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Industrial Concentration as a Predictor of Slum Agglomeration in Dhaka Metropolitan Development Plan Area: A Spatial Autocorrelation Approach

Anindya Kishore Debnath*
Naznin Sultana Daisy**

Abstract

This paper articulates the measurement of the degree of spatial agglomeration and the identification of thana wise location patterns of Dhaka Metropolitan Development Plan (DMDP) in respect to slums and industries. It develops an understanding of spatial agglomeration of slums among geographic spaces due to spatial convergence of industrial investment. The study has been conducted through calculating the weight matrix, Moran's *I* values and spatial auto regressive model to develop the present scenario of spatial auto-correlation in Dhaka city. The spatial econometric analysis reveals that spatial dependence between slum agglomeration and industrial concentration exists and ignoring this spatial dependency in policy making would mislead the capital investment for future.

Introduction

Dhaka has been developed in an organic pattern since its inception. Land use distribution all over the city seldom complies with its spatial attributes. National policies and economic resource allocation strategies have caused the city to be emerged as a prime and easily accessible option for the migrants and poor people from the time immemorial for managing livelihood and earning a dignified life while contributing to various service sectors, manufacturing and processing sectors, industrial sectors etc. as skilled and unskilled labour. Like any other developed or developing countries Bangladesh has always been trying to increase its financial strength through industrial activity promotion even from the pre liberation period. Though industrial development has not been occurred with a planned manner but ushered a prospective opportunity for the increasing population (mostly for the poor, migrants and skilled labour) to be employed with a minimum wage level (though not conceived as well paid employees). But interesting thing is that despite these industrial workers randomly choose the location of their housing (mostly in slum) the question is whether there exists any spatial dependence between slum and industrial development in case of Dhaka Metropolitan Development Plan (DMDP).

Slum or squatter settlement development has never been a modern housing solution for Dhaka rather the phenomenon of slums and squatters is as old as the city itself (Taylor,

* Lecturer, Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology. Email: shuvro_kishore@yahoo.com; anindya_debnath@urp.buet.ac.bd.

** Urban Planner, Rangpur Master Plan Project, Engineering and Planning Consultants (EPC)
Email: daisy_naznin05@yahoo.com

1964 cited in Hossain, 2008). But the city has experienced a prolific growth of slums and squatters since the independence of the country in 1971 (Qadir, 1975 cited in Afsar, 2003). By the end of 1976 only 10 slums existed with a population of 10,000. The number increased to 2,156 settlements with a population of 718,143 in 1993, and 3007 settlements with a population of 1.1 million in 1996 (CUS, 1996 cited in Hossain, 2008). About 90% of the total slums and squatter settlements have developed in the last three decades. The highest concentration of growth (45%) took place between 1981 and 1990 followed by the previous decade's 26%. Only 18% of these clusters were established since 1991(Ibid cited in Hossain, 2008).

A large concentration was found in Khilket, directly opposite to the Zia International Airport. South of this, another agglomeration was identified in Badda-Satarkul area, which is in the vicinity of the Gulshan and Baridhara residential areas. Both the rate of growth in the slum population and their, tendency to emerge in more peripheral locations are likely to persist in the near future with continuing heavy rural to urban migration in the face of an ongoing dearth of land for cheap housing in more central locations.

In Bangladesh, historically, the major urban centres developed around industrial concentrations of cotton and silk production and indigo processing (Dani, 2009). During the British rule most of the urban centres served as tax collection and export-import centres for the British Empire. Other urban centres were used as administrative or religious centres, and many of these centres subsequently flourished as commercial and industrial centres (Hossain, 2008). Hazaribagh, Nawabganj areas in the western quarter of the city, were developed in the same period as industrial areas (Islam, 2008).

Objective of the Study

The study would mainly try to identify the existence of spatial dependence of slum area development on industrial development. In some other way, it would also be conceivable to address the spontaneous industrial development as parameter for unplanned and haphazard slum development in and around Dhaka City. The specific objectives of the study are: i) to explore whether there exists spatial dependence between industrial development and slum concentration for DMDP area; and ii) to identify the location, where industrial concentration would invite slum concentration within the study area.

Methodology of the Study

Data collected from census of slum and floating population, 1996 has been used as baseline data for estimating no. of slum for the year 2005 where as no. of industry for each thana has been directly collected from economic census, 2005. Data collected from various sources were analyzed through GIS and GeoDa. The base map of thana wise distribution of DMDP has been operated using mainly ArcGIS 9.2. Spatial auto-regressive model, Moran's *I* values and Moran scatter plot have been constructed by using GEODA and hence statistically analyzed.

Constructing Weight Matrix

Spatial autocorrelation measures such as Moran's *I* requires a weights matrix that defines a local neighborhood around each geographic unit. The value at each unit is compared

with the weighted average of the values of its neighbors. A weights' file identifies the neighbors. Weights can be constructed based on contiguity to the polygon boundary (shape) files, or calculated from the distance between points (points in a point shape file or centroids of polygons).

The formula for each weight is:

$$w_{ij} = \frac{C_{ij}}{\sum_{j=1}^{N} C_{ij}} \text{ with } C_{ij}=1 \text{ when i is linked to j, and } C_{ij}=0 \text{ when otherwise}$$

Rook congruity has been used where contiguity refers to what polygons are selected as neighbours for a single target polygon. Rook congruity calculates weights based on the common boundary shared polygons/ administrative units (Anselin, 2003).

Moran's I

The spatial dependence (global spatial autocorrelation) measure of Moran's *I* s represented by the following equation

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

N is then number of regions, z_i and z_j are log of percentage of electricity connection of each district, w_{ij} are the elements of weight matrix W(n x n) and it is equal to one if i and j are neighbours and zero if they are not. S is the sum of all elements of W (spatial weights). A binary contiguity matrix was used adopting the familiar rules. There are two constructions of used for the binary spatial weight matrix, namely rook and queen. Rook computes only common boundaries and nodes. Here the weight matrix has been constructed using rook contiguity (Anselin, 2003). The Moran scatter plot is divided into four different quadrants corresponding to the four types of local spatial association between a region and its neighbours.

- Quadrant 1 (on the top right corner) displays the regions with a high per capita income surrounded by regions with high per capita income (above the average).
- Quadrant 2 (on the top left corner) shows the regions with low value surrounded by regions with high values.
- Quadrant 3 (on bottom left) displays the regions with low value surrounded by regions with low values.
- Quadrant 4 (on bottom right) shows the regions with high value surrounded by regions with low values (Anselin, 2003).

Univariate moran's *I* value has been calculated to identify the spatial dependence among spaces regarding slum location and industrial concentration respectively. As the univariate moran's *I* reveals spatial dependence in respect of number of slums and industries, so multivariate moran's *I* has been calculated to explore the spatial

autocorrelation among spaces considering industrial concentration as independent variable. Later on spatial auto-regressive model has been generated to quantify the spatial correlation among these two incidences. Hence, excess risk map has been produced from a predictive perspective to get an insight into the risk of slum agglomeration due to industrial concentration.

Results and Analysis

Dhaka, during 2000-2015 is expected to grow at a 3.6% annual growth rate and will reach a total population of 21.1 million in 2015 (The World Bank, 2007). In Bangladesh, high growth rate of urban centres are the result of migration from rural to urban areas. Rural people are migrating to Dhaka city because of rural push factors like landlessness, agricultural intensification, and occasional loss of harvest and also for natural hazards. These migrants cannot but manage their habitat in the slums of Dhaka city. Simultaneously, higher income earning, job opportunities attract the rural poor to urban areas. For better income rural poor migrate to Dhaka city mostly as the industries, manufacturing units, readymade garments have been constructed in Dhaka city most. An industry requires an area suitable from three aspects: raw material, labour and market. But Dhaka from its inception as capital city remains the focus of capital investment and construction activities. For running these industries like readymade garments industries, manufacturing industries; cheap labour is obvious thus rural poor migrating to slums in Dhaka city and playing this role.

Distribution of Industry and Slum in DMDP Area

Two quartile maps have been produced to generate a preliminary idea regarding thana wise distribution of industries and slums of DMDP area, shown in Figure 1 and Figure 2. Table 1 provides the corresponding list of thanas comprising each quartile from where it is plausible to consider the issue of spatial dependence between these two variables with a more insightful attitude. Each quartile of both figures (Figure 1 and 2) is comprised of some common thanas, more importantly total 18 thanas in common out of 24 thanas of DMDP area (five thanas in common for 1st quartile, three thanas in common for 2nd quartile, five thanas in common for 3rd quartile and five thanas in common for 4th quartile), which indicates some sort of spatial compliance, though may not directly, between these two spatial phenomena.

Spatial mismatch does also exist among thanas in respect to slums and industrial concentration, like Cantonment thana falls in 1st range in respect to industrial concentration, but falls in 2nd range in respect to slum agglomeration. It is also revealed that thanas within Dhaka City Corporation (DCC) area have higher concentration of slums and industries presenting the core city centred investment strategy as well.

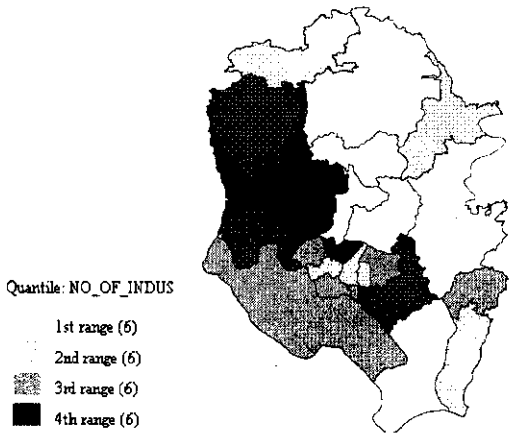


Fig. 1: Quartile map of Industrial Concentration

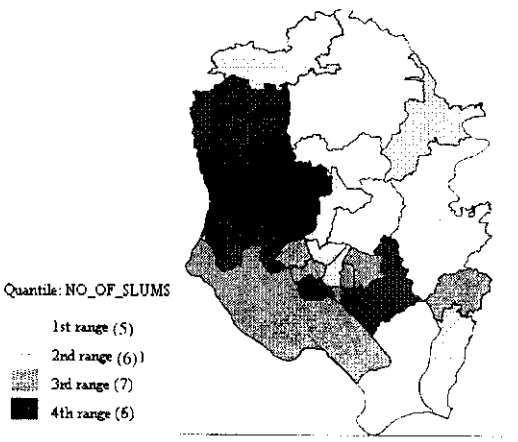


Fig. 2: Quartile map of projected Slum Concentration

Table 1: Moran's *I* values for 24 Thanas of Dhaka.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Locations of Industrial concentration	(7 thanas) Gazipur, Uttara, Cantonment, Gulshan, Rupganj, Narayanganj Sadar	(6 thanas) Joydevpur, Kaliganj, Dhanmondi, Ramna, Motijheel, Bandar	(6 thanas) Keraniganj, Mohammadpur, Kotwali, Lalbagh, Sabujbagh, Sonargaon	(6 thanas) Savar, Pallabi, Mirpur, Tejgaon, Sutrapur, Demra
Locations of slum concentration	(5 thanas) Gazipur, Uttara, Gulshan, Rupganj, Narayanganj Sadar	(6 thanas) Joydevpur, Kaliganj, Bandar, Ramna, Tejgaon, Cantonment	(7 thanas) Keraniganj, Mohammadpur, Dhanmondi, Lalbagh, Motijheel, Sabujbagh, Sonargaon	(6 thanas) Savar, Pallabi, Mirpur, Kotwali, Sutrapur, Demra

Univariate Moran's I Scatter Plotting

Global autocorrelation statistics provide a single measure of spatial autocorrelation for an attribute in a region as a whole. Informally, +1 indicates strong positive spatial autocorrelation (i.e., clustering of similar values), 0 indicates random spatial ordering, and -1 indicates strong negative spatial autocorrelation (i.e., a checkerboard pattern). These scatter plots show the values of original variable (No. of slums and industries) on the horizontal axis and the spatial lag of the variable (No. of slums and industries in the tract's neighbours) on the vertical axis. Both variables are standardized and the graph is

divided into four quadrants: high-high (upper right) and low-low (lower left) indicating positive spatial autocorrelation; and high-low (lower right) and low-high (upper left) indicating negative spatial autocorrelation. The slope of the regression line is Moran's *I*.

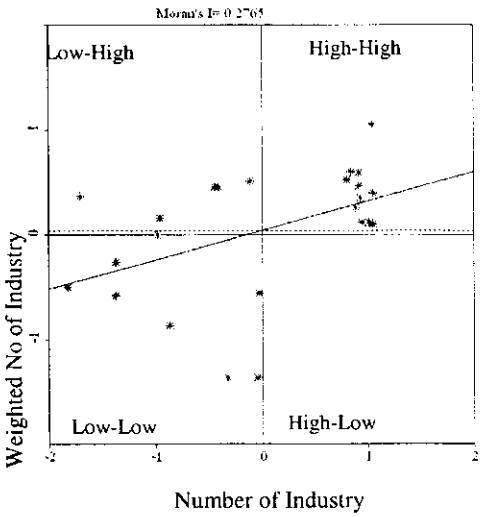


Fig. 3: Moran's *I* value for industrial concentration.

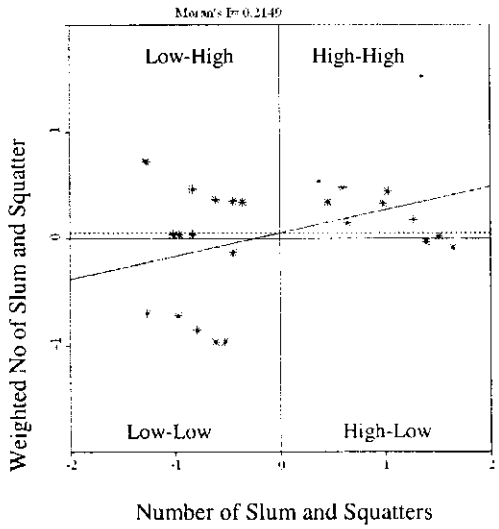


Fig. 4: Moran's *I* value for slum concentration.

Positive Moran's *I* values are observed in Figures 3 and 4, for thana wise number of industry and number of slum in DMDP are nothing but the reflection of presence of some degree of homogeneity among the neighbouring thanas of DMDP with respect to industrial concentration and slum concentration respectively. From an orthodox understanding, it simply means that impact of low-high and high-low spatial relations are offset by the dominance of high-high and low-low spatial correlations. Closer inspection into Table 2, showing the distribution of thanas of the four quadrants of the scatter plots, would exhibit more insightful and advanced understanding behind the reasons of such spatial correlation.

High-high spatial dependence means that the thana with high industrial concentration or slum concentration is surrounded by high industrial concentrated thanas or slum concentrated thanas respectively. This scenario might specially commensurate with the spread effect in case of industrial concentration, which happens due to external scale of economies in a location whereas high slum concentrated thanas surrounded by high slum concentrated thanas can be explained by greater income opportunities. Another interesting fact is that most of the thanas (i.e. Sutrapur, Sabujbagh, Lalbagh, Kotwali and Keraniganj) falling under the high-high spatially correlated quadrant are recognized as highly unplanned and organically developed thanas of DMDP area. Therefore, it is revealed that high-high spatial association is mostly high in thanas of DCC area.

Table 2: Distribution of industrial concentration and slum concentration.

	High – High	Low - High	Low-Low	High - Low
Industrial Concentration	11 Thanas (Tejgaon, Sutrapur, Sabujbagh, Pallabi, Mohammadpur, Mirpur, Lalbagh, Kotwali, Keraniganj, Demra, Savar)	6 Thanas (Narayanganj Sadar, Motijheel, Dhanmondi, Cantonment, Ramna, Gulshan)	7 Thanas (Uttara, Bandar, Gazipur, Joydevpur, Kaliganj, Rupganj, Sonargaon)	
Slum Concentration	8 Thanas (Sutrapur, Sabujbagh, Pallabi, Mohammadpur, Lalbagh, Kotwali, Keraniganj, Savar)	8 Thanas (Uttara, Tejgaon, Narayanganj Sadar, Motijheel, Dhanmondi, Cantonment, Ramna, Gulshan)	6 Thanas (Bandar, Gazipur, Kaliganj, Joydevpur, Rupganj, Sonargaon)	2 Thanas (Demra, Mirpur)

Again low-low spatial autocorrelation implies that less industrially concentrated thanas or slum concentrated thanas are surrounded by less industrially developed thanas and less slum concentrated thanas respectively which corresponds to the similar geographic spatial influence among places adjacent to each other. In case of industrial concentration, this may happen for not being suitable for industrial location and less strategic concentration for industrial development from both private and government sectors in these thanas. The same consequence for slum concentration could be addressed by the presence of fewer income opportunities or job certainties in those thanas. Thanas of low-low spatial association are mostly observed outside the core Dhaka City like Gazipur, Bandar, Rupganj, Joydevpur, Sonargaon.

High-low quadrant of the scatter plot infers that though the thana is industrially developed or considered as highly slum concentrated but it's neighbouring thanas are industrially less developed or slum concentration is less in comparison. This may happen due to locational advantage of an area for the availability of labor, market and capital in case of explaining industrial concentration, but the data used in this study does not identify any such thana for this quadrant. Thanas with high-low spatial correlation exhibit slum concentration in Mirpur and Demra, this is because the surrounding thanas of these two thanas are developed with less slum concentration. This may be partly because of low land price in those localities.

Thanas fallen in low-high quadrant are those having lower industrial development in its own jurisdiction but surrounded by high industrially developed thanas. This may happen due to locational disadvantage of that thana. Low-high quadrant showing thanas with fewer slums are surrounded with higher slums concentrated thanas which depicts that the thana has less pull factors than its surrounding neighbours. Thanas fallen in Low-high quadrant for slums and industries indicating mostly areas with special interests like Cantonment for defense, Dhanmondi for residential zone, Gulshan as the posh residential area of the City.

Cluster Analysis for Slums and Industries

Thanas with the significant spatial association at 95% confidence level are investigated from cluster mapping (Figures 5 and 6), which reveals the high-high and low-high spatial associations are higher for the two variables (e.g. no. of slum and no. of industry).

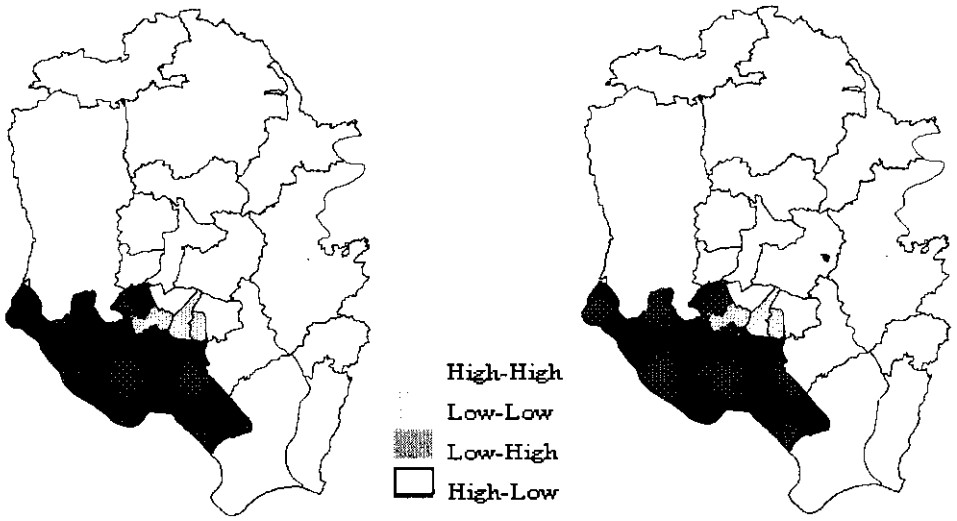


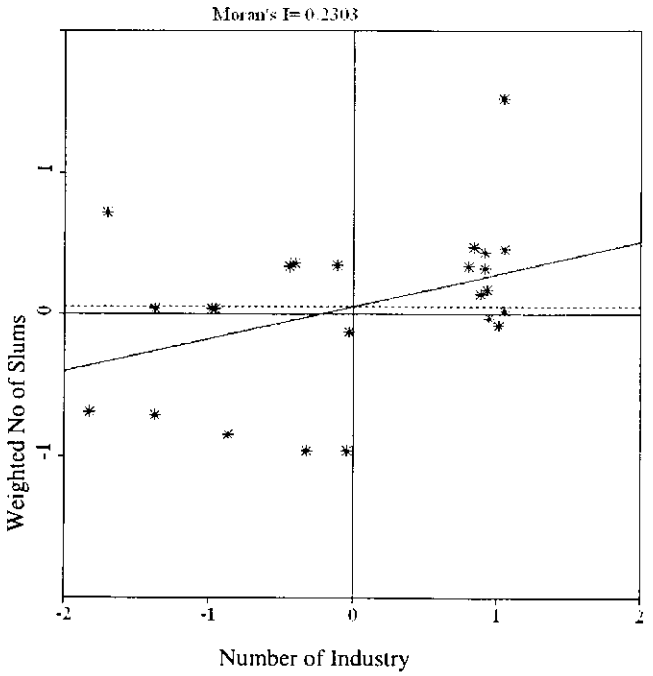
Fig. 5: Cluster Map of Industrial Concentration at 95% confidence level

Fig. 6: Slum Concentration at 95% confidence level

In Figure 5, cluster map for industrial concentration shows high-high correlation is dominating, which depicts the Dhaka city centred industrial agglomeration clearly. This is because industries, readymade garments etc. are developed in Dhaka city due to reduced transportation costs of marketing and exporting. Being the capital of Bangladesh, urban gigantism in case of investment seems to have a spill over effect on the peripheral thanas of DMDP due to economies of scale. For significant slum cluster (Figure 6), high-high association pattern is prominent too with identical spatial match between these two incidences, which strongly dictates existence of spatial dependence between industrial concentration and slum concentration.

Multivariate Moran's *I* Analysis

For above univariate Moran's *I* analysis separately for slums and industries reveals the same aerial concentration. Thus there may have a correlation between these two events. As industries are the pivotal of urbanization, so number of industries is taken as the independent variable and on the other hand slums concentration may be invited by industrial concentration in a location to ensure availability of cheap man skilled and unskilled man power, thus slum concentration has been taken as dependent variable. Therefore, the migration of rural poor may be accelerated by the industrial development in a location as the industry requires cheap labour for its production initially as a factor of production.



High-High:
Tejgaon, Sutrapur, Sabujbagh, Pallabi, Mohammadpur, Lalbagh, Kotawali, Keraniganj, Savar

High-Low:
Mirpur, Demra

Low-High:
Uttara, Naraynganj Sadar, Motijheel, Dhanmondi, Cantonment, Ramna, Gulshan

Low-Low:
Bandar, Gazipur, Joydevpur, Kaliganj, Rupganj, Sonargaon

Distribution of thanas of DMDP area for the quadrants of scatter plot

Fig. 7: Multivariate Moran's I value

In Figure 7, it is observed that there is positive spatial associations as well as homogeneity, which are dominating among thanas in Dhaka with respect to slum agglomeration due to industrial concentration. From the multivariate Moran's *I* value and scatter plotting, it is evident that there is positive influence of industrial development in Dhaka city with its increasing number of slums and squatters. Thanas of high-high quadrant reveals that these areas are with high industrial development along with high slum concentration and the surrounding neighbours also showing high spatial homogeneity and influence on a specific thana like Lalbagh, Savar. Low-low spatial association containing areas are less developed in industrial sector and these thanas inviting slum agglomeration in a rate lesser than high-high spatial association. These areas are in the peripheries like Bandar, Rupganj etc. High-low quadrant contains thanas with less number of slums though the areas have high number of industries. This may be because of the thanas are characterized with high land price and high rents and standards of living or these locations may have cheaper land prices in their neighbouring areas like Mirpur and Demra. Areas of the low-high quadrant indicate areas with higher slums but having low number of industries. This identifies those thanas which are in the peripheries of the cities featured with cheap low lying land for slum settlements and areas with lower rents and living standards like Uttara, Narayanganj etc.

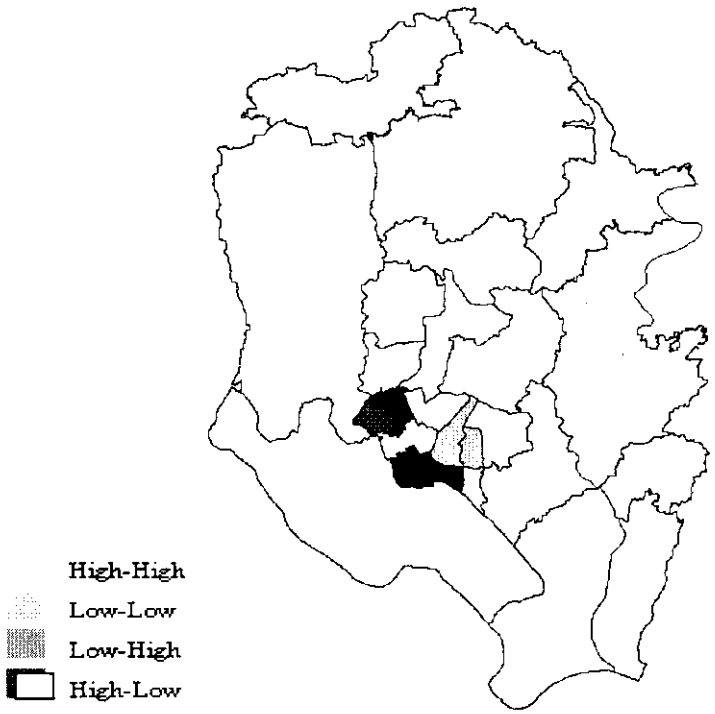


Fig. 8: Cluster map of significant Thanas at 95% confidence level.

Figure 8 reveals the significance oft auto-correlations among thanas on the basis of industrial concentration as the key factor and slums agglomeration as the effect of that. Areas showing high-high and low-high spatial associations are significant. Surprisingly all the thanas are in DCC area revealing the fact that higher intensity of this event are in core of Dhaka city. Tejgaon, Mohammadpur, Lalbagh, Kotwali - these four thanas have higher number of industries with higher number of slums where as Ramna and Motijheel thanas are characterized with less numbers of industries where numbers of slums are higher. Hence high-high, homogeneous spatial auto correlation are higher than heterogeneity in Dhaka city. Thus there is possibility that the higher the industries in an area, the higher will be number of slums and there is higher probability that this will happen in the neighbouring areas of an area having this homogeneity.

Now the equation from spatial auto-regressive model is:

$$\text{Slum Cluster} = 109.305 + 0.49598 * \text{Industrial Concentration}$$

From above equation, if the industrial concentration / number of industries increase by one, then number of slum will be increased by 0.5 times of industrial concentration. From the R-squared value and adjusted R-squared value, it has been revealed that the model expresses the variability of dataset used by more than 70% (Table 3). As there may have other reason of slum concentration along with industries, the constant value is high which are unobserved factors of slum settlement.

Table 3: Spatial Regression Analysis

Variable	Coefficient	Std. Error	t-Statistic	Probability
Constant	109.3052	56.80919	7.980511	0.2222921
No. of Industry	0.440554	0.04168785	11.89743	0.2320503
Dependent Variable	No. of Slum	Number of Observations	24	
Number of Variables	2	Degrees of Freedom	22	
R-squared	0.746626	F-statistic	64.8282	
Adjusted R-squared	0.735109	Prob(F-statistic)	0.23205	

Excess Risk Mapping

It is the ratio of the observed rate to the average rate computed for all the data. It is calculated as the ratio of the total sum of all events over the total sum of all populations at risk. If the risk of event due to base variable is less than average, excess risk ratio would be < 1 and if the risk is higher than average, excess risk ratio would be > 1 (Figure 9). In Figure 9, event variable is number of slum and the base variable is the number of industries.

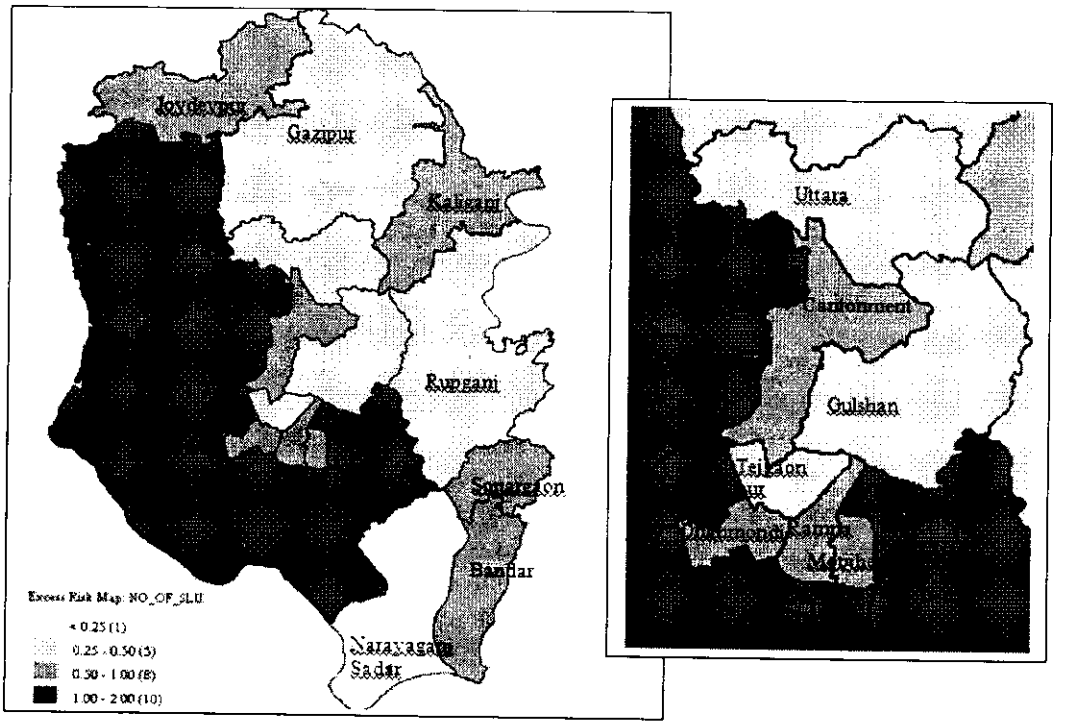


Fig. 9: Excess risk map of slum and industrial concentration.

In Figure 9, it has been revealed that most of the thanas have excess risk ratio greater than 1.00 which reveals that the possibility of having slum agglomeration due to industrial concentration is higher in 10 thanas. From the figure it is also evident that the probability of slum agglomeration due to industrial development is high in western part of the DMDP area. From the magnified image of DCC area, it has been found that eight thanas have higher possibility of inviting slums due to industrial concentration. So development of industries in these areas should be controlled. Ramna and Motijheel areas have risk value near 1.0 which may increase in future if adequate industrial development control measures are not taken.

Conclusion

The study reveals that positive autocorrelation among spaces between industrial concentration and slum concentration is dominating in DMDP area, so a location's development in industrial sector will bring industrial development in neighbouring areas. At the same time, these areas inviting slums as the multivariate moran's *I* value is positive. As the peripheral expansion of the city is prevailing, city area becoming non-manageable. Hence hundreds of unauthorized factories in the inner-city areas those inviting poor migrants from other parts of the country must be relocated to improve the capital's traffic congestion and pollution levels. Establishment of industrial parks with housing, educational and medical facilities should be done for existing industrial labours which would reduce the present slum scenario.

In Bangladesh, investment in industrial infrastructure is concentrated mainly in Dhaka city. From spatial regression model, it has revealed that 70% slum agglomeration in Dhaka city is due to the increase in industries. Urban gigantism should be lessened through decentralization of industries. Decentralization should be done in urban centres of the peripheral DMDP where cheap labour is available and the transportation network of those urban centres should be improve to a level of efficient movement. Incentives could be offered for industrial establishment in areas outside the DMDP area while utility facilities (e.g. electricity, gas, water etc.) should be ensured in other city centres to encourage industrial decentralization since Entrepreneurs want to relocate the units out of the capital but they cannot get gas or electricity supplies outside Dhaka city.

Excess risk map extract the probability of higher slums in Dhaka city as a result of industries in locations and it also convey that the tendency is higher in DCC area. Thus Taxes should be imposed at a high rate to control industrial establishment in areas with high risk. Further Industrial development should be limited in areas having excess risk of more than 1.0.

DMDP earmarks Savar municipality, Dhaka EPZ, Gazipur and Tongi as special incentive zones for industrialization. Nevertheless, from this study it has been revealed that industrial development in these areas would invite slums highly. Therefore, the declaration of DMDP contradicts with spatial dependency aspect of space. Though relocating the garment and tannery industries will significantly help to improve the city's messed-up transport situation (Islam, 2011), but it should consider the spatial relation of geographic space.

Industrial development invites labour intensity that attracts a huge number of rural poor to the capital city. These migrants, for their inability to have better housing, reside in peripheries of the city and influence the expansion of city area in every census year. This expansion of city area should be controlled through green belt strategy in the transition areas and peri-urban agriculture can be introduced in the fringe areas. Over two million garment workers are also living within the DMDP area officially (The Daily Star, 2011). Hence, the unauthorized increasing number of industries invites slums in Dhaka city that has been claimed by experts and it also goes with the findings of this study. Therefore, emphasis should be given in such industrial development by observing the spatial dependency pattern of that study area with regard to negative external impacts. In case of Dhaka city, the historic city is now deemed in its blight appeal due to traffic congestion, environmental pollution, rapid population increase and low standard of living. The root cause is the mushroom like growth of authorized and unauthorized development of factories, garments and manufacturing industries in the city area making the job opportunities for rural poor and thus inviting migrants from other rural areas. At the same time, the number of slums and area of slums are increasing. Hence for improving the situation, policies should be taken to improve the condition of slums and industrial worker by industrial park development, which is the solution for short term. The long term solution should be decentralization of industrial sector throughout the country based on raw material availability and labor availability. Hence the study showing strong findings for further policies regarding industrial establishment in Dhaka city.

Dhaka being the capital of the country, it has been the centre of all industrial investment from the very first, while at the same time, attracting rural poor to city centre making the city problematic day by day. It may be a while, before we may reach the state of 'cities without slums', but at least the beginning can be 'no planning for cities without planning with slums' which will require finding out the spatial allocation of industries and investments.

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