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Regional Disparities in Educational Facilities: Evidence from a Developing Country

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Research Article

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Abstract

Purpose. This study examines how schools and colleges are distributed geographically throughout the district and pinpoints the causes, including socioeconomic circumstances, population density, transit systems, and governmental regulations.

Methods. This study uses Geographic Information System (GIS) tools and descriptive statistical methods to investigate regional differences in the distribution of educational facilities in developing country Bangladesh's Narsingdi District.

Results/findings. The results show notable disparities in educational access, especially in isolated and rural sub-districts.

Conclusion. In order to address these disparities, the study suggests policy interventions such as better transport, more infrastructure investment, and the opening of new educational facilities in underprivileged areas. In order to guarantee a more equitable distribution of educational resources throughout the district, it also highlights the necessity of community involvement and public-private partnerships.

1. Introduction

The just allocation of education resources is crucial for social progress as well as for providing equal access to education of appropriate quality in all areas. As Isard (1960) pointed out, regional geography is important for understanding the differences in regions and for implementing policies aimed at achieving equity. In the context of Bangladesh, which is undergoing rapid urbanization and socio-economic stratification, the inequitable distribution of educational resources is a chronic problem (Abbassi et al., 2020; Greco et al., 2018). These inequities not only stunt personal and socio-economic development but also hinder more comprehensive regional development objectives (Pasha, 1991; Mazumder & Tamima, 2006). Thus, it is important to analyze the socio-economic and spatial factors underpinning the distribution of educational facilities to formulate appropriate policies to foster balanced regional development (Ding et al., 2018; Doni et al., 2020). It has been established that gaps in the provision of educational facilities stem from socio-economic, infrastructural, and demographic factors (Demirgüç-Kunt, et al., 2018). For example, resource allocation tends to be greater in areas with high population concentration, existing transport infrastructure, and economic activity (Ohlan, 2013; Narain et al., 2000; Thomas, et al., 2021).

On the other hand, rural and remote regions are often underserved, which deepens socio-economic disparities and restricts educational access for marginalized groups (Mitrică et al., 2017; Friedman et al., 2020). These inequities are worse in developing nations such as Bangladesh, which faces serious obstacles in attaining universal education due to uneven distribution of resources (Guo et al., 2020; Xiang et al., 2023). The socio-economic and geographic diversity of Bangladesh adds to the challenges of equitable allocation of educational resources. While the government has made attempts to improve access, there remains disproportionate service availability for schools and colleges in the rural and underserved regions (Pasha, 1991; BSS, 2002; Haak et al., 2020; World Bank, 2020). The Narsingdi district, which is in close proximity to Dhaka city, illustrates such conditions well. It is an interesting case for studies of spatial inequality due to its strategic importance and potential for industrial development, in which growth often benefits some regions while bypassing others (Mazumder & Tamima, 2006; Koo & Lee, 2015). Studying the distribution of educational resources in Narsingdi can reveal some of the persistent regional inequalities that characterize Bangladesh.

Fair allocation of educational establishments is essential for inclusive development and for minimizing socio-economic differences in developing states. Although there are many policy efforts, discrepancies in the physical and socioeconomic accessibility of schools and colleges persist, especially in areas characterized by socioeconomic and infrastructure difficulties. Past studies also show that resource allocation is typically skewed towards cities and populated areas, while rural and remote regions are often ignored, thereby increasing discrepancies in access to education across regions (Abbassi et al., 2020; Greco et al., 2018; Zannat & Mortoja, 2010). The uneven distribution of education infrastructure has been illuminated using spatial analysis tools, including GIS, Location Quotient, and nearest-neighbor analysis, which have helped identify clusters and gaps in education infrastructure (Dong & Liang, 2014; Hasugian et al., 2020; Mitricica et al., 2017). Nevertheless, the current research tends to be conducted at macro-levels or in certain regions, and thus there is a gap in micro-level, district-based research that fully incorporates socio-economic factors.

The proposed research will address this gap by offering a detailed spatial and socio-economic scenario of educational facilities distribution in the Narsingdi District, Bangladesh- a region that is representative of disparities in the region since it is close to Dhaka and has a diverse socio-economic profile. The research aims to target underserved sub-districts by using GIS and more sophisticated spatial statistics to determine which socio-economic variables affect the placement of

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facilities and present policy-specific interventions. The importance of the proposed study is that it may be used to inform policy-making and planning at the district level to ensure equal access to high-quality education, which will in turn lead to the overall development of the region and social justice.

The research questions that will inform this study are as follows: RQ1: Which sub-districts in Narsingdi District have a lack of educational facilities? RQ2: The spatial distribution of these facilities, are they clustering or dispersed? RQ3: Which socio-economic and infrastructural conditions are related to the patterns of distribution observed? The answers to these questions will help in identifying evidence-based solutions to the problem of disparities in the region and the need to develop educational processes in Bangladesh sustainably and without discrimination.

In summary, the existence of regional discrepancies in educational facilities is a key aspect to be addressed in terms of promoting inclusive growth, diminishing socio-economic disparities, and attaining sustainable development in Bangladesh. This paper adds to the current literature by providing an in-depth analysis of the distribution of educational facilities in Narsingdi District, pinpointing areas of failure, and suggesting prescriptions for a fairer distribution of the facilities. Above all, the idea of making quality education accessible to every child in Bangladesh, irrespective of geographical settings, is central in terms of the national development agenda.

2. Literature Review

The distribution of educational and socio-economic systems has been researched a great deal to describe regional disparities and provide development policy (Isard, 1960; Mazumder & Tamima, 2006; Zhang et al., 2015). In Bangladesh context, some studies have reported having unequal distribution of the social infrastructure such as education and health facilities (Zhang et al., 2023, Zhu & Peyrache, 2017, which were often lined with socio-economic variables such as population density (Zhang et al., 2015; Liao et al., 2012), accessibility and economic activity (Bahauddin, 1989; Pasha, 1991). Bahauddin (1989) and Majumder et al. (2023) presented regional renewal challenges on physical infrastructure development, mentioning that the rural and remote regions have poor infrastructure facilities, making development hard to achieve (Rao et al., 2016; Su et al., 2018). The same uneven allocation of health facilities is evident by Pasha (1991) as he indicates the relevance of geographic considerations in planning (Lien, 2019). A study by Zannat and Mortoja (2010) investigated regional imbalances in socio-economic facilities in the district of Narsingdi through spatial analysis.

Education and socio-economic systems have been examined extensively to be able to comprehend regional differences and make development policy (Isard, 1960; Mazumder and Tamima, 2006; Zhang et al., 2015). At the core of this literature is the fact that spatial inequalities are based on multi-layered processes between geographic, socio-economic, infrastructural, and political dynamics. The theoretical contribution of Peter Dunleavy on the distribution of collective consumption goods is useful in understanding why socio-economic and political priorities will tend to make collective consumption goods cluster together in specific areas (Dunleavy, 1981). Dunleavy claimed that collective goods are frequently distributed unevenly, with more allocated to geographical areas that are more economically powerful, politically engaged, or strategically valuable, thereby solidifying inequalities between spaces. This view corresponds with the modern studies that show that regional capacities, governance, and infrastructural development determine resource allocation, with the impact of processes of urbanization being more significant.

The urbanization literature provides the essential information about how urbanization and rural-to-urban migration underlie the spatial inequalities in service accessibility, including education, in the global context (Petrakos, 2001; Ding et al., 2018). The urban centers are more likely to receive disproportional amounts of the infrastructural investments, which creates an

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agglomeration effect contributing to the regional inequalities (Toufique & Zaman, 2005; Liu et al., 2020). On the other hand, in rural and peripheral areas, services are typically inadequate, which contributes to the expansion of socio-economic disparities and inhibits the development of the region (Xiang et al., 2023; Zhang et al., 2024). The dynamics are more specifically strong in the developing world, where urbanization is at a very fast pace but mostly uneven, leading to spatial misbalances that affect the quality and access to education.

The use of spatial analysis tools in international studies that include the Location Quotient (LQ), Average Nearest Neighbor (ANN), and standard deviational ellipses has been helpful in the identification of patterns of clustering, gaps, and trends in the distribution of facilities (Dong and Liang, 2014; Mitricia et al., 2017; Hasugian et al., 2020). These methods are based on the theories of regional science, which underline the idea that the existence of spatial differences is not accidental, but the result of socio-economic and infrastructural factors. To illustrate this, the theory put forward by Dunleavy indicates that endogenous regional capacities create resource concentration in some areas that are strengthened by the cumulative processes of causation with the passage of time (Perrons, 2010).

Within the framework of South Asia and Bangladesh in particular, it has consistently been demonstrated that population density, accessibility, economic activity, and governance affect disparities in the educational infrastructure (Zannat & Mortoja, 2010; Guo et al., 2020). Research has shown that population density and improved transportation infrastructure have a higher propensity to attract more educational institutions (Ohlan, 2013; Rao & Ye, 2016). Nevertheless, rural and remote communities are under-resourced, thereby continuing to generate socio-economic disparities and restricting opportunities for marginalized communities (Friedman et al., 2020; Xiang et al., 2023). This trend reflects the claim of Dunleavy that collective goods have a tendency to be unevenly allocated because of regional capabilities and politics, particularly in developing countries.

Moreover, literature on urbanization emphasizes that the spatial concentration of services is commonly caused by the agglomeration economies of cities, which bring investments and skilled labor, which only increases the differences between urban and rural areas (Pasha, 1991; Koo & Lee, 2015). Hypothetical explanations like the New Economic Geography expound on the effects that transportation expenses, economies of scale, and market reach have on the geographical distribution of infrastructure (Fujita et al., 1999). The models are applicable in the particular case of Bangladesh, where the fast process of urbanization in the region of Dhaka and other big cities has given rise to the unequal distribution of educational resources, and rural and peri-urban regions are falling behind.

The application of empirical research on space supports the nature of the integration of quantitative tools with qualitative knowledge to mitigate inequalities that are experienced in the region (Mitricica et al., 2017; Liu et al., 2020). They suggest combined methods based on taking socio-economic variables, infrastructure capacity, and involvement of the community (Perrons, 2010). Those frameworks follow the view of Dunleavy that inequalities in resource distribution can only be solved by comprehending the structural processes that can consolidate spatial inequalities, such as governance, economic development, and patterns of urbanization.

Overall, the theoretical basis for analyzing spatial differences in educational amenities can be significantly enriched by Dunleavy's work on collective consumption goods, which focuses on the uneven distribution of these amenities under the influence of socio-economic and political factors. This approach, together with studies of urbanization theories and the application of spatial analysis, provides a comprehensive picture of regional inequalities. Using such views, with Bangladesh and Narsingdi District, in particular, as examples, it is possible to conduct a careful analysis of the impact

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of urbanization and infrastructure development on educational access and to provide valuable recommendations on how policy interventions can be implemented to promote balanced growth in the region.

Prior research indicates that the allocation of educational infrastructure is influenced by socio-economic factors, geographic accessibility, population density, and political decisions (Parveen, 1984; Zannat & Mortoja, 2010). For instance, regions with higher population density usually require more schools, but actual supply is determined by local governance, infrastructure capacity, and community engagement. Furthermore, spatial analysis tools like Location Quotient (LQ), Average Nearest Neighbor (ANN), and other spatial distribution methods have been applied to uncover clusters, gaps, and trends in the distribution of facilities (Dong & Liang, 2014; Mitrică et al., 2017; Hasugian et al., 2020). These approaches assist both researchers and policymakers in conceptualizing the gaps and inequities that can then be addressed in focused development initiatives.

The literature concurs that localized inequalities in educational infrastructure support the interplay among geographic, socioeconomic, and infrastructural issues. To address these inequalities, it is imperative to develop interventions that use spatial analysis applications, involve community participation, and initiate policy changes to ensure the equitable distribution of resources (Perrons, 2010; Mitrică et al., 2017).

3. Methodology

3.1. Study Area and Data Collection

The locality considered in this research is Narsingdi District, which was chosen for its proximity to Dhaka and its high industrial potential. The strategic position of Narsingdi offers the opportunity to decongest Dhaka to some extent by providing a planned dissection of socio-economic facilities. With more facilities and methods for connecting to them, Narsingdi would be able to promote regional development and deter the over-centralization of facilities in Dhaka. To determine the areas of deficiency and the reasons behind these aspects, the research considers four major sets of social-economic amenities: the primary institutions, the high schools, the colleges, and the Hats and Bazars. The three earlier categories are encompassed by education as part of social infrastructure, whereas Hats and Bazars are essential in economic activities. These facilities have been selected because they represent a resource for socio-economic development and accessibility within the district. The research evaluates the location of such facilities in 6 Sub-districts of Narsingdi, so that the facilities selected and analyzed would affect coverage of the socio-economic facilities in the area.

3.2. Data Sources and reliability

The secondary data were collected mainly from credible and authoritative sources, such as Banglapedia (Bangladesh Asiatic Society, 2004) and the Bangladesh Bureau of Statistics (BBS, 2002). Banglapedia is considered a reliable source of encyclopedic information compiled by professionals and scholars and provides verified information on Bangladesh's geography, demographics, and infrastructure. Nevertheless, because of the possibility of outdated or incomplete data, the cross-verification process used local government reports and missing field observations to increase data validity. Bureaucratic sources were used to obtain spatial data, such as district maps, which are under the local government engineering department (LGED) and provide official, recent geographic data for spatial analysis.

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Table 1. Distribution across the study area

Name of Facility	No. of Facilities	Mean + 1 SD	Percentage (%)
Primary School	518	301	58.11
High School	121	73	60.33
College	16	10	62.50
Hats and Bazars	27	15	55.56

Source: Local Government Engineering Department of Bangladesh

3.3. Field Survey and Data Collection Instruments

A structured field survey was conducted in four selected sub-districts, namely Raipura, Palash, Belabo, and Narsingdi Centre, to validate secondary data and collect up-to-date, accurate geo-spatial data on educational and socio-economic facilities. The survey used GPS devices to map the facilities correctly, ensuring reliable spatial data. The qualitative data were to be collected using a standardized questionnaire on facility capacity, accessibility, infrastructure quality, and operational status. A pilot survey was conducted to pre-test the field survey instrument to make it clear, consistent, and reliable. Enumerators were also trained to standardize data collection procedures and reduce interviewer bias and measurement error. The consistency of the survey tool was evaluated using test-retest and inter-rater reliability tests conducted in the pilot trial, and the scores obtained were high (Cronbach's alpha> 0.8).

3.4. Sampling Technique

Four sub-districts were selected using a purposive sampling method, and a detailed field investigation was conducted in these areas due to suspected disparities identified after analyzing secondary data. In these sub-districts, a list of facilities, which included schools, colleges, Hats, and Bazars, was obtained from secondary sources, and a stratified random sampling method was used to select certain facilities for on-site verification. This design ensured representativeness across the various types and geographic locations of facilities in the sub-districts, enabling extensive validation of the secondary data and possible spatial variations.

After analyzing these data sources, a field survey was conducted in four Sub-districts (Raipura, Palash, Belabo, and Narsingdi Centre) to validate the findings and ensure the accuracy of the analysis.

The secondary data sources were comprehensive and included:

i) Socio-economic data, as well as facility inventories and population figures, were acquired from Banglapedia (Bangladesh Asiatic Society, 2004) and the Bangladesh Bureau of Statistics (BBS, 2002).

ii) Spatial data, including maps of Narsingdi District, were obtained from Local Government Engineering Department (LGED).

iii) Field surveys from the four selected Sub-districts also provided qualitative data, which included primary data on the facility's geo-spatial coordinates, capacity, and accessibility to cross-validate the secondary data and the reliability of the analysis.

3.5. Analytical Framework

An analysis of the district's socio-economic aspects, such as population strength, population density, literacy rate, and transportation infrastructure, as well as the spatial patronage of

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educational institutions, has been conducted. Tools such as the Location Quotient can be used to evaluate the concentration of facilities relative to population, and computational methods, such as spatial analysis tools (ANN) or standard distance measurements, can be used to visualize clustering and dispersion. These procedures are essential in the discovery of root causes of inequalities and in the development of targeted policy initiatives. The study fits within the broader development agendas, such as the call for universal primary education and even for equitable growth at the regional level in Bangladesh (Bangladesh Development Strategy, 2011; Jose, 2019; Kumari & Barman, 2021). Policymakers should be aware of the spatial patterns of educational infrastructure to address inequalities. The results in Narsingdi District provide a microcosm of the needs for interventions appropriate to other districts within Bangladesh, taking into account the local socio-economic conditions.

The study employed a combination of descriptive statistics, spatial analysis techniques, and geographic information systems (GIS) tools to comprehensively assess regional disparities. The core analytical methods included:

3.5.1. Location Quotient (LQ) Method

The Location Quotient (LQ) is a widely used tool in location analysis, providing an index to compare an area's share of a particular activity or facility with its share of some broader phenomenon (such as population or regional economy). In this study, the LQ is used to assess the concentration or dispersion of socio-economic facilities across the Sub-districts of Narsingdi District.

The LQ is calculated by comparing the proportion of each facility in a specific Sub-district to the overall proportion of that facility in the district. The formula for LQ is:

LQ=(Ei/Pi)(Et/Pt)LQ = \frac{(E_i / P_i)}{(E_t / P_t)}LQ=(Et/Pt)(Ei/Pi)

Where:

- EiE_iEi is the number of facilities in the Sub-district,
- PiP_iPi is the population of the Sub-district,
- EtE_tEt is the total number of facilities in the district,
- PtP_tPt is the total population of the district.

An LQ value can be interpreted as follows:

- LQ < 1.00 indicates that the area is underserved, meaning it does not meet the local demand for the specific facility.
- LQ = 1.00 suggests that the area meets the local demand for the facility.
- LQ > 1.00 means the area exceeds the local demand for the facility, indicating a higher concentration than expected.

For the purposes of this study, the Sub-districts are categorized based on their LQ values:

- LQ > 1.5: Highly served Sub-districts with an excess of facilities.
- LQ = 1.0 to 1.5: Well-served Sub-districts, with facilities that are considered self-sufficient.
- LQ < 1.0: Underserved Sub-districts, facing a shortage of essential facilities.

3.5.2. Mean and Standard Deviation Analysis

To further assess the deficiencies in socio-economic facilities, the study uses the Mean and Standard Deviation (SD) technique. This method helps classify the facilities in each Sub-district, allowing for a clearer understanding of which areas are most deficient in certain services.

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The mean X¯\bar{X}X¯ is calculated as:

X¯=∑XN\bar{X} = \frac{\sum X}{N}X¯=N∑X

Where XXX is the value of each socio-economic facility in an Sub-district and NNN is the number of Sub-districts being analyzed.

The standard deviation σ\sigmaσ is calculated using the formula:

σ=∑(X−X¯)2N\sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{N}}σ=N∑(X−X¯)2

This helps to classify Sub-districts based on their relative deficiency or abundance of socio-economic facilities. Areas with higher deviations from the mean may indicate greater imbalances or greater needs for improvement.

3.5.3. Average Nearest Neighbor Analysis

The Average Nearest Neighbor (ANN) analysis is used to evaluate the spatial distribution of socio-economic facilities within the district. This analysis calculates the average distance between each facility and its nearest neighbor, comparing the observed distances with those expected under a random distribution.

The formula for the ANN index is:

ANN=Observed DistanceExpected Distance\text{ANN} = \frac{\text{Observed Distance}}{\text{Expected Distance}}ANN=Expected DistanceObserved Distance

Where:

- A value of **ANN < 1** indicates clustering, suggesting that facilities are grouped together in certain areas.
- A value of **ANN > 1** indicates dispersion, suggesting that facilities are spread out across the region.

This analysis helps identify whether facilities are concentrated in specific regions or if their distribution is more evenly spread across the Sub-districts.

3.5.6. Directional Distribution (Standard Deviational Ellipse)

The Standard Deviational Ellipse method is used to assess whether the distribution of socio-economic facilities follows a directional trend. This method calculates the orientation and extent of the distribution by considering the spread of the facilities in relation to a central point (e.g., the town center).

The standard deviational ellipse helps identify whether facilities are distributed in a particular direction, such as being more concentrated to the north, south, or other directions relative to the district's center. This analysis provides further insights into the spatial dynamics and regional imbalances.

3.5.7. Standard Distance (Mean + 1 SD)

Standard distance is another critical measure used in this research to analyze the degree of concentration or dispersion of socio-economic facilities around central points in the district. By calculating the standard distance, the study evaluates how far facilities are from their geographic centers or centroids, providing insights into how well-distributed or clustered the facilities are.

This method gives a single summary measure that describes the degree of concentration of socio-economic facilities within the district, offering helpful information for understanding the extent of imbalances and the distribution patterns of key services.

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This comprehensive methodology combining statistical analysis and spatial tools allows for a detailed assessment of the regional imbalances in the distribution of socio-economic facilities in Narsingdi District. The combination of secondary data, field surveys, and advanced analytical methods enables the identification of deficiencies and provides a clear understanding of the factors contributing to these imbalances, thereby offering valuable insights for future policy planning and development initiatives.

3.6. Software and Tools

For data processing and statistical analysis, SPSS and MS Excel were utilized, and spatial analysis and mapping were conducted using ArcGIS. These tools helped in providing exact recognition of spatial patterns and performing statistical validation.

4. Analysis of Results

4.1. Primary Schools

The number of primary schools in Narsingdi District is 755, and the highest proportion of these establishments belongs to Narsingdi Centre Sub-district. To determine the level of concentration and distribution of the primary schools, Location Quotient (LQ) was used. The results showed that Raipura and Palash Sub-districts were in the underserved region using the LQ values with respect to population, area, and density. This is compared to the Narsingdi Centre Sub-district, which is highly served with high population concentration in primary schools (Figure 1).

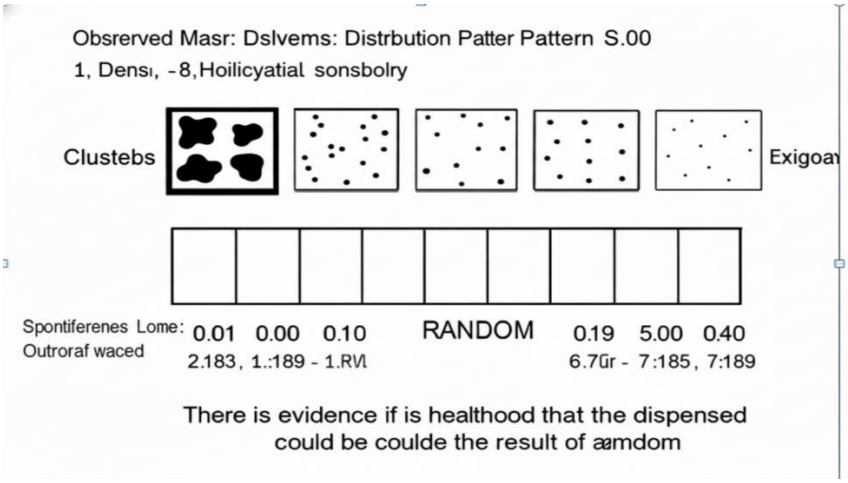

Figure 1: Average Nearest Neighbor Analysis of Primary School

Source: Zannat, M. E. U., & Mortoja, M. G. (2010)

Further analysis was conducted by the Average Nearest Neighbor (ANN) Analysis, which aids in ascertaining whether there are clusters of primary schools, a random pattern, or an irregular distribution of the primary schools. The outcomes depicted that the primary schools of the Narsingdi District are clustered. The observed mean distance/remaining expected mean distance gave an index value of 0.89, which is less than 1, and this means that the schools are more concentrated than under a random distribution. This is indicative of a form of clustering of Primary schools in selected Sub-districts, namely Narsingdi Centre, Manohardi, and Shibpur. Figure 1 is the graphical representation of the clustering.

The magnitude of the Z-score lies at the value of -4.6 standard deviations, which also supports the clustering pattern, claiming that most primary schools are located in certain areas, specifically Narsingdi Centre. The value of a Z-score is indicative of an extreme deviation in comparison to the expected distribution, meaning that primary schools in these regions are far denser than in other

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places. Such grouping is representative of the uneven access to primary education in the district, where some Sub-districts are more littered with schools than others (Figure 2).

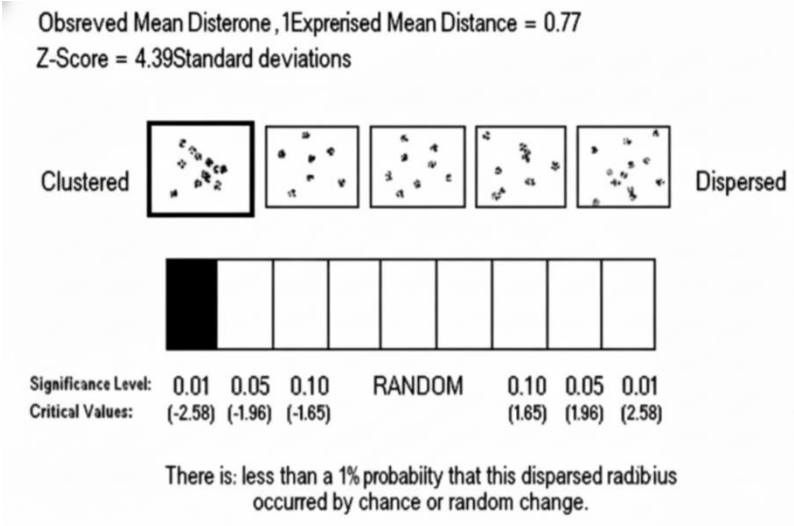

Figure 2. Average Nearest Neighbor Analysis of High School

Source: Zannat, M. E. U., & Mortoja, M. G. (2010)

4.2. High Schools

The distribution of the high schools within the Narsingdi District offers a more complicated situation. Factoring in the Location Quotient (LQ), the analysis pairs Narsingdi Centre Sub-district under the underserved category, given the general anticipation that Centre Sub-districts are in a better vantage position to access educational facilities. This is contrary to what is observed in most districts of Bangladesh, that the Centre Sub-districts tend to be better off in terms of education infrastructure. Nevertheless, it is important to mention that the quantitative analysis would not be sufficient to evaluate the situation. Qualitative factors, namely the quality of high schools, the quality of education, and the ability of respective schools to enrol students, also have to be taken into account. The study, however, does not examine the qualitative dimensions of the facilities, which may give a better insight into the real availability of high school education. Employing ANN analysis using high schools, there is a clustering tendency similar to that of the primary schools. The mean value of distances between high schools divided by the expected mean gives an index value of 0.77; this too is less than 1. This implies that high schools are unevenly spread out in Sub-districts as opposed to clustering in others. This clustering is, however, more prominent in the Sub-districts of Manohardi, Shibpur, and Palash.

High schools were found to have a Z-score of -4.7 SD, further suggesting high schools in these regions are much closer together than would have been expected had the distribution been random. The small negative value of the Z-score indicates that the cluster of high schools in these Sub-districts is quite large as compared to other parts of the district. This agglomeration strengthens the evidence that there are distinct high school locations within the district, but it also creates doubt in ensuring equality in accessing secondary education in the district. Although the clustering can be seen as evidence of a sufficient number of high schools in some Sub-districts, an imbalance in terms of regional access and quantity is implied in others, with Narsingdi Centre being notably low.

4.3. Discussion of Patterns

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Another important finding is the clustering of both the primary and the high schools in select Sub-districts that the ANN Analysis indicated. Such a distribution shows the spatial disparities involved in the distribution of educational facilities in Narsingdi District. Such grouping of schools in the Sub-district has some historical, socio-economic, and infrastructural insights connected to the establishment of schools in the Sub-districts. The disproportionate access to basic educational services can be a result of more fundamental socioeconomic inequalities, where those regions with lower levels of schooling have fewer opportunities to gain access to education, thus leading to long-term development issues in these areas. The similarity of the Z-scores between the primary and high schools indicates that the location of both types of facilities is not a random outcome, but that patterns of development are the pattern. The negative Z-scores show that there are some areas that exceed the number of educational facilities, and there are those that are not even sufficient. This imbalanced allocation has the potential to worsen the socio-economic gaps that exist between the Sub-districts, especially in relation to access to quality education and the opportunities it can give in life.

The results imply that future planning activities must put efforts into eliminating such imbalances by paying much attention to developing schools in underserved Sub-districts and particularly in those with an LQ value of less than 1. Moreover, future investigation of the distribution and accessibility of education facilities is required to take into account school quality and capacity as a qualitative feature of the educational facilities. The spatial study of the location of the facilities of primary and high schools in the Narsingdi District indicates some serious regional patterns referring to the concentration of facilities and access to the facilities. The concentration of schools in a few Sub-districts like Narsingdi Centre, Manohardi, and Shibpur is a sign of having a grouping of educational resources in the district. Such imbalances need to be resolved in future policy formulation, in order to promote more equal access to education for all inhabitants of Narsingdi District. Considering the quantitative and qualitative aspects, by correcting the distribution of schools and taking into consideration the aspect of balanced regional development as well as the reduction of the differences in the sphere of education, planners will be able to reduce disparities in education.

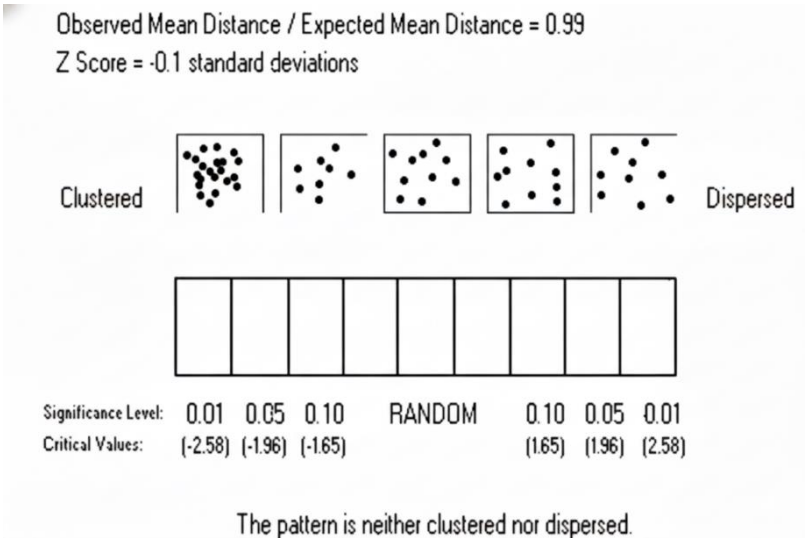

Figure 3. Average Nearest Neighbor Analysis of College

Source: Zannat, M. E. U., & Mortoja, M. G. (2010)

4.4. College

The Location Quotient (LQ) of the colleges in Narsingdi District indicates that there is a considerable gap in the distribution of the colleges. The analysis reveals that Shibpur and Raipura

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Sub-districts are underserved in terms of all three criteria- population, area, and population density, meaning that the number of colleges is lower than in the district overall. These sectors lack access to higher education buildings, which may cause difficulties in coming across students seeking to further their education after primary or high school.

Although the LQ indicates that some Sub-districts do not have many colleges, the average nearest neighbor analysis is more representative of a balanced pattern in the distribution of the colleges. Analysis on the ANN indicates that the index value of the ANN is about 1, which implies that the distribution of colleges is not highly concentrated and or dispersed in the six Sub-districts. Put another way, the placement of colleges is reasonably fair across the district, with Raipura being an apparent exception, where there is a shortage. This interpretation may be supported by the Z-score, which is -0.1, indicating that the distances of colleges to their mean are near the average distance estimate, and this measures the extent of equilibrium in the distribution of colleges.

However, what must be put in perspective is that the distribution is equitable, but does not really contribute to meeting the education needs of all the people in the district. LQ and ANN analyses offer some understanding of the spatial distribution of educational facilities, but they do not cover the qualitative aspects in terms of capacity, infrastructure, and quality of the respective colleges. Since some of these Sub-districts, such as Shibpur and Raipura, are underserved, future interventions should aim to strengthen the capacity and quality of current colleges in these underserved areas, along with addressing the shortage.

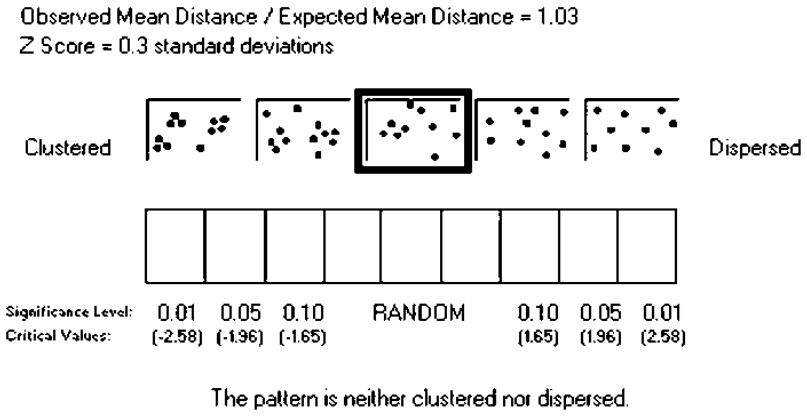

Figure 4. Average Nearest Neighbor Analysis of Hats and Bazars

Source: Zannat, M. E. U., & Mortoja, M. G. (2010)

4.5. Interpretation of Proximity Results:

The information presented in Table 2 evidently demonstrates that all the socio-economic amenities in the Narsingdi District are located within 3 km of the growth center. The allocation of these facilities in terms of distances evokes some important insights:

Primary Schools: The structure of distribution of primary schools is more dispersed in the district, with the majority being concentrated within 3 km of the growth center. Nevertheless, the concentration of these schools is in the lower proximity to the growth center, as 29.25 percent of the schools lie in a two-kilometer radius. Only 7.07 percent of the primary schools are located within 1km of the central growth area, which is indicative of the fact that the inhabitants are not evenly distributed around the main artery.

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Table 2. Proximity analysis of socio-economic facilities

Name of Facility	Within 1 Km	Within 2 Km	Within 3 Km
Primary School	7.07	29.25	63.67
High School	14.18	32.09	53.73
College	21.21	33.33	45.45

Source: Local Government Engineering Department of Bangladesh

High Schools: The high schools take a similar pattern as the primary schools, but with a greater concentration in the 1 km and in the 2 km buffer. It is found that approximately 14.18% of the high schools are within 1 km of the growth center, whereas 32.09% are within 2 km. So, almost half or 53.73 percent of high schools are within 3 km, which indicates that, whereas high schools are more concentrated around the growth center than primary schools, they are also distributed fairly well around the district.

Colleges: Colleges are found in the most significant numbers in the 1km and 2km buffers, where 21.21 and 33.33 percent of the colleges, respectively, are located within the specified buffers. Only 45.45 percent of colleges are within 3 km, which shows that they are more concentrated in the growth center than in central schools.

On an overall view, it is clear that the farther the growth center is, the higher the percentage of facilities in each of the corresponding zones becomes. This is indicative of the growth centre being a key focal point of socio-economic facilities, but with socio-economic influence not limited to the growth centre but spread throughout the district. The buffer of 3 km seems to be the offspring of the maximum practical impact of the growth center of such facilities.

4.6. Relation Between Social Variables and Socio-Economic Facilities

To further determine the regional imbalance in the allocation of the socio-economic facilities, a relationship between the social facilities and different social criteria was profiled. Six social factors were chosen to evaluate their role in the concentrations of facilities: population, the area, population density, the communication facilities, the average literacy, and the distance in kilometers to Narsingdi Headquarters. Correlation coefficients between these criteria and the different socio-economic facilities were estimated and tabulated as shown in Table 3.

Table 3. Correlation among Different Socio-Economic Facilities and Social Criteria

Criteria	Primary School	High School	College	Hats and Bazars
Population	0.56347	-0.13444	0.34610	0.65825
Area (Sq. Km)	0.12736	0.32166	-0.1153	0.96712
Population Density (per Sq. Km)	0.59246	-0.66942	0.70053	-0.37718
Communication Facilities (in Km)	0.57690	0.68568		0.62097
Average Literacy	-0.30426	-0.21956	0.02194	-0.70068
Distance from Narsingdi Headquarters (Km)	-0.64650	0.53002	-0.5767	0.16456

Source: Asiatic Society of Bangladesh, 2024

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5. Discussion

The strongest correlation coefficient of primary schools is with population density (0.59246), and the latter means the region with high densities of population tends to have high densities of primary schools. It is reasonable since more populated areas necessitate more facilities in education. Also, between primary schools and communication facilities, there is a moderate positive correlation of 0.57690, indicating that functional transportation and infrastructure also contribute to the establishment of the primary schools (Banerjee & Kuri, 2015). There was a negative association with average literacy (-0.30426) and distance to Narsingdi Headquarters (-0.64650), which are believed to reduce the number of primary schools in an area (Aslam Memon & Jabeen, 20218). The results of this research are well supported and build on the body of literature concerning regional inequalities in education infrastructure in the developing world. In line with the previous studies (e.g., Zannat and Mortoja, 2010; Mitricia et al., 2017; Dong & Liang, 2014), we find that there is a high concentration of educational facilities in sub-districts, especially Narsingdi Centre, whereas the rural and isolated regions are underserved. These disparities are found to be identified effectively using spatial analysis tools, including Location Quotient and Average Nearest Neighbor, as is consistent with the methodologies used in other similar studies (e.g., Hasugian et al., 2020; Liu et al., 2020).

The strongest correlation was found with the communication facilities (0.68568) and distance to the Narsingdi Headquarters (0.53002) among high schools, implying that high schools tend to have better infrastructure and are further away from the headquarters of the district. The negative relationship with the population density (-0.66942) does not mean that there were high schools consistently occurring in densely populated areas, but in more accessible, less densely populated areas and with a better infrastructure (Baker et al., 2016). Communication facilities have the highest positive association with colleges (0.62097), and so does population density (0.70053). This will imply that colleges will tend to be located in places with larger population density and an excellent transport system. The correlation with average literacy is not significant (0.02194), thus it is clear that literacy level is not a significant determinant in the siting of colleges. Based on the correlation analysis, it would be apparent that there are various factors that cause the regional imbalances where social-economic facilities are distributed (Berchoux & Hutton, 2019; Fauzi et al., 2024). Another similarity with the existing literature is that the distribution of educational facilities is affected by socio-economic factors, including the population density and transportation infrastructure (Ohlan, 2013; Narain et al., 2000). We verify our hypothesis of correlation by demonstrating that the more densely populated and well-developed the region is, the more educational facilities are located in it, which supports our belief that the distribution of resources typically depends on the availability of the most convenient and economically active areas. Nonetheless, in contrast to certain studies (e.g., Guo et al., 2020), which focus on the relevance of policy interventions, the patterns of spatial clustering, which indicate the presence of some socio-economic inequalities, are explicitly mentioned in our findings, particularly in rural sub-districts.

The first break with the previous studies is in the distribution of colleges, in which we observe that it is more equitable (ANN index near 1), spatially spread across the district. This is contrary to the situation in other developing settings (e.g., Kallingal and Mohammed Firoz, 2022), when in many cases, higher education institutions are centralized in the cities. This implies that there might have been a special push towards the establishment of higher education institutions in disadvantaged regions in Narsingdi, or that colleges are more attentive to the socio-economic requirements of the local population than primary and secondary education. The research is also unique as it has investigated the district of Narsingdi as a micro-level area of examination of disparities in the regions in Bangladesh- a setting that has not been subjected to much spatial analysis as compared to national studies (e.g., Pasha, 1991; Mazumder & Tamima, 2006). It also fills

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in a gap that is very essential, as it incorporates various spatial and socio-economic variables in a GIS framework and presents a holistic spatial diagnosis that other studies have not provided, which were only done by qualitative or macro-level analysis. Additionally, this study contributes to the understanding by explicitly connecting patterns of the spatial distribution to socio-economic factors, including literacy rates, population density, and transportation access, to the picture of the multidimensionality of educational inequalities. This combined strategy can include the linkage between macro-level policy discourses and micro-level spatial realities to provide precise knowledge on a localized policy intervention.

Population density and communication infrastructure are the key factors that have resulted in the concentration of primary schools. High schools are more attracted by the proximity to the growth center and communication facilities, whereas the college institutions are highly biased towards population density and better access to the communication systems. In the case of Hats and Bazars, the influence of area and communication facilities has been a significant contributor to their concentration. The width of the transportation network and the size of the region also contribute a lot when it comes to establishing these markets, primarily in the regions where there are more people to take advantage of the wider-ranging business.

The three-pronged analysis of socio-economic facilities, along with the social criteria, can bring in useful information on what is causing the imbalance in regions in Narsingdi District. Although population density, communication infrastructure, and neighborhoods with the growth centre may contribute highly to the concentration of facilities, other factors, such as average literacy and the size of the area, also play pivotal roles. These relationships are critical for informing policymakers on how best to intervene to address disparities in facility distribution, ensuring that all regions in Narsingdi have effective access to both educational and economic facilities. One of the strategic planning initiatives should be enhancing the infrastructure and parity in the accessibility of the socio-economic amenities to underserved areas, especially low population areas and areas lacking adequate transportation infrastructure.

6. Conclusion

This paper discussed the inequality in terms of the availability of educational facilities in the six Sub-districts in Narsingdi District. Several statistical approaches were used to determine imbalances, but the study was confronted with the unavailability of primary data, a lack of time, and a shortage of resources. Notwithstanding these restrictions, the study offered important information on unevenness in the location of educational facilities, meaning that there were Sub-districts experiencing a shortage of educational services. The results indicated significant regional disparity, especially in the rural and far-flung regions.

This research systematically explored the research questions that were based on the equity of the distribution of educational resources in Narsingdi District. The results show that there is an observable unequal distribution of schools and colleges throughout the sub-districts, which signifies that there are substantial regional inequalities. Under-serve sub-districts like Raipura and Palash, in particular, are mainly caused by such socio-economic perspectives as low population densities, poor infrastructures, and outskirts geographical areas, which obstruct a fair share of access to learning institutions.

On the other hand, such locations as Narsingdi Centre have the advantage of institutional concentration because of their closeness to the transport networks and the centres of economic activity. The analysis shows clearly that the distribution of educational facilities is not entirely equitable. More advanced areas, which have superior infrastructure, larger population, and more connections with transportation routes, have a more convenient way to access education. This spatial imbalance enhances the socio-economic inequalities since the underserved areas experience

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hindrances to good education, and this constitutes a hindrance to their developmental opportunities. The spatial analysis tools assisting with the process of clustering schools and colleges help highlight the long-term presence of regional inequalities, with their basis in the infrastructural and socio-economic inequalities. These results highlight why special policy interventions are required to fill these gaps. Some infrastructural shortcomings, the increase in educational opportunities in underserved regions, the enhancement of transportation access, and community engagement are all vital measures toward a more balanced allocation of educational opportunities.

Also, promoting the social-business connections may be crucial in mobilizing resources and the development of educational infrastructure on a sustainable basis. Finally, it is important that every area receives equal access to quality education to facilitate inclusive growth, minimize the socio-economic inequalities, and achieve sustainable regional development in Bangladesh. The findings of the study provide valuable evidence to guide future policies to establish educational equity in a variety of geographic and socio-economic settings.

With such realizations, the paper described some policies and strategies to overcome the above educational disparities and bring the equal distribution of educational facilities within the district. I hope these suggestions will inform policymakers in fostering balanced growth and that they will start providing all areas with access to good education. The research also acts as a source of future research and future planning, not only to the Narsingdi district but to the rest of the districts in Bangladesh. On the whole, the research will help to make the educational development more sustainable and inclusive in the district and, in the ultimate form, the quality of life of all residents.

6.1. Policy Recommendations

This paper will offer landmark insights not only into Regional Disparities in Educational Facilities in Narsingdi District but also to help guide policymakers to channel development resources in a bid to create equitable regional development. On the basis of the findings, the following suggestions are proposed in order to accommodate the regional disequilibrium and to facilitate sustainable growth.

- Combine qualitative analysis (quality/accessibility / capacity/user satisfaction) with quantitative data to see how educational facilities are doing. This would make sure that there is a detailed awareness about the quantity that is being served, as well as the quality of education services in the district.

- Plan the distribution of the education facilities using social, economic, and environmental variables (such as density of population, local industry, and infrastructure). The peculiarities of every region should be tailored to strategies in this direction in order to provide equal chances to education.

- Formulate decisive guidelines on the number of educational institutions required per capita in the different regions. Enhance collection and analytical frameworks on the availability and distribution of institutions.

- Enhance cooperation among government agencies, nongovernmental organizations, the business sector, and community groups to coordinate educational objectives and maintain efficient, sustainable schools, colleges, and universities.

- Focus educational resources on the needs of vulnerable groups (e.g., families with low income, women, children, people with disabilities). Subsidies or grants may be given to ensure that education becomes a reality for everyone.

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- Switch to sustainable infrastructure that is environmentally friendly in developing education facilities so that there is long-term sustainability to the education facilities and environmental degradation is also minimized.

Declarations

Availability of data and material. Data will be provided by the Corresponding Author upon reasonable request.

Competing interests. The authors are declaring there is no Conflict of Interest.

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