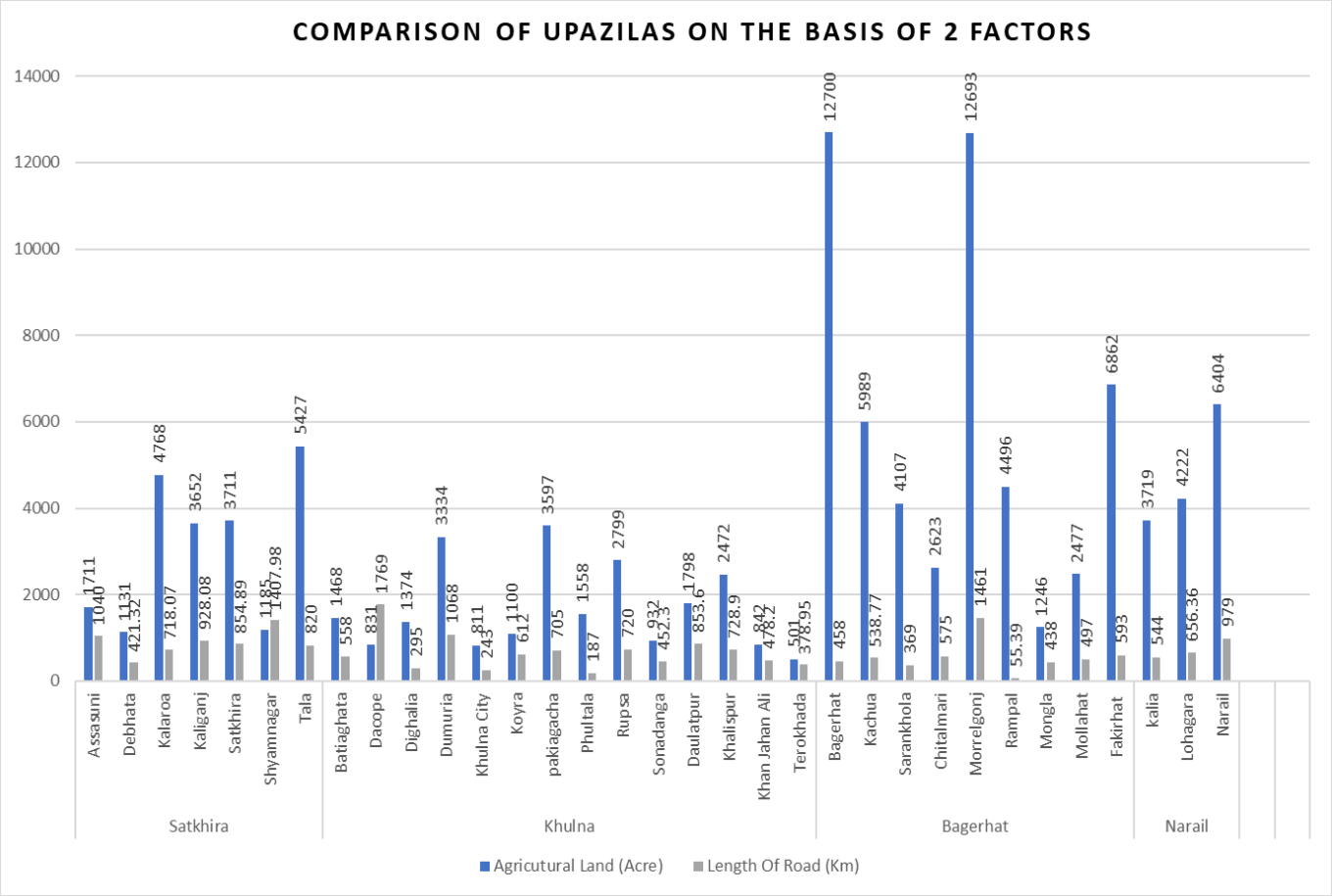


Figure 3-5: Comparison of Upazilas Based on Agricultural Land and Road Length Factors

The number of industries is analysed to rank the functional regions. In Satkhira district, Assauni, Satkhira Sadar, and Tala have the highest industries. Because of the land port with India and the sea connection, massive industries have grown for a long time. However, the condition of the Bagerhat district industry is relatively poor. The agricultural section is widely spread all over the Bagerhat district. So, the number of industries is lower in Bagerhat. Batiaghata, Dacope, and Dumuria have the highest number of industries because of the railway network nationwide. Batiaghata is considered the satellite town for Khulna City. So, a massive industrial sector has grown in the steel and iron fields. Narail is potentially a zone for EPZ after the construction of the Padma Bridge. So, industries such as garments, cargo services, and export offices are rapidly expanding.

The second factor is that vocational institutions significantly impact the creation of skilled labourers. According to the chart, Satkhira Sadar in Satkhira, Khulna City in Khulna, and Morrelganj in Bagerhat have the highest number of vocational institutions. Being the central city, vocational institutions are growing at a high rate.

The number of growth centers and hat bazaars significantly impacts the growth of industrialisation and the economy in the long run. The transportation scenario also impacts the number of growth centers. Kaliganj, Shyamnagar, Tala, and Assauni have the highest growth centers. “Assauni and Tala are in the top 2 in terms of industry factors”: Satkhira Sadar has a higher number of industries than Assauni. Because of their industrial impact, the number of markets has increased significantly. Dumuria and Pakiagacha have the highest number of growth centers, making these two upazilas in Khulna the most influential area. The number of growth centers has emerged because of the agricultural influence. From the factor analysis of raw material production, these two areas have the highest proportion of agricultural land. The market scenario in the Bagerhat district is relatively low despite being the prime fish distributor in the southern regions. In contrast to Satkhira and Khulna, shrimp production in the Bagerhat area has decreased dramatically between 2015 and 2017 (Karim et al., 2019). Only Bagerhat Sadar Upazila can handle such a large market. As a result, production is getting harmed. Kalia and Narail have the highest number of markets in the surrounding districts of Jessore and Faridpur.

The quantity of agricultural land vastly influences industrial growth and other factors, such as the market and labour force. Kalaroa, Kaliganj, and Tala have the highest amount of agricultural land for raw materials, which influences the upazila's market sector. Kalaroa and Tala in Satkhira, Dumuria and Paikgacha in Khulna, Bagerhat Sadar and Morrelganj in Bagerhat district, Lohagara, and Narail Sadar in Narail have the highest number. of the production field. That has made them the most influential areas in the southern regions. These places rank in the top 15 in the number of influential areas.

The development of transportation has increased, and with the development of industry, the transportation service has gotten better. Assauni and Shyamnagar have the highest road linkage in the Satkhira district. That helps Shyamnagar to attain the highest IA in the southern regions. Same for Paikgacha and Khalispur Upazila in Khulna District. Morrelganj in Bagerhat has the highest road network and the highest agricultural industry. That is the prime reason for their frontier ranking. In the Narail district, Narail Sadar holds a massive industrial connection with the surrounding boundary.

3.5. Service Comparison Among the Highest and Lowest Ranked Upazilas in the Region

The highest-ranked upazilas are more significant regarding facility integration and supply to more people. The comparative analysis helps to form a more significant growth strategy that requires different social aspects in the country.

Table 3-6: Service Comparison among The Highest Ranked Upazilas

Upazila	No of Growth Center& Hat Bazar	Agricultural Land	Number of Industries	Several vocational Ins.	Length Of Road(km2)
Shyamnagar	51	1185	47	2	1407
Koyra	34	1100	42	0	612
Mongla	24	1246	21	1	438
Narail Sadar	48	6404	165	1	979

Source: Author's Preparation, 2024

Table 3-6 indicates the highest rank of the upazila of the four districts. The number of growth centers and hat bazar, agricultural land, number of industries, number of vocational institutions, and length of the road are the crucial factors behind the ranking. Technological advancement, highly skilled activities or facilities, and the consideration of authorisation are key factors influencing the district's ranking. Shyamnagar has the highest number of growth markets, Vocational institutions, and road areas among the highest-ranked areas. That makes it the most influential part of the Southern economy. Narail Sadar holds the highest agricultural land and industry. The interdependence between these two factors enhances each other to grow the service range.

Table 3-7: Service Comparison among The Lowest Ranked Upazilas

Upazila	No of Growth Center & Hat Bazar	Agricultural Land	Number of Industries	Several vocational Ins.	Length Of Road
Debhata	19	1131	52	1	421
Sonadanga	21	932	12	2	452.3
Kachua	22	5989	33	0	538.77
Lohagara	34	4222	166	1	656.36

Source: Author's Preparation, 2024

The table shows the lowest rank of the upazilas. The district ranking affects the number of gr centers, road quality, industries, and less agricultural land. The ranking variation is the lack of consciousness of authorisation, limited institutional capacity, and less expertise-skilled institutions. Sonadanga, Kachua, and Lohagara are in better condition among the low-influential areas. Lohagara has the highest growth centers, industries, and road services. It clearly shows how influential the smallest district is in the southern part.

3.6. LISA/Moran's I Analysis

Influence Area (IA): The application of Moran's I determines the highly influential areas and the surrounding influence neighbours using Influence Area (IA) as an indicator. The analysis explains Bagerhat and Khulna as 'High-Low clusters (HL)' and Satkhira and Khulna as 'not significant'. It clearly describes that Khulna and Bagerhat have influence areas but are surrounded by lower influence neighbors.

Unserved area (UA): Moran's I identify unserved areas by following the unserved area (UA) indicator. The findings explain Khulna as a 'High-Low (HL) cluster,' and the others are considered 'not significant areas' by applying Moran's I. Khulna has a high unserved area among other districts, and its neighbours have lower unserved areas.

Number of Industries: The third indicator is the number of industries. The Moran's analysis finds Khulna as a ' Low-High cluster' and others considered as 'not significant'. So, Khulna has lower industrial concentration, and it is surrounded by higher industrial neighbors.

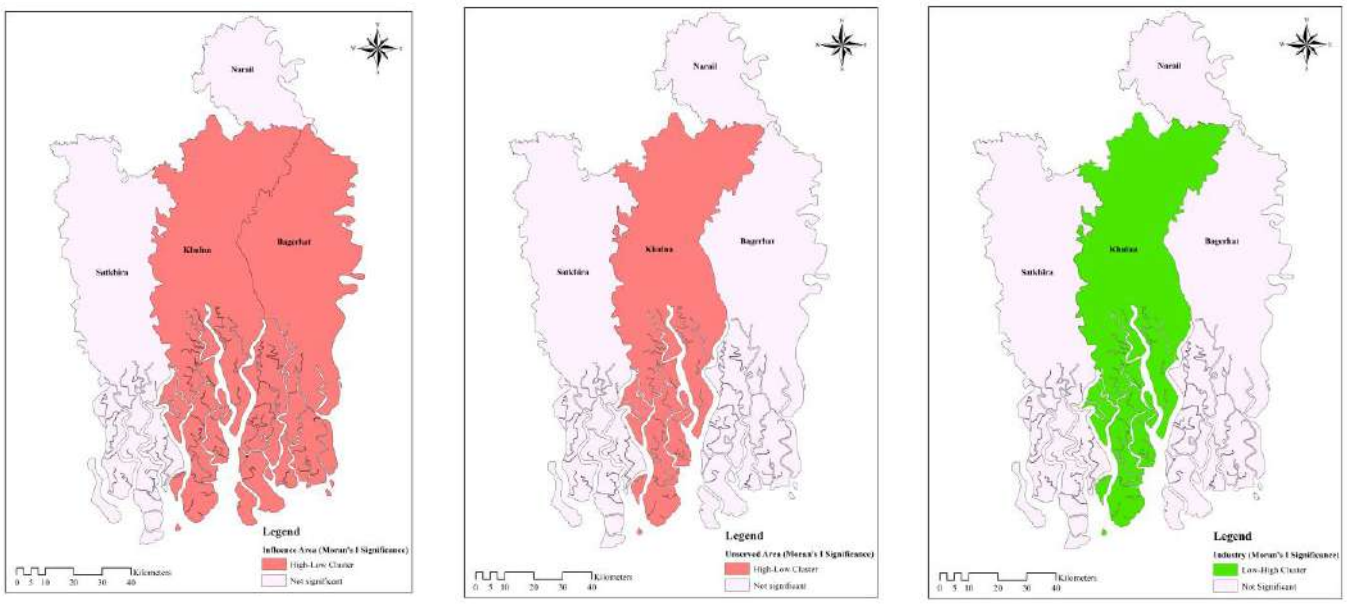


Figure 3-6: Moran's I significance (IA, UA and Industry)

Overall Findings: The LISA analysis expresses the absence of significant high-high clusters, indicating a lack of strong industrial independence within the southern region of Bangladesh. However, the high-low and low -high outliers suggest spatial imbalance and uneven development. Khulna has the highest influence area and unserved areas, but comparatively lower industrial concentration. The findings demonstrate weak surrounding linkage of Khulna, which reveals the disparity between functional importance and industrial development. On the other hand, Bagerhat shows localized dominance, but the surrounding areas are not equally developed, while Satkhira and Narail express weak clustering and no clear spatial pattern, indicating statistically insignificant patterns. Overall, the analysis suggests that the southern region is not concentrated in development; rather, it is fragmented in development, highlighting the particular policy to enhance industrial independence and balanced growth.

4. Recommendations

The significant recommendations for developing the industrial sector in the southern region incorporate variable-based development and initiating an upazila-based development framework. The factor-based strategic solutions are tabulated in **Table 4-1**.

Table 4-1: Factor-Based Development Strategic Actions

Variable	Supporting Facilities for achieving objectives	Strategic Action or relevant Organization
Number of industries	• Development of the employment sector. • Boosting the economy through production. • Expansion of industry reduces the spatial disparity between the low-low and low -high areas.	• International Labour Organization in Bangladesh (ILO) • Environment-Friendly Textiles and Garments.
Number of vocational institutions	• Entrepreneurial skills training in unserved areas reduced dependency on the core industrial zone as well as improving functional interdependence. • Reduce dependence on the paid job system.	• Bangladesh Technical Education Board (BTEB) • Registered Technical Training Center • Root Level (SSC) Vocational advertisement
Number of growth centers and hat bazars	• Existing facilities within a set boundary. • Try to set all facilities at the nearest distance to fulfil the demand and spatially distribute developed accessibility in unserved areas.	• Local Government Engineering Department (LGED). • Unauthorised construction is prohibited on such land. • We are not grabbing the government-owned khas land for the hat bazaar.
Agricultural land	• Suitable use of land and focused on crop production. • Protecting agricultural land enhances raw materials across regions and create linkage between Agro - based industries and industry regions, as well as strengthens interdependence.	• Upazila Agriculture Department • Monitoring land, increasing activities to protect agricultural land, and enforcing laws for vacant land
Transportation Network	• Improving road networks between high – low and low -high will reduce spatial isolation and enhance connectivity among industrial nodes. • Strengthen industrial independence and integrate unserved areas into the regional economy.	• LGED • RHD • Road width needs to be fixed according to local industrial demand. Frequently Renovation of Road (International et al. India- Bangladesh)

Recommendations supporting upazila development programs are differentiated between lower and higher influential areas. Low-influential upazilas require urgent improvement. Highly influential upazilas already have better facilities, but require sustainable resource allocation to ensure continued development. As a result, the recommendations differ based on the upazila's influence.

Low-influential upazilas have been selected for recommendations as they need to improve badly. The ranking is based on transportation networks, the number of industries, vocational institutions, agricultural land, and growth centres or hat bazaars.

These suggestions aim to improve accessibility in underserved areas and promote industrial interdependence in order to overcome the spatial imbalance found by LISA research. The study's goal of creating a more connected and balanced regional economic structure is supported by the emphasis on connectivity, decentralized development, and functional linkages.

1. Road Network: Local-level planning, project preparation, maintenance, monitoring, road safety plan, and Speed limitation plan in high-risk areas.
2. Industries: PPP involvement, renowned local production industry innovation, fostering international growth, and investing in the research and development sector.
3. Agricultural land: Data entry of land at the local level, khas land identification, Registered land monitoring, and sustainable use of land.
4. Vocational Institutions: Understanding the importance of technical works, root-level advertisement, Government bodies' influence, and strong involvement of organizations.
5. Hat Bazar / Growth Center: Identify the boundary, set all priorities, and locate facilities at the nearest distance. Digital services are available.

The highly influential upazilas have already been improved, but need sustainable recommendations.

1. Environment-friendly industry: The recycling and Reuse process, proper use of natural raw materials, and cottage industry innovation.
2. Fixed Route Network: Route Rationalization, Limitation of Heavy Vehicle Numbers.

The southern region has a high potential for growth in the coming years, with proper planning for individual upazilas, better comprehensive planning, and overall economic growth.

7. Conclusion

Bangladesh is guiding us towards an industrial revolution. With a comprehensive assessment and spatial correlation analysis, the study explicitly distinguishes interdependence and spatial service equity across the southern region of Bangladesh. The research outcomes collectively reveal that the southern region remains a fragmented rather than an agglomerated pattern of industrial development, as evidenced by the LISA analysis. Influence area analysis confirms pronounced intra-regional heterogeneity at Koyra and Shyamnagar, which emerge as the most functionally dominant upazilas owing to their vast territorial catchments, dense transport networks, and proximity to international border zones, while Daulatpur records the lowest influence area, reflecting structural deficiencies in connectivity and economic infrastructure. The multi-factor analysis further reveals that transport network density, vocational institution availability, growth center accessibility, and agricultural land productivity jointly determine the spatial hierarchy of industrial influence. At the district level, Khulna's elevated unserved area (18.61%) demonstrates a critical planning gap between administrative and functional service delivery. Additionally, the LISA-identified low-high cluster status of Khulna with respect to industrial concentration reveals structural decoupling between functional urban growth and productive industrial capacity. High land costs, institutional fragmentation, and the absence of a coherent national land policy cumulatively continue to suppress industrial investment despite Khulna's logistical centrality within the region. These findings carry substantive implications for policy: spatially targeted interventions focusing on road network densification, decentralized vocational training, agro-industrial linkage development, and proactive land-use planning along the Padma Bridge and Mongla Port corridors are urgently required to convert the region's latent geographical and infrastructural endowments into sustained industrial growth and to reduce the spatial disparities that currently impede cohesive regional economic integration. While the reliance on 2011 Bangladesh Bureau of Statistics data introduces temporal constraints, the methodological framework combines composite index construction, gravitational delineation of functional regions, and local spatial autocorrelation analysis, helping to constitute a replicable and scalable contribution to the empirical study of regional industrial geography in developing-country contexts. Future research should incorporate updated census data, network-based accessibility models, and formal subnational input-output tables to further refine the quantification of industrial interdependence, while extending the spatial scope to include the functionally linked districts of Jessore, Pirojpur, Barguna, and so on. Ultimately, the research outlines the need for coordinated spatial governance and alignment with the Sustainable Development Goals (SDGs) for achieving spatially balanced and industrially integrated development in southern Bangladesh.

Declarations

Author(s) Contributions

Shams Nur Islam Badhon: Formal Regionalization Methodology & Analysis, Software, LISA Analysis, Recommendation, Writing –Original Draft. Rowdra Dip Chackroborty: Conceptualization, Functional analysis, Writing – Original Draft, Methodology, Software, Data Curation, Visualization.

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Conflict of Interest

The author declares no conflict of interest related to this research work.

Competing Interest

The authors declare no competing interests.

Data Availability Statement

The data will be provided upon request.

References

Anselin, L. (2010). Local Indicators of Spatial Association—LISA. Geographical Analysis, 27, 93-115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x.

Bangladesh Bureau of Statistics (BBS). (2011). Statistical Yearbook of Bangladesh, Dhaka: BBS.

Alkaabi, N. M. R. N. (2024). Socio-political aspects in framing narratives of conflict (Version 1). *University of Leicester*. https://doi.org/10.25392/leicester.data.25061255.v1.

Chackroborty, R. D., Badhon, S. N. I., Das, A., & Roy, S. (2024, February 25). Assessment of economic extension of the southern region, Bangladesh: A comparative analysis through short run and long run approach. *Journal of South Asian Exchanges 1.1*. https://saexchanges.com/v1n1/v1n109.pdf.

Fan, J., & Li, P. (2009). The scientific foundation of major function-oriented zoning in China. *Journal of Geographical Sciences*, 19, 515–531. https://doi.org/10.1007/s11442-009-0515-0.

Islam, A. S., Bala, S. K., Hussain, M. A., Hossain, M. A., & Rahman, M. M. (2011, August). Performance of coastal structures during cyclone Sidr. *Natural Hazards Review*, *12*(3), 111–116. https://doi.org/10.1061/(ASCE)nh.1527-6996.0000031.

Islam, M., Jantan, A., Hashim, H., Chong, C., Abdullah, M., & Hamid, A. (2018). Fourth industrial revolution in developing countries: A case on Bangladesh. *HEN: Mid/Trans East (Topic)*.

Karim, M., Zhang, X., & Li, R. (2019). Dynamics of shrimp farming in the southwestern coastal districts of Bangladesh using a shrimp yield dataset (SYD) and landsat satellite Archives. *Sustainability*. https://doi.org/10.3390/SU11174635.

Lutfa, N., & Shanto, R. (2023). Foreign policy of Bangladesh towards India-China tussle: A neoclassical realist analysis. *NUST Journal of International Peace & Stability*. https://doi.org/10.37540/njips.vi.138.

Mallick, F., Naqi, M., Islam, A., & Hakim, S. (2022). User point perspective as a process for urban (re)development: The case of riverfront CBD in Khulna City.*Khulna University Studies.* https://doi.org/10.53808/kus.2008.9.1.0707-e.

Manik, M. (2023). Movement of the economy of Bangladesh with its sector-wise contribution and growth rate. *Journal of Production, Operations Management and Economics*. https://doi.org/10.55529/jpome.32.1.8.

Sayedur, R. M., Masum, M., Ullah, M. S., Ishiro, T., & Kazuo, I. (2026). Structural dependence of the textile and clothing industry in Bangladesh: a comparative input–output analysis with Vietnam and Pakistan. Journal of Economic Structures. https://doi.org/10.1186/s40008-026-00376-7

Tao, R., & Chen, Y. (2022). Applying Local Indicators of Spatial Association to Analyze Longitudinal Data: The Absolute Perspective. *Geographical Analysis*. https://doi.org/10.1111/gean.12323.