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Research Article

A GIS Based Integrated Approach to Measure the Spatial Equity of Community Facilities of Bangladesh

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Abstract: The distribution of public facilities and their spatial equity is an important matter to be considered while planning public facilities. However, most of the studies in the literature have taken into consideration only a single type of facility while leaving other facilities unconsidered. In this paper an integrated spatial index for public facilities has been developed integrating GIS and spatial analysis models. The index measures the spatial equity based on the accessibility of 6 different types of public facilities for 5247 unions and 476 sub-districts of Bangladesh. Spatial autocorrelation techniques have been applied to understand the spatial pattern of accessibility. In fact it helps to understand the characteristics of spatial equity both for disaggregated and aggregated levels. It has been found that variation accessibilities to the facilities across the space are significant. Distribution of some facilities are spatially clustered to some particular areas means those areas are in an advantageous position in terms of accessibility while other areas are in a backward condition. The proposed index and the spatial autocorrelation will help to identify which areas should receive more priority in allocating particular types of public facilities in the future.

Keywords: Integrated Spatial Equity Index; accessibility; spatial autocorrelation; Moran's *I*; Getis-Ord *Gi** statistics

1. Introduction

During the last two decades, the issue of spatial equity has received much importance in literature [1–3]. Different studies have been carried out to develop a generic model concerning this issue. However, it has not been possible to give spatial equity a comprehensive evaluation till now [4]. Specifically, there is no reasonable mechanism available to measure the spatial equity of public facilities in an integrated manner for planning facilities throughout an area. Although some studies have been carried out, these were limited to single facilities. A considerable number of these studies have focused on the provision of parks [36–39] while others focused on the distribution of health care facilities [40–42]. Those studies found that there was a spatial disparity in the distribution of such facilities due to lack of accessibility. However, comparatively less research has been carried out analyzing the spatial equity of multiple facilities at a time [43].

In fact, each type of public facility has its own unique characteristics that satisfy particular needs of people. Hence, the preference and importance for different types of facilities are not the same. If a study concentrates on allocation of only a single type of public facility and ignores the relationship between other public facilities and their varied preferences, it will fail to analyze the overall equity status of an area.

Geographic scale is an integral component to be considered for spatial equity of public facilities. Lacking spatial data processing techniques and strong theoretical background, most of the previous empirical studies on spatial equity used aggregate indices considering larger spatial units [5,34,35]. In fact, equity of community level facilities in an integrated manner considering smaller geographical units was seldom been studied. To fill the gap, this paper proposes a GIS based integrated spatial equity index, considering spatial analytical perspectives, such as accessibility theories, and spatial association, and most importantly to indicate how these can be applied to examine whether and to what degree the distribution of public facilities is equitable. This paper focuses especially on the relevant factors for spatial equity as well as spatial patterns of equity of entire public services, based on the proposed index.

2. Spatial equity of community facilities

The general connotation of the term "spatial equity" refers to the equal distribution of services and facilities in space [15]. It also implies the equal distribution of facilities for people living in different places in relation to their needs and preferences. Although its definition and the way it is measured vary widely, the perception of accessibility occupies the central concept of spatial equity in the literature [6]. Most of the studies have explained spatial equity in terms of accessibility to facilities such as schools, markets, hospitals, health-care facilities etc. measured in terms of proximity or distance [2,3]. Of the many available means, accessibility indices have therefore been the most widely used for measuring spatial equity in context of planning public facilities.

The relative proximity of one place to another can be simply termed as accessibility. It can be defined as travel impedance (in terms of distance or time or both) to the desired facility location [7]. The further the distance, the more time it takes to reach the facility and the less likely the residents can reach and use that particular facility.

A considerable effort has been made to develop suitable accessibility indices in the past [8]. Existing literature on spatial accessibility measure can be categorized under three approaches: 1) container approach, 2) travel cost approach and 3) gravity based spatial interaction models [32]. A common approach is the container based method which takes the number of facilities in a specific geographic unit for measuring accessibility into account [33]. The travel cost approach simply measures accessibility based on average distance to the facilities or distance to the nearest facility. However both approaches have drawbacks. The container approach only takes the number of facilities into account, not how easily they can be reached by the people and the travel cost method never includes more than one facility for measuring accessibility. However, the travel cost approach has an advantage over the container based method as it takes into account the nearest distance not limited to a specific geographic unit because the nearest facility may be located in the neighboring unit as well. Therefore the most widely applied method is the gravity based spatial interaction method [9,10,45]. It overcomes the limitation of the above two approaches as it considers both the number of facilities and distance to the facilities as well. The general formula of gravity based spatial accessibility model can be expressed as following:

$$\mathrm{A}_i = \sum_j \frac{s_j}{d_{ij}^{\beta}}$$

Where A_i is the spatial accessibility of public facilities for the population living at *i* which may be the centroid of a geographical unit [30]; S_j is the service capacity of the given facility at location *j*, which can be expressed as the number of facilities at the location and their individual capacity; d_{ij} is the travel impedance, e.g. shortest network distance between points *i* and *j*; and β is a gravity decay coefficient, (it is sometimes referred to as the travel friction coefficient), representing level of impedance to travel created by distance .

Accessibility of a particular facility greatly depends on how near the facility is located. Proximity is the central concept of spatial analysis and the distance to the nearest facility from the demand point has been most widely used for measuring spatial proximity [22]. A particular area may have a sufficient number of facilities; however, if the distances to those facilities are beyond the service impact range, then accessibility will be reduced. There are different methods to measure distance. The physical distance to the closest facility is a good measure of spatial proximity [11,12,31]. The most common types of distance measure used for determining spatial accessibility in the literature are the Euclidean distance (more often known as straight line distance) and the distance along the transport network. Different studies have suggested that straight line distance is a good measure of spatial accessibility considering a wide analysis of numerous public facilities covering a large number of geographical units [13,22].

A facility may be well located, however the number of facilities may not be adequate to meet the demand of the residents and thereby the accessibility and spatial equity are affected. Apparicio *et al.* (2008) have used the number of facilities within a specified distance to measure spatial accessibility [14]. Talen and Anselin (1998) demonstrated that accessibility improves if either the number of facilities or the capacity at any facility provider increases [3].

Residents' preferences for different types of facilities differ. For example, accessibility to the elementary school in a neighborhood may be more important than that of a college. For modeling spatial equity of different types of facilities in an integrated manner, such variations have to be considered. Tsou *et al*. (2005) have used an attitude scale (Likert scale) for assessing residents' preferences and needs for different types of facilities [15].

3. Spatial patterns and spatial associations

Spatial patterns can be defined as the spatial arrangement pattern of features on a designated surface according to their location. Spatial statistics have been used in a range of accessibility studies. Both global and local patterns of spatial associations have been used for analyzing the pattern of spatial autocorrelation. In addition to analyzing global patterns, more emphasis has been recently put on analyzing local patterns of spatial association such as in [3,16,17].

3.1. Measures of global spatial patterns:

The most widely used index to measure spatial autocorrelation is Moran's *I*. The global spatial statistic Moran's *I* measures global spatial autocorrelation based on feature geographic locations and associated attribute values [18]. Moran's *I* measures the proximity of locations according to similar characteristics of their features. Moran's global *I* statistic measures spatial autocorrelation without distinguishing between patterns of high or low values.

Given a set of features and an associated attribute, Moran's global *I* statistic evaluates whether the pattern is clustered, dispersed, or random on a range from -1 to +1. The negative value indicates spatial dispersion while a positive value indicates spatial correlation [15,23].

3.2. Measures of Local Spatial Patterns:

In spatial analysis it is often required to know the degree of spatial association between variables. More recently additional models of spatial statistics, known as local spatial statistics have been developed to measure association between a single geographical area and its neighbors within a specified distance [19]. Local Indicator of Spatial Association (LISA) is a local spatial statistic which measures local spatial autocorrelation. It provides information on spatial clusters and spatial outliers [21,25]. Local Moran's I developed by Anselin (1995) indicates the similarity of a geographical unit with respect to its neighboring units. A positive value for I indicates that the feature is surrounded by features with similar values. Such a feature is part of a cluster. A negative value for I indicates that the feature is surrounded by features with dissimilar values. Such a feature is an outlier. A limitation of this method is that the positive I value could be determined also for zones with low values if they are surrounded by other zones of low values [26,27,29]. Thus, Local Moran's I usedto identify hot spots of zones can lead to ambiguous results.

Getis-Ord G- statistics (G_i and G_i*) is another way to measure the local spatial association introduced by Getis and Ord (1992). G_i calculates the effect of a target feature on neighboring features excluding the target itself [24]. It was later improved to G_i* (z-transformed form of G_i) in order to improve statistical testing which is known as the standardized $Gi*$ statistic [28]. Unlike G_i it can include the value of the target features while measuring local spatial association. The $Gi*$ statistic indicates whether features with high values or features with low values tend to cluster in a specified location: if a feature's value is high, and the values for all of its neighboring features are also high, it is a part of a hot spot; if a feature's value is low, and the values for all of its neighboring features are also low, it is a part of a cold spot. The Getis-Ord $Gi*$ statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij} x_j - \bar{X} \sum_{j=1}^{n} w_{ij}}{s\sqrt{\frac{[\sum_{j=1}^{n} w_{ij}^2 - (\sum_{j=1}^{n} w_{ij})^2]}{n-1}}}$$

Here, x_j is the attribute value for the feature j; w_{ij} is the spatial weight between feature i and j and n is the total number of features.

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}$$

The *Gi** statistic returns for each feature in the dataset a z-score: for statistically significant positive z-scores, the larger the z score, the more intense the clustering of high values (hot spot); for statistically significant negative z-scores, the smaller the z-score, the more intense the clustering of low values (cold spot) [28]. As mentioned, Anselin's Local Moran can only identify positive or negative spatial autocorrelation, that is, whether the zones are similar or dissimilar. Those zones with positive spatial autocorrelation could occur because of clustering of zones with high values or they could occur because of clustering of zones with low values. The Getis-Ord *Gi** can distinguish between these two types [26, 27,29].

4. Developing a new integrated spatial equity index for public facilities

Most of the indices developed so far have originated from the very fundamental equation based on gravity model [20]. However, it cannot state how disaggregated the measurement of accessibility is in terms of geographical units. For example, the distance of individual facilities can be considered on district level (from the centroid of individual districts), but not on the community level (centroid of unions). Hence, the measurement might not reflect the actual scenario of spatial equity of accessibility. This is also true while considering the number of facilities in each geographical unit. While the number of facilities in a particular district overall may be sufficient, some areas within the district may be over supplied while on other areas it may be lacking. Hence, while considering the spatial equity, the accessibility should be considered at the disaggregated level.

Again, although the accessibility of facilities is considered in an integrated manner, the range of service impact of these facilities are different. Some facilities are provided at community level like primary schools, high schools and family welfare centers. On the other hand, service impact ranges of some other facilities are beyond the community level like hospitals, colleges and growth centers. In this study six important public facilities have been considered; three at the union level and another three at the sub district level (Table 1).

Table1. Public Facilities at union and sub-district level

Public Facilities at Union Level	Public Facilities at Sub-district Level
Primary School	Growth Centers
High School	Hospital
Family Welfare Center	College

Spatial equity considering the facilities at the union level:

$$E_{ij(k")} = \frac{\sum_{n=1}^{N}\sum_{k"=1}^{k"=3} x_{n(k)} \times \frac{1}{d_{nj(k)}}}{N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$E_{ij(k")}$ is the value of spatial equity of the public facilities j(k”) in the sub district i, i = 1,2,. .., I; k” is the kth type of all public facilities at union level, k”= 3;
j(k”) is the jth public facility of the kth type of public facility, j = 1,2,. . ., J;
$x_{n(k")}$ is the number of kth type of facility at union, n;
d_{nj} is the nearest distance of kth facility from the centroid of the union;
N is the total number of unions in the sub district;

Spatial equity considering the facilities at the sub district level:

$$E_{ij(k')} = \sum_{k'=1}^{k'=3} x_{i(k')} \times \frac{1}{d_{ij}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$E_{ij(k')}$ is the value of spatial equity of the public facilities j(k’) in the sub district i, i = 1,2,. .., I; k’ is the k th type of all public facilities at sub-district level, k’= 3;
j(k’) is the jth public facility of the kth type of public facility, j = 1,2,. . ., J;
$x_{i(k')}$ is the number of kth type of facility sub district, i;
$d_{ij(k)}$ is the nearest distance of kth facility from the centroid of the sub district;

Integrated Spatial Equity Index for Public Facilities:

$$E_{ij(k)} = w_k\left[\frac{\sum_{n=1}^{N}\sum_{k"=1}^{k"=3} x_{n(k)} \times \frac{1}{d_{nj(k)}}}{N} + \sum_{k'=1}^{k'=3} x_{i(k')} \times \frac{1}{d_{ij}}\right] \ldots\ldots \text{(3)}$$

W_k is the score of preferences for different types of facilities

4.1. Score of Preference for Different Types of Public Facilities

AHP (Analytical Hierarchical Process) has been applied in this study to get the score of preference for different types of facilities. An effective way to determine the weights under AHP can be pair-wise comparison of the indicators. According to Satty (2008) a pair-wise comparison involves three tasks: (1) Developing a comparison matrix at each level of the hierarchy starting from the second level and working down, (2) Computing the relative weights for each element of the hierarchy and (3) Estimating the consistency ratio to check the consistency of the judgment [44]. Generally, the measurement scale of 1-9 is used to represent such relative importance, as shown in Table 2.

Table 2. Pair wise comparison scale proposed by Satty

Importance Intensity	Definition	X' compared with 'Y'
1	Equal importance	X is as equally important as Y
3	Moderate importance	X is moderately more important than Y
5	Strong importance	X is strongly more important than Y
7	Very strong importance	X is very strongly more important than Y
9	Extreme importance	X is extremely more important than Y
2,4,6,8	Intermediate values	X is compromise between two judgment of Y

First of all, a pair-wise comparison matrix is constructed. Then vector of weights, $w = [w_1, w_2, \ldots, w_n]$, is computed on the basis of Satty's eigenvector procedure. The computation of the weights involves two steps. First, the pair wise comparison matrix $A = [aij]_{n\times n}$ is normalized by and then the weights are computed by the following equations.

$$A = [a_{ij}]_{n\times n} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

$$\overline{a_{ij}} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

$$w_i = \frac{\sum_{j=1}^{n} \overline{a_{ij}}}{n}$$

To determine whether the level of consistency in the pair-wise comparison is 'reasonable' or not, a consistency checking is required. Therefore consistency ratio (CR) is to be calculated with the help of following formula.

$$CR = \frac{CI\ (ConsistencyIndex)}{RI\ (RandomIndex)}$$

$$CI = \frac{\lambda_{max} - n}{n-1}$$

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	0.12	1.24	1.32	1.41	1.46	1.49

If CR < 0.1, then the comparisons are acceptable. If, however, CR > 0.1, then the values of the ratio are indicative of inconsistent judgments.

5. Results and findings

In this study, GIS is used for the analysis for the following reasons: (1) to store and analyze the spatial distribution of each public facility; (2) to quantitatively process the spatial data and provide the proposed index; (3) to support the discovery and verification of spatial equity of public facility; and (4) to display the results of the index. ArcGIS 10.0 was used in this study for spatial data analysis. The process involved several steps mentioned below:

Step 1: First of all the centroid of the respective unions and sub districts was determined by transforming the polygon features into point features. It was assumed that, the population is concentrated at the central area of the unions and the sub-districts. Then the nearest distance of the public facilities from the centroid point was found through *near analysis*. In this case, Euclidean distance was considered for the reason mentioned earlier in this paper.

Step 2: The number of facilities in an area is a crucial determinant of spatial equity. The numbers of facilities for each unions and sub districts were counted through spatial join.

Step 3: Not all the facilities are equally important. Accessibility to some particular facilities is more important than others to the community people. Score of preferences for the facilities was determined through pair wise comparison according to Satty's AHP method.

Step 4: After measuring the nearest distance of the facilities and their numbers, the spatial equity of the facilities provided at the union and sub-district level was determined from equation (1) and (2) respectively. Finally, using the score of preference for each six types of facilities, the integrated index for spatial equity was calculated for each sub districts of Bangladesh (equation 3).

Step 5: The global pattern of spatial association for the index was analyzed through *spatial autocorrelation* method. *Moran's I* value was found for each facility indicating which one is more clustered or uniformly distributed across the space considering the accessibility of the facilities. For global Moran's *I*, a threshold distance needs to be specified indicating the search radius within the neighborhood. In this study the minimum distance required to ensure that each geographical unit has at least one neighbor (27.19 km) was chosen as the threshold distance [26].

Step 6: The local pattern of spatial association indicates which regions are advantageous region and which ones are in a underprivileged condition. The *Getis-Ord Gi* statistic* (*hot-spot analysis*), a local spatial statistics was preferred over local Moran's I for assessing local spatial patterns. Unlike local Moran's I, a high value of *Gi** indicates a cluster of features (sub-districts) with high attribute values and a low value of *Gi** indicates the cluster of features (sub-districts) with low attribute values which was required to identify the advantaged and disadvantaged regions considering the accessibility of facilities. For *Getis-Ord Gi**, the same threshold distance (27.19 km) was chosen as in global Moran's *I* for showing clusters of high and low values.

5.1. Integrated Spatial Equity Index for Public Facilities:

Score of preference indicates the weights of different types of facilities. Expert opinion has been considered for the pair wise comparison method. The consistency ratio of the given score was checked.

CR in this analysis has been found 0.0163 which is less than 0.1. Hence the scoring of weights is acceptable. The score of preferences in this study for different types of facilities are shown in table 3.

Table 3. The score of preferences for different types of facilities

Types of Facilities	Score of Preferences
Primary School	0.35
High School	0.10
Family Welfare Center	0.27
Growth Center	0.14
Hospital	0.10
College	0.04

Finally, the proposed index value was calculated. The index integrates the accessibility of six different types of public facilities. The value ranges from 0.59 to 44.10. The index values are shown in figure 1 and in the appendix.

5.2. Spatial Auto-Correlation (Global):

Table 4. Moran's *I* for different types of public facilities

Facilities	Moran's *I*
Primary School	0.19154
High School	0.231979
Family Welfare Center	0.116283
Growth Center	0.073146
Hospital	0.038351
College	0.154822
Aggregate for all facilities	0.13333

S.N: $P < 0.001$

The value of Moran's *I* for all public facilities are positive. It means the index values of the facilities are spatially clustered in some areas (Table 4). Some areas are advantaged while other areas are in disadvantaged locations.

Moran's *I* values for educational facilities are greater than the other facilities. It implies that there is more spatial inequality regarding the accessibility to the educational institutions in Bangladesh.

The index value is lower for hospitals and growth centers. It implies that the distribution is random and spatially uniform for these facilities.

The aggregate value is 0.13. It implies that there may be uniform distribution of facilities considering some particular facilities like hospitals and growth centers; but considering all of the selected facilities, there is spatial clustering.

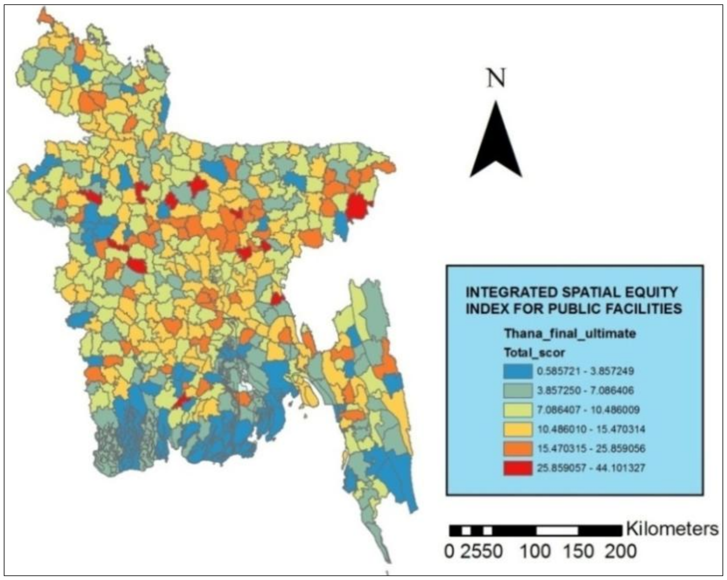

Figure 1. Integrated Spatial Equity Index for Public Facilities in Different Sub Districts of Bangladesh

5.3 Spatial Auto-Correlation (Local):

Accessibility to primary schools is more concentrated in central and North Eastern region of Bangladesh (Figure 2). The sub-districts of Dhaka division are in more advantageous locations than others considering primary schools. On the other hand, the cold spots suggest that the coastal areas of Bangladesh (Barisal and Chittagong division) are in more vulnerable positions than others.

Like primary schools, accessibility to high school is also concentrated in central and south central region of Bangladesh. However, along with the coastal region, sub-districts of North Eastern region (Netrokona, Kishoreganj, Shunamganj districts) are more in disadvantaged locations (Figure 3).

In case of family welfare facility, areas of Chittagong hill tracts are in disadvantaged locations while the areas of central region surrounding the capital are in advantageous position (Figure 5).

Unlike primary school, high school and family welfare center, accessibility to growth center, college and hospital is not concentrated in the central region of Bangladesh (Figure 4, 6, 7). As the spatial autocorrelation is not high for hospital and growth center (value of global Moran's *I* is 0.038 and 0.073 respectively), only few areas are in advantageous position than others compared to other facilities.

In aggregate level, considering all the selected facilities, it is clear from the hot spots that the central region of the country surrounding the capital Dhaka receives more accessibility for the public facilities than any other regions of Bangladesh. However, the southern coastal hill tracts region (Barisal, Patuakhali, Bhola, Barguna, Satkhira, Noakhali, Feni, Chandpur, Bandarban, Khagrachari, Rangamati) are in disadvantaged locations (Figure 8).

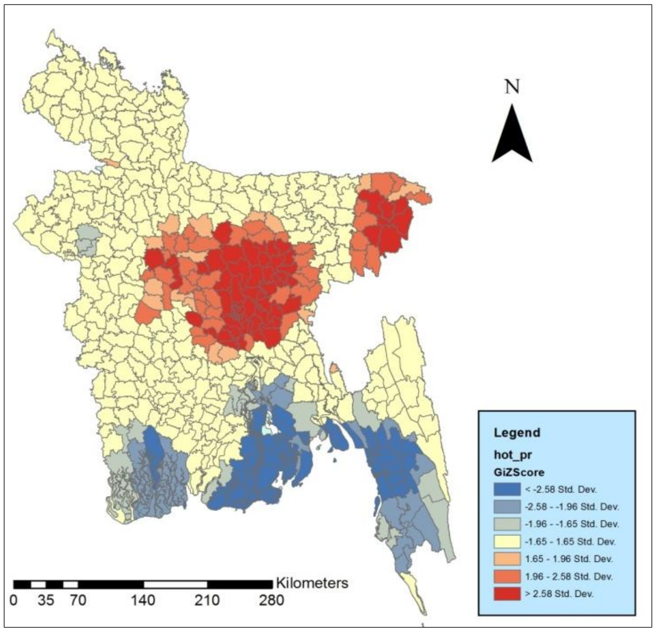

Figure 2. Local spatial autocorrelation pattern: Primary School

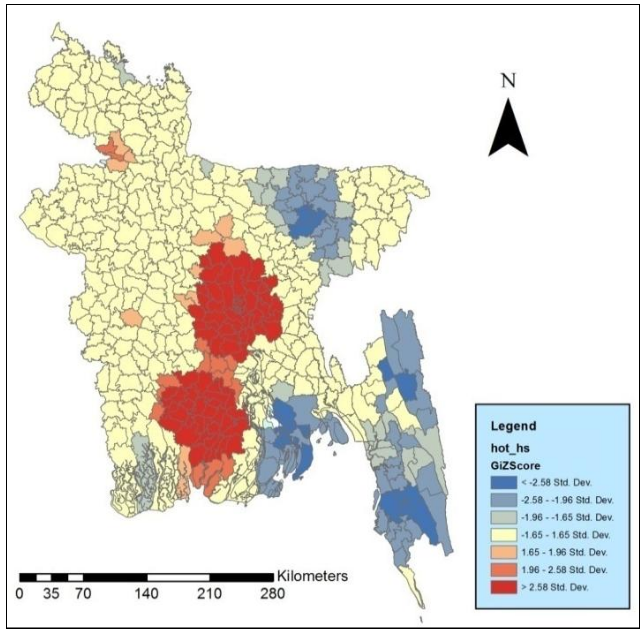

Figure 3. Local spatial autocorrelation pattern: High School

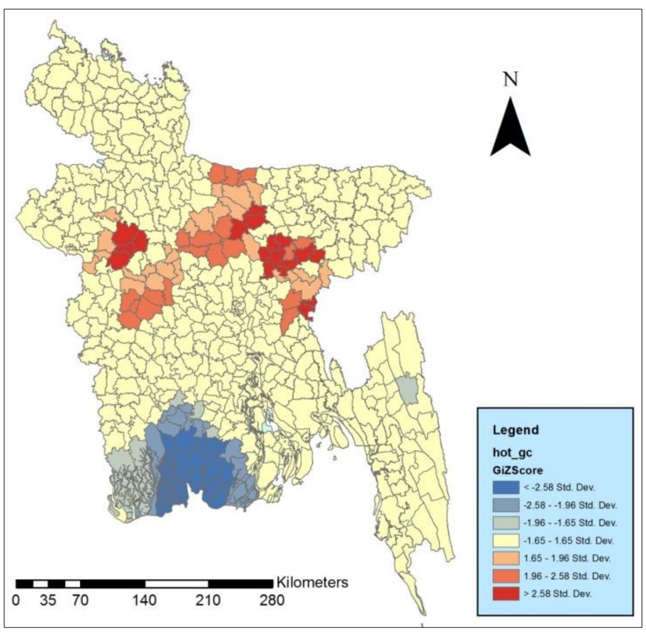

Figure 4. Local spatial autocorrelation patterns: Growth Center

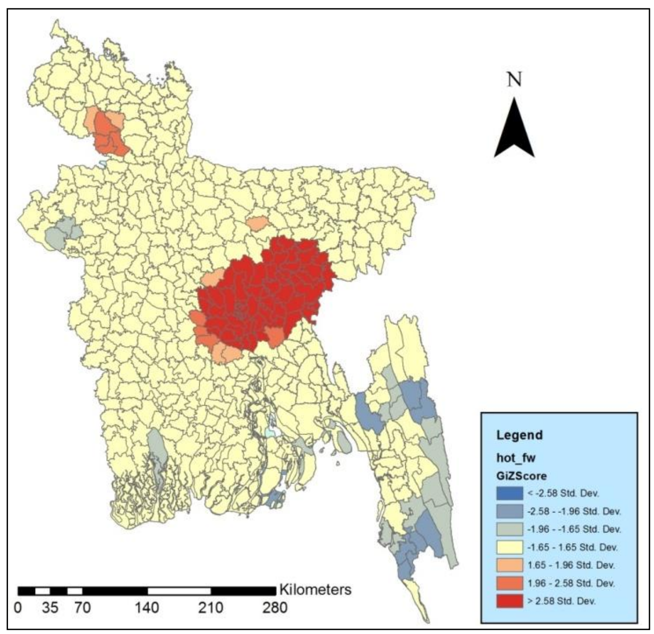

Figure 5. Local spatial autocorrelation pattern: Family Welfare Center

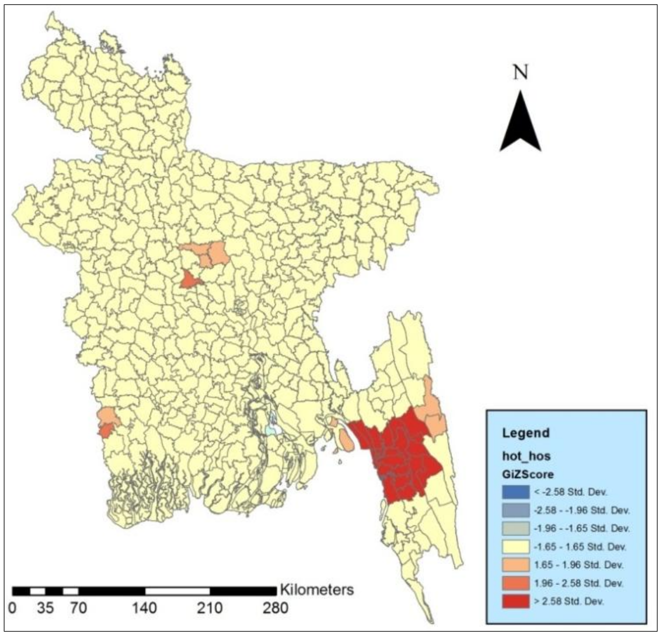

Figure 6. Local spatial autocorrelation patterns Hospital

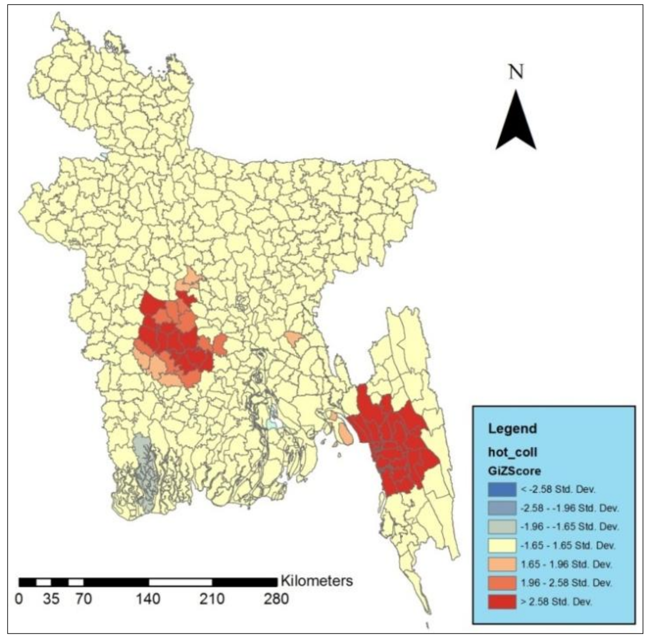

Figure 7. Local spatial autocorrelation patterns College

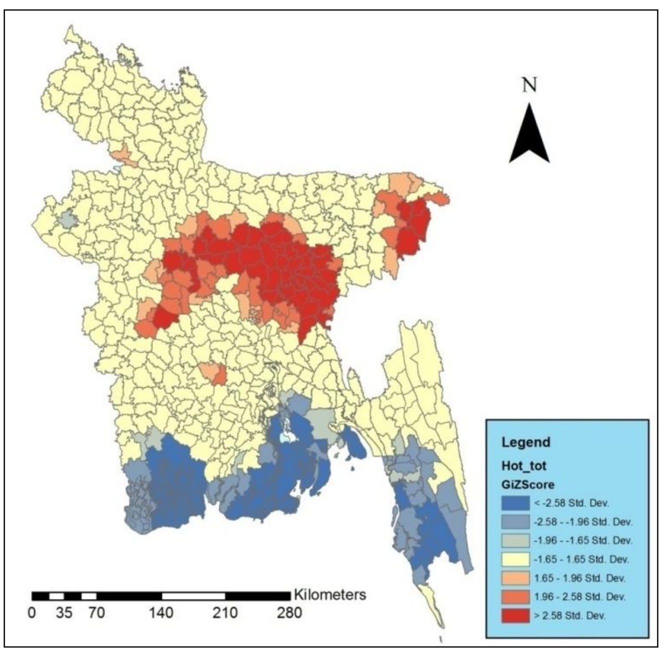

Figure 8. Local spatial autocorrelation patterns of public facilities (aggregated level)

6. Conclusion

In recent years, spatial equity of public facility planning has become a critical issue in many countries. As the research concerning public facilities involves dealing with complex characteristics of different types of facilities with varied preferences and importance, existing indices fail to meet this need. To solve the problem, this paper has proposed a GIS based integrated spatial equity index as a set of integrated indices to measure spatial equity based on accessibility. Here, the accessibility to the facilities has been considered at the community level and both in aggregate and disaggregated level for different types of facilities. GIS and spatial analysis techniques, offer an easily and intuitively interpreted summary of the data. Future studies can integrate more types of facilities according to the proposed method. Moreover, travel time, travel cost and population demand can also be considered in a more extensive level. By doing so, the spatial equity of public facilities at different levels can be better discerned.

Conflict of Interest

All authors declare no conflicts of interest in this paper

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Appendix

Sub-district	Final Integrated Score	Sub-district	Final Integrated Score	Sub-district	Final Integrated Score	Sub-district	Final Integrated Score
Amtali	6.2229	Barura	6.5062	Brahman Para	10.5988	Shib Char	7.7011
Bamna	8.3162	Rowangchhari	6.3703	Burichang	31.4962	Zanjira	7.4542
BargunaSadar	2.2586	Ruma	4.6681	Chandina	7.0864	Dhanmondi	0.7368
Betagi	8.4025	Thanchi	2.4830	Daudkandi	10.7027	Kotwali	4.9158
Patharghata	5.9963	Akhaura	8.1345	Debidwar	7.4514	Lalbagh	1.3673
Agailjhara	12.1372	Banchharampur	11.7840	Homna	11.8668	Gauripur	10.9038
Babuganj	15.2723	Kasba	10.1749	ComillaSadar (kotwali)	6.0625	Ishwarganj	12.2586
Bakerganj	10.4657	Nasirnagar	11.0440	Laksam	11.8892	SirajganjSadar	15.3103
Banari Para	4.3464	ChandpurSadar	7.6750	Muradnagar	4.5353	Bhuapur	3.2134
Gaurnadi	8.3154	Faridganj	22.7603	Chakaria	4.1332	Sarishabari	8.0728
Hizla	2.9107	Haim Char	5.6023	Cox's Bazar Sadar	9.1456	Madarganj	14.6621
Barisal Sadar (kotwali)	1.8565	Hajiganj	11.7097	Kutubdia	14.7795	Bhangura	2.2577
Mehendiganj	4.3725	Kachua	8.3580	Maheshkhali	1.5473	Faridpur	16.4420
Muladi	8.3101	Matlab	10.5740	Ramu	4.3474	Chatmohar	10.5472
Wazirpur	10.5673	Matlab	10.5740	Teknaf	4.0950	Sherpur	11.2351
BholaSadar	6.1290	Shahrasti	14.4498	Ukhia	6.8030	Royganj	9.2335
Burhanuddin	5.7618	Anowara	10.8635	Chhagalnaiya	17.8600	Islampur	7.0051
Char Fasson	2.4660	Banshkhali	9.2628	Daganbhuiyan	4.0495	Dewanganj	6.4143
Lalmohan	4.4151	Boalkhali	9.7829	FeniSadar	12.9875	Bakshiganj	12.5466
Manpura	2.0327	Chandanaish	6.4837	Parshuram	9.3584	Chilmari	9.5674
Tazumuddin	4.1020	Chandgaon	0.9492	Sonagazi	14.1100	Char Rajibpur	11.3606
Kanthalia	2.4460	Chittagong Port	0.6528	Dighinala	9.5580	Madhukhali	8.8946
Rajapur	13.8780	Double Mooring	0.7301	Khagrachhari Sadar	3.0347	Mohammadpur	9.0368
Bauphal	20.4939	Fatikchhari	12.0171	Lakshmichhari	3.7100	PatuakhaliSadar	12.4369
Dashmina	3.8109	Hathazari	11.4121	Mahalchhari	4.4955	Dharampasha	9.4875
Galachipa	2.2528	Kotwali	4.9158	Manikchhari	9.3720	Jamalganj	5.5244
Kala Para	2.3093	Lohagara	8.7649	Matiranga	11.2399	SunamganjSadar	8.4333
Mirzaganj	11.2682	Mirsharai	4.5433	Panchhari	8.6845	Dowarabazar	5.9225
Bhandaria	35.6156	Pahartali	1.3082	Ramgarh	24.5667	Chhatak	13.4245
Kawkhali	22.0364	Panchlaish	0.5857	Lakshmipur Sadar	5.1792	Baniachong	8.3842
Mathbaria	8.8611	Patiya	21.5643	Roypur	2.5033	Ajmiriganj	7.0388
Nesarabad (swarupkati)	3.3776	Rangunia	11.0474	Ramganj	4.0741	JhalokatiSadar	9.2877
Alikadam	0.7524	Raozan	16.8526	Ramgati	4.1544	Nalchity	17.0239

Bandarban Sadar	8.6054	Sandwip	10.7311	Begumganj	13.3319	Singra	9.4691
Lama	3.5757	Satkania	4.5102	Chatkhil	9.8268	Raninagar	6.1973
Naikhongchhari	9.6745	Sitakunda	4.5411	Companiganj	8.6359	Chauddagram	12.4354
JuraiChhari	3.4158	Hossainpur	37.8828	Hatiya	3.5677	Nangalkot	16.6516
Langadu	6.3006	Itna	6.2138	Senbagh	5.9427	Balaganj	16.9672
Nanner Char	5.7524	Karimganj	22.5498	NoakhaliSadar (sudharam)	2.7134	Maulvi Bazar Sadar	15.6907
Rajasthali	6.0196	Katiadi	8.4239	BaghaiChhari	4.2127	Nabiganj	11.7126
RangamatiSadar	8.2976	Kishoreganj Sadar	17.4676	Barkal	23.4317		
Cantonment	7.6554	Kuliar Char	7.6533	Kawkhali (betbunia)	10.9693	Bishwanath	17.0118
Demra	9.9262	Mithamain	9.0805	BelaiChhari	12.0545	Palong	13.1297
Dhamrai	11.5065	Nikli	3.8142	Kaptai	8.0583	MadaripurSadar	13.5559
Gulshan	10.4569	Pakundia	15.8721	Bajitpur	16.8416	Nagarkanda	9.2213
Keraniganj	12.7498	Tarail	23.7294	Bhairab	44.1013	Rajoir	10.5633
Mirpur	10.0206	Daulatpur	7.2745	Sonargaon	8.2862	Bhanga	12.2863
Mohammadpur	9.0368	Ghior	10.6274	Bandar	7.9904	Sreenagar	16.6152
Motijheel	10.7190	Harirampur	4.4308	Narayanganj Sadar	10.9391	Dohar	8.9586
Nawabganj	12.3785	ManikganjSadar	11.8961	Rupganj	9.1140	Sadarpur	10.8507
Pallabi	9.5181	Saturia	9.8335	Belabo	21.7942	Maheshpur	3.5987
Ramna	8.7250	Shibalaya	8.5863	Manohardi	10.7645	Kalia	11.2899
Sabujbagh	9.5817	Singair	4.7209	Narsingdi Sadar	8.3053	Mollahat	10.0995
Savar	11.0836	Gazaria	16.8421	Palash	13.3738	Alfadanga	14.6069
Sutrapur	9.2347	Lohajang	21.4956	Roypura	10.8287	Muksudpur	16.1119
Tejgaon	9.5007	Munshiganj Sadar	14.8906	Araihazar	15.0650	GopalganjSadar	11.5194
Uttara	9.6123	Serajdikhan	15.9733	Austagram	11.7473	Kashiani	13.4267
Boalmari	14.9590	Tongibari	10.8923	Shibpur	40.7135	Kotali Para	9.4493
Char Bhadrasan	6.4957	Bhaluka	12.1802	Atpara	14.2436	Kalkini	17.0916
FaridpurSadar	9.1215	Dhobaura	4.7013	Barhatta	8.4213	Madhabpur	11.8741
GazipurSadar	11.2874	Fulbaria	4.5114	Durgapur	8.1262	Barlekha	9.6136
Kaliakair	15.3728	Gaffargaon	15.6399	Khaliajuri	7.4354	Kamalganj	1.7844
Kaliganj	7.2757	Haluaghat	4.5202	Kalmakanda	5.6105	Kulaura	34.1133
Kapasia	20.3610	Mymensingh Sadar	13.0019	Kendua	3.9529	Rajnagar	8.4057
Sreepur	15.7254	Muktagachha	28.5392	Madan	12.7021	Sreemangal	9.3515
Tungi Para	14.2954	Nandail	15.4135	Mohanganj	4.2154	Bishwambarpur	15.4703
JamalpurSadar	9.8471	Phulpur	2.9894	Netrokona Sadar	6.5960	Derai	3.1560
Melandaha	9.0462	Trishal	10.7438	Purbadhala	17.5488	Jagannathpur	7.3611
Mongla	5.3882	Kalaroa	3.7003	BaliaKandi	12.7847	Sulla	10.3610

Morrelganj	9.5505	SatkhiraSadar	17.5426	Goalandaghat	4.6373	Tahirpur	7.7264
Rampal	2.5282	Shyamnagar	6.8449	Pangsha	7.0524	Debiganj	6.4824
Sarankhola	3.5072	Tala	10.9285	RajbariSadar	7.3947	Tentulia	20.8699
ChuadangaSadar	12.7372	Adamdighi	2.8057	Bhedarganj	9.0857	Bagha	6.8623
Damurhuda	10.8650	BograSadar	2.9269	Damudya	10.2348	Baghmara	11.8762
Jiban Nagar	6.7668	Dhunat	27.3584	Gosairhat	8.1442	Charghat	9.1053
Abhaynagar	15.5936	Dhupchanchia	11.8456	Naria	16.3799	Beani Bazar	22.1221
Jhikargachha	8.3572	Gabtali	14.0042	Jhenaigati	9.6958	Saidpur	7.5412
Keshabpur	19.3955	Kahaloo	11.3866	Nakla	7.8092	Atgharia	31.8570
Manirampur	9.1805	Nandigram	9.2565	Nalitabari	14.8337	Bera	10.1501
Sharsha	7.5651	Sariakandi	5.0521	SherpurSadar	7.5704	Ishwardi	19.4788
Harinakunda	9.3233	Shibganj	7.2532	Sreebardi	9.0184	PabnaSadar	9.5129
Jhenaidaha Sadar	9.2227	Sonatola	9.4272	Basail	15.5907	Santhia	10.4860
Kotchandpur	6.1922	Birganj	9.2958	Delduar	9.9400	Sujanagar	42.1718
Shailkupa	4.0289	Biral	11.8292	Ghatail	12.7975	Atwari	10.9873
Batiaghata	6.9706	Bochaganj	9.8352	Gopalpur	27.7170	Shah Mokhdum	1.4679
Dacope	3.3261	Chirirbandar	12.1701	Kalihati	18.6493	Paba	4.2417
Dumuria	7.2371	Fulbari	8.8127	Madhupur	6.8441	Rajpara	1.2363
Dighalia	8.0370	Ghoraghat	10.9455	Mirzapur	9.5258	Boalia	0.8624
Khalishpur	1.6167	Kaharole	14.6290	Nagarpur	11.4480	Godagari	6.9373
Khan Jahan Ali	3.4417	Khansama	7.3958	Sakhipur	19.4891	NawabganjSadar	8.3909
Khulna Sadar	1.0134	DinajpurSadar	10.0017	TangailSadar	14.2748	Alamdanga	8.6074
Koyra	1.9079	Nawabganj	12.3785	BagerhatSadar	6.3673	Mirpur	10.0206
Paikgachha	11.4641	Parbatipur	18.5990	Chitalmari	25.8591	Bagher Para	8.5612
Phultala	8.3874	Fulchhari	14.3739	Fakirhat	12.5191	Chaugachha	10.5366
Rupsa	6.4020	GaibandhaSadar	7.9283	Nageshwari	6.1038	Ranisankail	6.5508
Sonadanga	0.8453	Gobindaganj	12.4366	Rajarhat	17.0825	Bahubal	7.9808
Terokhada	8.1853	Palashbari	10.8457	Raumari	3.1194	Chunarughat	15.5710
Bheramara	3.1837	Sadullapur	21.7455	Ulipur	9.6942	HabiganjSadar	8.8415
Khoksa	14.1593	Saghatta	5.6150	Hatibandha	7.6697	Lakhai	9.0547
Kumarkhali	15.6448	Sundarganj	10.3596	Lalmonirhat Sadar	10.4066	Dimla	11.2232
KushtiaSadar	9.1906	Akkelpur	8.3640	Patgram	8.3129	Domar	18.1001
MaguraSadar	13.7504	JoypurhatSadar	8.5201	Atrai	27.4303	Jaldhaka	8.1759
Shalikha	14.3068	Kalai	14.0872	Badalgachhi	10.9808	Kishoreganj	8.1371
Gangni	12.1161	Khetlal	13.8867	Dhamoirhat	12.2319	Nilphamari Sadar	3.5432
MeherpurSadar	8.8528	Panchbibi	9.6352	Manda	11.4834	Bholahat	10.8060
NarailSadar	14.9660	Bhurungamari	7.2357	Mahadebpur	7.0615	Nachole	10.6486
Assasuni	8.1040	Phulbari	11.3166	NaogaonSadar	7.8559		
Debhata	6.8592	KurigramSadar	7.3607	Niamatpur	7.9321		

Motihar	0.8780	Fenchuganj	15.6915	Patnitala	9.4701
Mohanpur	23.4481	Golabganj	18.8651	Porsha	1.8487
Puthia	25.6319	Gowainghat	7.2368	Sapahar	11.0546
Tanore	9.0964	Jaintiapur	6.6629	Bagati Para	3.0398
Badarganj	16.9827	Kanaighat	8.3355	Baraigram	1.9229
Gangachara	6.9389	Zakiganj	23.8580		
Kaunia	3.7671	Nazirpur	3.8572		
RangpurSadar	5.3709	PirojpurSadar	3.8039		
MithaPukur	12.5039	Sarail	4.2363		
Pirgachha	10.6807	Nabinagar	10.8384		
Pirganj	8.3442	BrahmanbariaSadar	9.3980		
Taraganj	12.0139	PanchagarhSadar	11.0186		
Belkuchi	18.0353	Boda	10.9212		
Chauhali	5.7657	Aditmari	5.0361		
Kamarkhanda	16.9398	Hakimpur	13.3770		
Kazipur	10.1384	Birampur	12.1872		
Shahjadpur	16.8758	ThakurgaonSadar	6.2385		
Tarash	12.6800	Gomastapur	3.4606		
Ullah Para	9.7909	Gurudaspur	2.4182		
Baliadangi	9.8125	Lalpur	2.8180		
Haripur	10.4222	NatoreSadar	2.6931		