

# SPATIAL MODELLING OF URBAN INFRASTRUCTURE: A STUDY FROM A DEVELOPING COUNTRY (INDIA)

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*Key-words:* disparity, utility services, Cronbach's Alpha, Principal Component Analysis.

**Abstract.** Regional disparity is a challenging issue for urban planners, policy makers, academicians, bureaucrats and technocrats in the developing countries. In India, a wide-range of socio-economic disparities are commonly evident even in Class – I cities. Such an undesirable phenomenon reflects on the spatial variation of the quality of life, level of living, as well as well-being and welfare of the inhabitants. Moreover, it is against the constitutional law of equity and social justice. The present study is based on the empirical observation focused on ward wise variation of availability and accessibility to the socio-economic utility services and infrastructure accessibility in Rajarhat – Gopalpur Municipality of West Bengal. On the basis of 'Cronbach's Alpha' and 'Principal Component Analysis', the entire set of data has been arranged by five factors of which the first three (cumulative percentage of variance is 89.84) have been considered to examine the dimension of socio-economic disparities and the level of development in the city. From Cronbach's Alpha Analysis of thirty-four variables, eleven were eliminated, while transport facilities (i.e. Auto stand, Bus terminus, Bus stop, Post Office), health facilities (i.e. Hospital, Nursing Homes, PHC, etc.) and education services (Schools and Colleges) were taken into consideration for further study. The factor score determines the first three components with 89.84 % of variance. In the first component the highlight falls on the economic factors, while the second and the third components depict education and transport factors, respectively.

## 1. INTRODUCTION

The development of the socio-economic infrastructure and urban facility-utility facilities indicate the quality of life of the people of a particular area (Clark, 1997; Densam, 1994). The availability of all socio-economic infrastructures in itself is not meant for development until and unless it is adequately available, corresponding to population-size and extent of area. Such an adequacy should ensure people's accessibility to the socio-economic infrastructure (Guo *et al.*, 2001). But, unfair political practices, physiographic characteristics and the socio-cultural dogma have resulted in the unequal and irrational distribution of infrastructure in the region, leading to regional disparities (Batty, 1997; Brown *et al.*, 2004; Harris and Batty, 1993). Regional disparity emerges when any state fails to a certain extent to ensure development distribution assets equitably to all the corners of the region. An unchecked and uncontrolled process of growth, leading to regional disparities, may result in economic, social and cultural problems (Augustijn-Beckers, 2011; Hungaragi 2008). The coexistence of developed and underdeveloped regions in a country, or state, produces misallocation and underutilization of resources with untapped potential of some areas. Such disparities are not conducive to regional development (Almedia *et al.*, 2008; Kumar 2009), a phenomenon characteristic of a developing economy. The poor countries of the world are characterized by great and growing regional disparities, while rich countries generally present small and diminishing development gaps (Williamson 1965; Itzhak *et al.* 2002).

Inequalities at the level of development have been an integral feature of the history of India's economic development. The magnitude of regional disparity widened during the British colonial period, when, the colonists' own business interest, led to the development of a few port-areas alone, other parts of India being left in a very backward state. After independence in 1947, considerable emphasis

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was placed on eliminating this disparity. In the Third Five-Year-Plan (1961–1966), a separate chapter was devoted to balancing regional development (Chapter IX). Policies for the development of backward areas, at central and state levels, identification of backward areas and indicators of development for different sectors etc., were initiated and all efforts were based on the Pandey Committee, Chakraborty Committee and National Council for Development of Backward Areas (NCDBA) recommendation in the Third Five-Year-Plan (Kumar, 2009). Despite the efforts made, India was still experiencing wide inter-and intra-regional socio-economic and cultural development disparities at both macro-and-micro level (Pradhan and Kaberi, 2015).

Several studies on the magnitude of regional inequality covered a broad area and so they did in India as well. Different scholars, like Mathur (1983) and Dadibhavi (1998), tried to address regional disparities in socio-economic development by measuring the per-capita income. Rao (1985) analysed the extent of inter-state development disparities measured on the basis of the per-capita state domestic product. A group of scholars, e.g. Rao (1984), Rao and Babu (1996), Soen *et al.* (1997), Mallikarjun (2000), Hassan (2007) and Paul (2012) attempted to focus on the leading factors of different regional socio-economic development disparities by adopting the Principal Component Analysis and the Composite Index techniques. Sao (2007), Paul and Dasgupta (2008), Rahaman and Salauddin (2009) and Julfikar and Deepika (2010) tried to find out the nature and determinants of disparities of urban utility-facility services in the intra-ward variation of urban centres.

A review of studies on the issue of regional disparities reveals that most of them are based on a broad area and not on the smallest unit like the ward in a municipality. Hence, the work is an attempt to examine the spatial distribution of facility-utility services and inter-ward disparities of socio-economic development in Gopalpur Municipality.

## 2. STUDY AREA

The Rajarhat Gopalpur Municipality, established in the year 1994, is one of the newly-built Urban Local Body of the state of West Bengal. It is situated in the southern part of district 24 Parganas North. The Geographical location is 22°37'12" latitude and 88°25'48" longitude. The municipal area is bounded by the following:

- In the north – Dum Dum Municipality, Netaji Subhas International Airport.
- In the east – Panchayat area, New Township.
- In the south – Bidhan Nagar Municipality, South Dum Dum Municipality,
- In the west – Dum Dum Cantonment Canal (Fig. 1).

The current Rajarhat Gopalpur Municipality includes 35 wards, covers a 28 sq km-area and has 402,844 inhabitants (census report of 2011, Govt. of India). The historically famous Najrul Sarani (previously known as V.I.P. Road) crosses the Urban Local Body. The Municipality is situated 11 km from Kolkata by road. It is accessible by the Eastern Railways from Sealdah. Nearest Railway Station is Dum Dum Junction and Dum Dum Cantonment. Dum Dum Metro Railway Station is also at a distance of 5 km from the Municipality. The nearest port is Kolkata at Kidderpore, at a distance of 25 km. However, Haldia port is also connected by the National Highways situated at a distance of 130 km. The city is only 5 km away from Dum Dum International Airport, which is known as Netaji Subhas Chandra Airport. The Municipality is well-connected by a road and flyover network, which takes only 10 minutes to reach the Airport (Draft Development Plan Main Handbook for 2007–12).

The main objectives of this study are as follows:

- To analyse the spatial distribution of socio-economic facilities for the people at micro level;
- To identify the leading factors of socio-economic disparities and
- To examine the magnitude of inter-ward disparities in the socio-economic development of Rajarhat-Gopalpur Municipality.

### 3. MATERIALS AND METHODS

The study is based on the primary data collected by an intensive field survey (2016) in all the wards of Rajarhat-Gopalpur Municipality. The primary information is supplemented with secondary data whenever needed. To estimate the quantitative weight of a variable (i.e. number of primary schools per 1,000 population) the total population of each ward as per Census of India, 2011 was projected to 2016, when the field investigation was carried out.

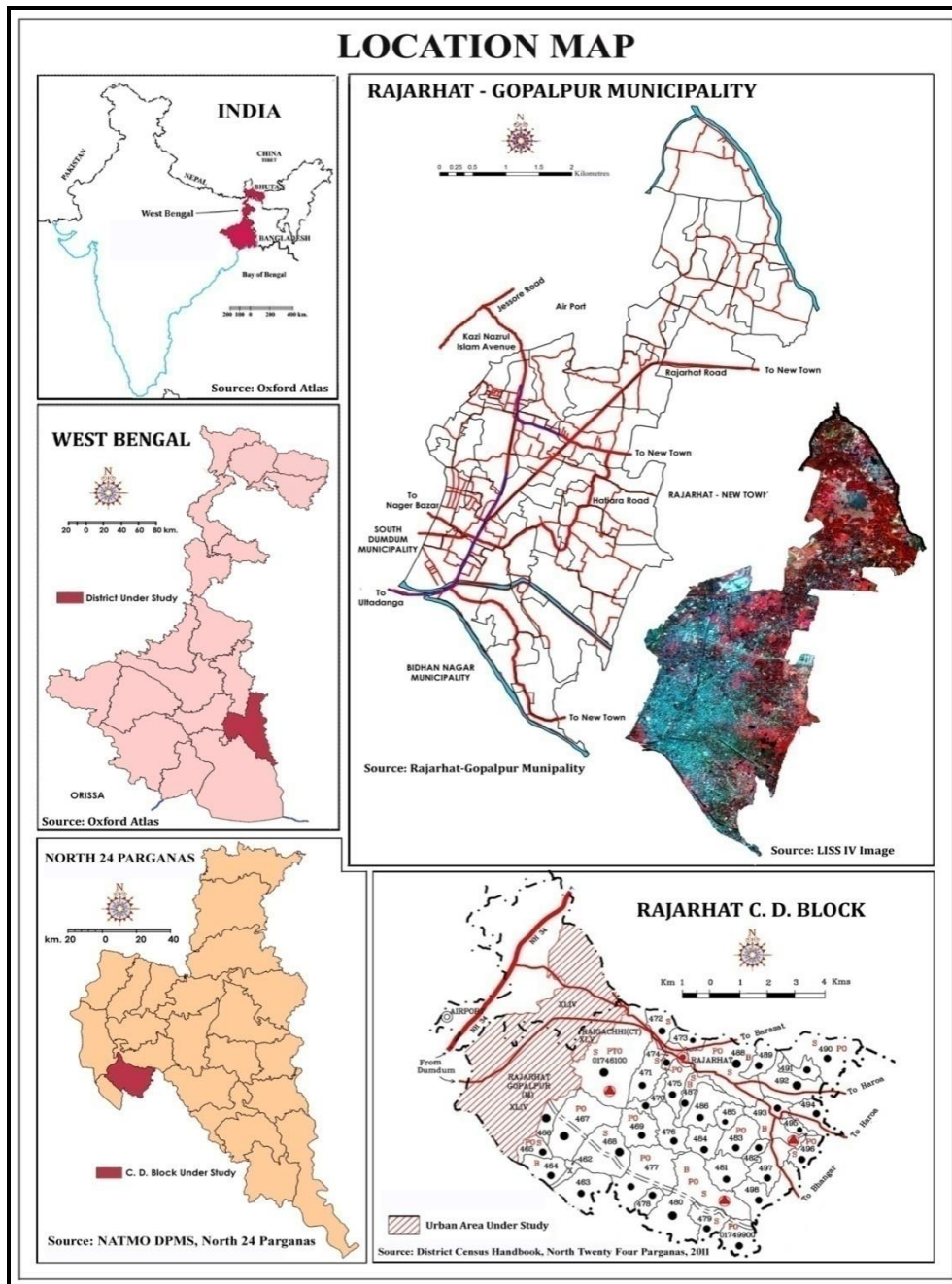


Fig. 1 – Location of the study-area.

### *Sample Design and Data Collection*

In order to access the unequal resource distribution leading to development variation among the core area, the intermediate area and the peripheral part of the Municipality, samples were selected from each part of the wards. All the thirty-five wards were selected for the purpose of sampling. Information on the number of selected socio-economic and facility-utility services were collected not in part, but as a whole, i.e. the total number of the facilities concerned being obtained by field investigation. The field survey was conducted during November–December, 2016 and collected data were analysed.

### *Use of Statistical Techniques*

For the purpose of the present study, both qualitative and quantitative methods were used. However, to infer the facts, the quantitative analysis relied on both simple and standard statistical techniques:

- The availability of infrastructure facility per unit of population was estimated in terms of the actual number of this facility per 1,000 projected population in 2016.
- The population for 2016 was projected using the simple arithmetic progression techniques.
- The accessibility of each facility in terms of the nature of distribution per unit area was measured by Mathur's method of Mean Spacing, which reads:

$$D = 1.0746 \sqrt{(A/N)}$$

where, **D** stands for the theoretical distance between facilities in a hexagonal pattern of area, **A** denotes the area of the ward and **N** represents the number of facility in that ward.

- In order to prove the internal reliability of the model used, the author checked it by **Cronbach's Alpha Test of Reliability**. Applying this test specifies whether the items pertaining to each dimension are internally consistent and whether they can be used to measure the same construct or dimension of service quality.
- Development levels were estimated after constructing a composite index based on selected physical indicators.

Certain weights were assigned to each indicator based on their value judgment to arrive at a meaningful and comparable composite index of development. For this purpose, **Factor Analysis** was used to derive factor loading, or coefficient of each variable.

The factor loading of each variable was multiplied by the corresponding standardized value to obtain factor score.

Finally, the factor score of each variable was added in order to estimate the index of development of each unit of the Municipality ward study.

The statistical model used can be expressed as:

$$P_1 = \sum a_{j1} X_j \text{ or } P_1 = a_{11} \cdot Z_1 + a_{21} \cdot Z_2 + a_{31} \cdot Z_3 + \dots + a_{n1} \cdot Z_n$$

where, **P<sub>1</sub>** denotes the composite index of development of a unit study, as first factor is the factor loading of **j<sup>th</sup>** variable and **1** indicates the factor number, i.e. first factor – vector of factor loadings. **Z<sub>j</sub>** denotes the standardized value of **j<sup>th</sup>** variable, which is expressed as:

$$Z_j = \frac{X_j - X_m}{\delta_j}$$

where, **X<sub>j</sub>** denotes the original value of **j<sup>th</sup>** variable, **X<sub>m</sub>** stands for the mean of **j<sup>th</sup>** variable and **δ<sub>j</sub>** for the standard deviation of **j<sup>th</sup>** variable.

## 4. RESULTS AND DISCUSSION

### 4.1. Availability of and Accessibility to Urban Facilities in Rajarhat-Gopalpur Municipality

The problem of the unequal distribution of facilities across the region is a common phenomenon in India. Such a problem leads to regional disparities in socio-economic development. The present study is an attempt to highlight the unequal distribution of socio-economic facilities by analysing availability per unit of population and per unit of area extension (**mean spacing**) of the different wards of the study area.

#### *Communication Facility*

Auto Stand, Bus Terminus, Bus Stop, Post Office and Telephone Exchange are important facilities of the urbanites. Basically, these communication facilities enable people to achieve different amenities located in the Municipality. Maximum number of Auto Stands is found in ward no. 11 (0.36 / '000 Population), Bus Terminus in ward no. 7 (0.14 / '000 Population), Bus Stops in ward no. 19 (0.28 / '000 Population), Post Offices in ward no. 13 (0.16 / '000 Population) and Telephone Exchanges in ward no. 25 (0.12 / '000 Population). The Post Office also determines the level of people's life. It is available only in 9 wards, with one in each ward (25.71%) out of all the wards. In ward no. 23 (0.54 km.), Bus Stop facility is better accessible as people can avail it within a shorter distance.

#### *Health Facility*

Providing availability and accessibility to health services can ensure better health conditions for the inhabitants. It is another important indicator of human development. Among the four selected health facilities, i.e. Hospital ( $X_6$ ), Nursing Home ( $X_7$ ), Integrated Child Development Services ( $X_8$ ) and Primary Health Centre ( $X_9$ ), the availability of ICDS per unit of population is much more consistent (C.V. = 75.00). Out of the 35 wards, nine (25.71 %) have a Hospital facility, twenty one (60.00%) have a Nursing Home facility. Wards no. 25 and 17 have been identified as having better availability to the first two health facilities ( $X_6$  and  $X_7$ ). However, the mean spacing analysis reveals better accessibility to health facility in wards no. 25 (0.66 km.) for  $X_6$  and no. 22 (0.41 km.) for  $X_7$ . It is evident from the analysis that the health facility is more accessible and more numerous in the core-area of Rajarhat-Gopalpur Municipality.

#### *Education Facility*

The Education facility is one of the most significant determinants of social well-being and welfare, as well as human development. Among all the educational facilities, the highest coefficient of variability (591.61) had the Library in Rajarhat-Gopalpur Municipality. However, among the education facilities, the lowest coefficient of variation, i.e. C.V. = 64.01 was computed in the distribution of Primary School. Highest availability of Primary School ( $X_{11}$ ) i.e. 0.49, followed by High School ( $X_{12}$ ), i.e. 0.39 per 1,000 inhabitants were found in wards no. 4 and 12, respectively. However, the respective analysis of the area, revealing a similar figure was depicted in the distribution of Primary School. Highest and lowest mean spacing of Primary School, 1.69 km and 0.34 km were recorded in wards no. 2 and 16, respectively. Primary Schools in ward no. 16 are much more closely spaced, ensuring better accessibility for the inhabitants than in the other wards, while a reverse situation is found in ward no. 2. High Schools are located at great distance (1.69 km) from one another in ward no. 2, the lowest distance (0.51) being recorded in ward no. 27. Further more, the highest availability of the College facility per 1,000 inhabitants was found in ward no. 12 (0.13), while thirty-one wards had no such facility at all. It comes out from the above assessment that better availability of and accessibility to education facilities were recorded in ward no. 4 (peripheral location) followed by ward no. 12 (peripheral location).

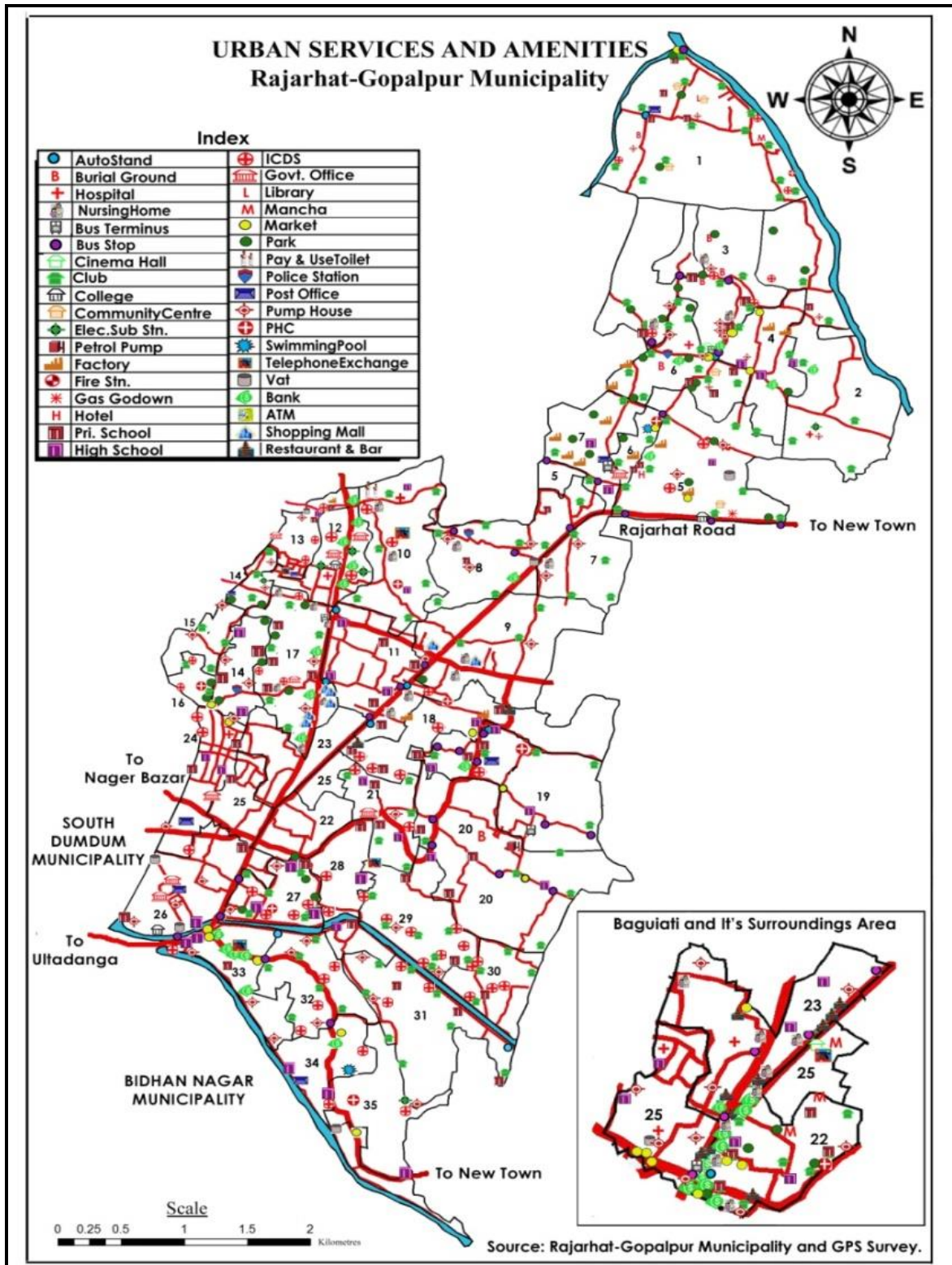


Fig. 2 – Distribution of different urban infrastructures and amenities in Rajarhat-Gopalpur Municipality.



### *Economic Facility*

This is an important indicator of economic development. The analysis reveals a disparity in the availability of and accessibility to Banking facility for people in Rajarhat-Gopalpur Municipality. Among the wards, the Banking facility ( $X_{17}$ ) is available in 17 wards (48.57 %). In case of availability per 1,000 of population, ward no. 22 (0.90) is in a better position, followed by ward no. 12 (0.65), while in the case of accessibility, the same positions are found in ward no. 22 (0.27 km) and no.12 (0.41 km) since banks are located centrally. In case of availability of ATM counters ( $X_{18}$ ), the central position of Rajarhat-Gopalpur Municipality was found to have the highest concentration of facilities. It is evident from the above analysis that the central portion of the Municipality has a better financial facility than the other wards.

Another financial indicator of socio-economic development is Markets ( $X_{16}$ ). Besides being the place of selling and purchasing goods, it is also the meeting-place of people who exchange social, cultural and political ideas leading to the socio-cultural transformation of society. It reveals a high degree of variability (C.V. =108.72) in availability among the other wards. Among wards, it is ward no. 25 that recorded a better position to market availability (0.48 per 1,000 population). However, accessibility to the market is by far better in ward no.25, where markets are located at an average spacing as low as 0.46 km, against 1.79 km mean spacing in ward no. 1.

### *Administrative Facility*

The Electric Sub-Station, Govt. Office, Police Station and Pump House are also important facilities of the urbanites. The highest Electric Sub-Station is found in ward no. 12 (0.39 / '000 Population), Govt. Office in ward no. 12 (0.26 / '000 Population), Police Station in ward no. 6 (0.16 / '000 Population) and Pump House in ward no. 14 (0.58 / '000 Population). The Police Station oversees the security of people's life. It is available only in 3 wards, with one station in each ward (8.57%) out of all wards. The Police Station facility ( $X_{23}$ ) in ward no. 14 (0.94 km.) has better accessibility, as people can reach it within a short distance.

### *Other Facilities*

The Cinema Hall, Community Centre, Petrol Pump, Gas Godown, Pay & Use Toilet, Vat, Mancha, Burial Ground, Park and Swimming Pool, etc. are very important facilities for urban people. Parks (C.V. =64.49) followed by Vats (C.V. =176.26) have the lowest variability among the other facilities. Also in case of accessibility, ward no. 22 (0.57 km) and no. 16 (0.34 km) have the least mean spacing in Pay & Use Toilets and Manchas ( $X_{29}$  and  $X_{31}$ ) and Parks ( $X_{33}$ ), respectively.

## **4.2. Reliability Statistics**

In order to prove the internal reliability of the model used, the authors have gone through Cronbach's Alpha Test of Reliability. Applying this test specifies whether the items pertaining to each dimension are internally consistent and whether they can be used to measure the same construct or dimension of service quality. According to Nunnally (1978), Cronbach's Alpha should be 0.700 or above. But in some of the studies, 0.600 is also considered acceptable (Gerrard *et al.* 2006, Kenova and Jonasson 2006). The table below indicates some of Cronbach's Alpha accuracy values (-.072 for  $X_{13}$ , .096 for  $X_{25}$ , .164 for  $X_{26}$ , .307 for  $X_{27}$ , .399 for  $X_{28}$ , .582 for  $X_{29}$ , .356 for  $X_{30}$ , .527 for  $X_{31}$ , .131 for  $X_{32}$ , .358 for  $X_{33}$  and .278 for  $X_{34}$ ) less than 0.600. Therefore, these items were eliminated from the factor analysis. However, if Cronbach's Alpha value of all items were acceptable, it means that the present data would be suitable for factor analysis.

Table 1

Reliability Statistics Using Cronbach's Alpha.

Description of Variables (Per ' 000 Population)	Cronbach's Alpha	Description of Variables (Per ' 000 Population)	Cronbach's Alpha
$X_1$ Auto Stand	.627	$X_{18}$ ATM	.801
$X_2$ Bus Terminus	.627	$X_{19}$ Shopping Mall	.751
$X_3$ Bus Stop	.684	$X_{20}$ Restaurant & Bar	.627
$X_4$ Post Office	.654	$X_{21}$ Electric Sub-Station	.682
$X_5$ Telephone Exchange	.698	$X_{22}$ Govt. Office	.642
$X_6$ Hospital	.613	$X_{23}$ Police Station	.639
$X_7$ Nursing Home	.780	$X_{24}$ Pump House	.623
$X_8$ ICDS	-.774	$X_{25}$ Cinema Hall	.096
$X_9$ PHC	-.654	$X_{26}$ Community Centre	.164
$X_{10}$ College	.738	$X_{27}$ Petrol Pump	.307
$X_{11}$ Primary School	.623	$X_{28}$ Gas Go down	.399
$X_{12}$ High School	.662	$X_{29}$ Pay & Use Toilet	.582
$X_{13}$ Library	-.072	$X_{30}$ Vat	.356
$X_{14}$ Factory	.662	$X_{31}$ Mancha	.527
$X_{15}$ Hotel	.653	$X_{32}$ Burial Ground	.131
$X_{16}$ Market	.812	$X_{33}$ Park	.358
$X_{17}$ Bank	.691	$X_{34}$ Swimming Pool	.278

Source: computed by the authors.

### 4.3. Socio-economic Development Levels

An unequal and irrational distribution of facilities in urban centres without considering the size of the population and extent of the area causes regional socio-economic development of disparities. This is characteristic of a developing economy. Development is a multi-facet phenomenon which a society, or a region, achieves. As a spatial phenomenon, the development of a region can be explained in two ways: firstly, as the state of change in the distribution of parameters between given time points, and secondly, as the state of their existing distribution. The state of development imbalance inspires regional planners to formulate a diagnostic plan in order to achieve a balanced regional development.

The analysis of the development index of each ward estimated each variable with a factor coefficient above 0.50 as factor score composite. Using the Principal Component Analysis, the factor coefficients were arranged by five factors (i.e. Factor I, Factor II, Factor III, Factor IV and Factor V) in which the first factor reveals a 54.65 per cent variance, while the second, third, fourth and fifth factors indicate 22.87, 12.32, 6.07 and 3.02 per cent, respectively. Therefore, all the five factors cumulated show a 98.93 per cent variance. Among them, the first three were taken into consideration for estimating development, as the combination of these three factors indicates an 89.84 per cent variance. A value of the factor coefficient higher than 0.5 was considered for determining the development index. Since variables  $X_7$ ,  $X_{15}$ ,  $X_{16}$ ,  $X_{17}$ ,  $X_{18}$  and  $X_{20}$ , showing a factor coefficient above 0.50 in Factor I, they were multiplied by the standardized value of the respective variable to derive their factor score and finally to estimate the composite index of development. Likewise, variables  $X_4$ ,  $X_{11}$  and  $X_{12}$  with their factor coefficient over 0.50 were identified in Factor II. Again, for Factor III,  $X_1$  and  $X_3$  are considered as they have a coefficient value above 0.50. But no single variable shows a factor coefficient above 0.50 in Factor IV though variables  $X_9$  and  $X_{18}$  factor coefficient in Factor IV is over 0.50, which reveals only a 6.07 per cent variance, have not been included in the estimation of the development index. Subsequently, out of the 23 variables, 14 variables were observed as significantly responsible and 12 variables were taken to examine the spatial variation of socio-economic development in Rajarhat-Gopalpur Municipality.



Table 2

Factor Loading of Variables, Rajarhat-Gopalpur Municipality, 2016.

Variables and Definitions (Per ' 000 Population)		Component		
		Factor - I	Factor - II	Factor - III
$X_1$	Auto Stand	0.328	0.746	<b>0.81</b>
$X_2$	Bus Terminus	0.479	-0.146	0.413
$X_3$	Bus Stop	0.382	0.036	<b>0.61</b>
$X_4$	Post Office	-0.049	<b>0.646</b>	-0.101
$X_5$	Telephone Exchange	0.131	-0.045	0.042
$X_6$	Hospital	0.294	0.322	0.059
$X_7$	Nursing Home	<b>0.754</b>	0.346	0.258
$X_8$	ICDS	-0.013	0.05	0.046
$X_9$	PHC	0	0.037	0.031
$X_{10}$	College	0.088	0.002	0.36
$X_{11}$	Primary School	0.376	<b>0.672</b>	-0.025
$X_{12}$	High School	0.493	<b>0.703</b>	0.164
$X_{14}$	Factory	-0.002	0.237	-0.002
$X_{15}$	Hotel	<b>0.84</b>	-0.12	0.069
$X_{16}$	Market	<b>0.696</b>	0.399	0.271
$X_{17}$	Bank	<b>0.795</b>	0.045	0.28
$X_{18}$	ATM	<b>0.859</b>	0.097	0.184
$X_{19}$	Shopping Mall	0.46	0.058	0.105
$X_{20}$	Restaurant & Bar	<b>0.587</b>	0.032	0.416
$X_{21}$	Electric Sub-Station	0.347	0.001	0.268
$X_{22}$	Govt. Office	0.248	0.399	0.155
$X_{23}$	Police Station	-0.149	0.728	-0.061
$X_{24}$	Pump House	0.034	0.789	0.019
% of Variance		<b>54.65</b>	<b>22.87</b>	<b>12.32</b>
Cumulative % of Variance		<b>54.65</b>	<b>77.52</b>	<b>89.84</b>

Source: computed by the authors.

Note. Extraction Method – Principal Component Analysis, Rotation Method

*Levels of Development – Factor I (Health and Economic Facility)*

On the basis of the composite development index of Factor I, all the wards were arranged by three levels in order to study the inter-ward development disparities in socio-economic amenities. Out of the 35 wards, seven wards (20%) with a development index above 1.00 fall into the high development level. These wards are located almost in the core-area of the Municipality. Due to the old built-up area, these wards have essential amenities like, education, health, communication, drinking water, marketing and easy transport facilities.

Eleven wards (i.e. ward no. 24, 6, 4, 33, 26, 3, 10, 8, 21, 19 and 5) with a development index ranging between 0.31 and 1.00 come under the medium development level. Further more, it emerges that with a development index under 0.31, seventeen wards (49%) fall under the low development level in the Municipality. All these wards are located in the buffer area and the peripheral part of Rajarhat-Gopalpur Municipality. People living in these wards have access difficulties to health and economic facilities. As a result, people's quality of life and living level in these areas are gradually deteriorating.

Table 3

Levels of Development – Factor I (Health and Economic), Rajarhat-Gopalpur Municipality.

Level of Development	Indices	Number of Wards	Identity of Wards
High	Above 1.00	07 (20 %)	Ward no. 22, 12, 25, 17, 23, 34 and 11
Medium	0.31-1.00	11 (31 %)	Ward no. 24, 6, 4, 33, 26, 3, 10, 8, 21, 19 and 5
Low	Below 0.31	17 (49 %)	Ward no. 13, 27, 18, 35, 7, 9, 32, 14, 20, 2, 1, 29, 15, 16, 28, 30 and 31

Source: computed by the authors.

*Levels of Development – Factor II (Communication and Education Facility)*

Variables  $X_4$ ,  $X_{11}$  and  $X_{12}$  in Factor II altogether explain the levels of development of communication (Post Office) and education (primary school and high school) in the Municipality. Only nine wards (9 %) i.e. ward no. 14, 4, 11, 25, 24, 12, 13, 6 and 22 with a development index above 0.40, fall into the high development level category. The nine wards in this category are scattered within the Municipality.

Table 4

Levels of Development – Factor II (Communication and Education), Rajarhat-Gopalpur Municipality.

Level of Development	Indices	Number of Wards	Identity of Wards
High	Above 0.40	09 (26 %)	Ward no. 14, 4, 11, 25, 24, 12, 13, 6 and 22
Medium	0.21–0.40	10 (28 %)	Ward no. 7, 17, 34, 16, 1, 27, 19, 3, 5 and 21
Low	Below 0.21	16 (46 %)	Ward no. 35, 10, 26, 20, 23, 28, 18, 33, 30, 8, 2, 31, 29, 32, 9 and 15

Source: computed by the authors.

Ten wards (i.e. ward no. 7, 17, 34, 16, 1, 27, 19, 3, 5 and 21), with a development index ranging between 0.21 and 0.40, registered a medium level of communication and education development in the municipality. Further, sixteen wards (i.e. ward no, 35, 10, 26, 20, 23, 28, 18, 33, 30, 8, 2, 31, 29, 32, 9 and 15) were found to have a development index below 0.21, being considered under the low level of the communication and education infrastructure facility in the municipality. These wards are scattered within the municipality.

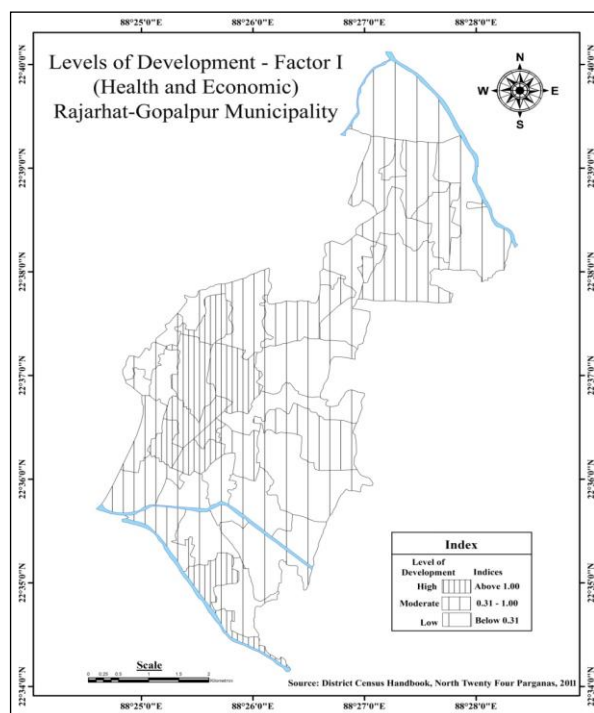


Fig. 3 – Development level – Factor I.

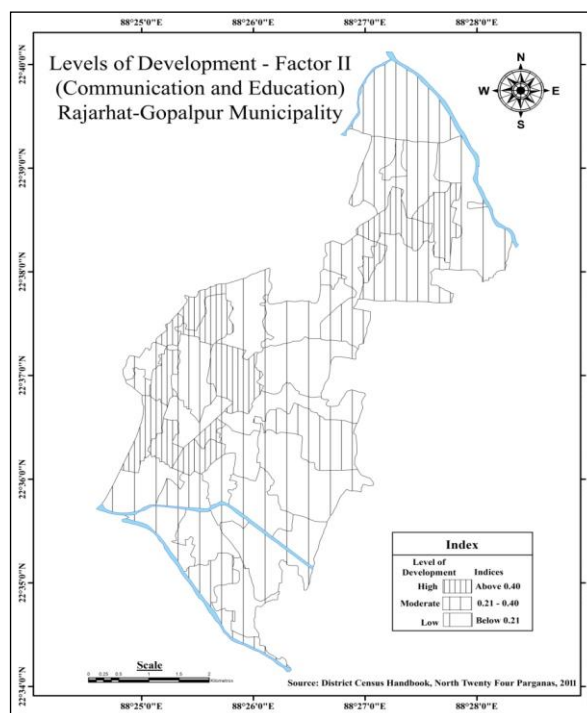


Fig. 4 – Development level – Factor II.

### Development Levels – Factor III (Communication Facility)

On the basis of Factor III, variables  $X_1$  and  $X_3$  were marked as important factor for the socio-economic development of Rajarhat-Gopalpur Municipality. Six wards with a development index above 0.20 fall into a high degree of development. These are ward no. 11, 12, 25, 34, 23 and 19. Due to the location of the Rajarhat-Gopalpur Municipality C.B.D., this area provides some good market, high transport and auto stand and bus stop facilities.

Table 5

Levels of Development – Factor III (Communication), Rajarhat-Gopalpur Municipality.

Level of Development	Indices	Number of Wards	Identity of Wards
High	Above 0.20	06 (17 %)	Ward no. 11, 12, 25, 34, 23 and 19
Medium	0.11–0.20	11 (31 %)	Ward no. 22, 17, 3, 1, 8, 21, 26, 32, 10, 9 and 20
Low	Below 0.11	18 (52 %)	Ward no. 33, 6, 14, 7, 5, 18, 27, 28, 31, 2, 4, 13, 15, 16, 24, 29, 30 and 35

Source: computed by the authors.

Eleven wards (i.e. ward no. 22, 17, 3, 1, 8, 21, 26, 32, 10, 9 and 20), with a development index between 0.11 and 0.20, fall under the medium development level. Again a majority (52 %) of the wards have a low development index level, that is, under 0.11. These wards are scattered within the Municipality. It was found that market, auto stand and bus stop facilities fail (see Figs. 5 and 6).

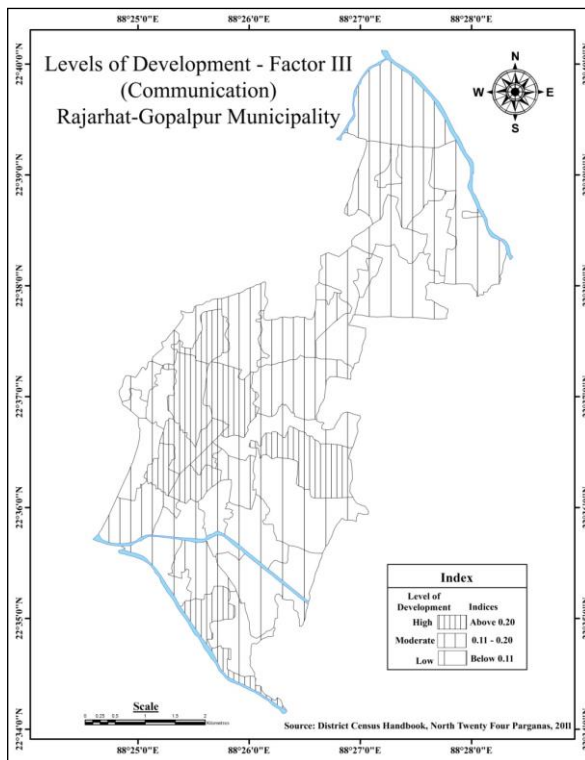


Fig. 5 – Level of Development – Factor III.

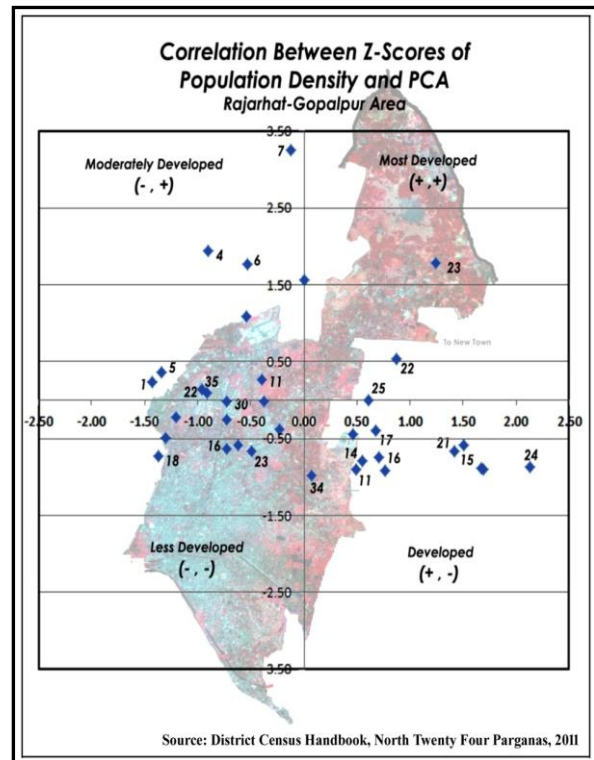


Fig. 6 – Clusters of Wards under Rajarhat Gopalpur Municipality based on Population Density and PCA.

#### 4.4. Correlation between Z-Scores of Population Density and PCA

A z-score is defined as the deviate score (the observed score minus the mean) divided by the standard deviation.

$$z = \frac{(X - \bar{X})}{s}$$

*The correlation*

- Provides means to assess the magnitude and direction of relationship between two variables.
- Although it does not prove causality, it is a first step toward investigating how one variable causes another.
- If one variable correlates with another, then it might be causally related.
- No correlation is evidence against a causal relationship.

If the **X** and **Y** variables are first standardised (to Z-scores) before the regression, the regression weight for **X** will be equal to the correlation between **X** and **Y**. This illustrates another interpretation of the correlation coefficient: it is the numbers of standard deviations that two cases are predicted to differ on **Y** if they differ by one standard deviation on **X**. So, for example, if applicant **A** scored one standard deviation higher than applicant **B** on the logical reasoning test, we would predict that applicant **A** would be about 0.736 standard deviations above applicant **B** on the creativity test (because the correlation is about 0.736).

Here, the Z-Scores values fall in 4 categories: Most Developed (+, +), Developed (+, -), Less Developed (-, -) and Moderately Developed (-, +). Thus, three wards (i.e. ward no. 22, 23 and 25) fall into Most Developed, eleven wards (i.e. ward no. 33, 34, 12, 14, 17, 2, 3, 31, 21, 15 and 24) fall into Developed, eleven wards (i.e. ward no. 30, 13, 19, 18, 27, 10, 9, 29, 8, 16 and 32) into Less Developed and ten wards (i.e. ward no. 35, 11, 5, 1, 20, 28, 26, 4, 6 and 7) into the Moderately Developed category.

#### 5. CONCLUSIONS

The foregoing analysis, based on field surveys, infers the inter-ward disparities in socio-economic development consequent upon the irrational, as well as unequal distribution of amenities and facilities. The study has revealed that the peripheral part of the city is lagging behind in socio-economic amenities, hence a low level of development. During the last decade (i.e. 2001–2011), the growth of population in this urban area was enormous and the nature of development of civic amenities was not keeping pace with the population growth. The gap in services provision was constantly widening during that period. The low level of development in the wards was due, mainly, to the allocation of facilities which did not correspond to the size of the population, the poor condition of the roads and finally carelessness of the city government to allocate resources. Another important finding of empirical observation is that the government banking facility is very little available to the people of Rajarhat-Gopalpur Municipality. To deal with this problem of inter-ward disparities in the socio-economic development of Class – I Indian cities like Rajarhat-Gopalpur, a diagnostic plan should be elaborated to provide and locate resources according to population size. Subsequently, balanced development should be achieved and social justice for the people would be ensured; consequently human well-being and welfare should be the desired result of relentless and selfless efforts made by the people, the government and the NGOs.

Presently, this urban area has merged with Bidhan Nagar Municipality and formed a new Corporation named Rajarhat-Bidhanagar Corporation, so that the local citizens could get all the urban facilities, amenities properly, according to the SMART CITY PROJECT declared by the Govt. of India in 2016.

## REFERENCES

- Almeida, C. M., Gleriani, J. M., Castejon, E. F., Soaresb., S. (2008), *Using neural networks and cellular automata for modelling intra-urban land-use dynamics*, International Journal of Geographical Information Science, **22**, pp. 943–963.
- Augustijn-Beckers, E., Bas Retsios, J.F. (2011), *Simulating informal settlement growth in Dar es Salaam, Tanzania: an agent-based housing model*, Computers, Environment and Urban Systems, **35**, pp. 93–103.
- Batty, M. (1997), *Cellular automata and urban form, a primer*, Journal of the American Planning Association, **63**, pp. 264–274.
- Brown, D. G., Page, S. E., Riolo, R. Rand, W. (2004), *Agent-based and analytical modeling to evaluate the effectiveness of greenbelts*, Environmental Modelling & Software, **19**, pp. 1097–1109.
- Clarke, K. C., Hoppen, S., Gaydos L. (1997), *A self-modifying cellular automaton model of historical urbanization in the San Francisco Bay area*, Environment and Planning B: Planning and Design, **24**, pp. 247–261.
- Dadibhavi, R.V. (1998), *Disparities in Development of North Karnataka*, Indian Journal of Regional Science, **30** (2), pp. 84–97.
- Dalal, S. (2007), *Infrastructural Facilities and Population Growth in Medium Towns in the States of Gujarat and Haryana, India*, Regional Symbiosis, **15**, pp. 103–120.
- Densham, P.J. (1994), *Integrating GIS and spatial modelling: visual interactive modelling and location selection*, Geographical Systems, **1**, pp. 203–219.
- Guo, H.C., Liu, L., Huang, G.H., Fuller, G.A., Zou, R., Yin, Y.Y. (2001), *A system dynamics approach for regional environmental planning and management: a study for the Lake Erhai Basin*, Journal of Environmental Management, **61**, pp. 93–111.
- Hangaragi, S.S. (2008), *The Dimension of Inter-Taluka Disparities in the Levels of Development of Old Bijapur District of Karnataka State*, Indian Journal of Regional Science, **40** (2), pp. 41–53.
- Hassan, M., I. (2007), *Regional Inequality in Orissa: Some Emerging Issues*, Indian Journal of Regional Science, **39** (1), pp. 40–49.
- Harris, B., Batty, M. (1993). *Locational models, geographic information, and planning support systems*, Journal of Planning Education and Research, **12**, pp. 184–198.
- Pradhan, J., Kaberi, S. (2015), *Site suitability analysis using remote sensing and GIS for proper selection of solid waste disposal ground within Rajarhat Gopalpur municipal area, Kolkata, West Bengal*, International Journal of Geomatics and Geosciences, Vol. **5** (4), pp. 640–654.
- Itzhak, B., Itzhak, O., Erez, H. (2002), *Entity-based modeling of urban residential dynamics: the case of Yaffo, Tel Aviv*, Environment and Planning B: Planning and Design, volume **29**, pp. 491–512.
- Julfikar, M., A., Deepika, V. (2010), *Factors of Inter-ward Socio-Economic Disparities in Aligarh City, Uttar Pradesh*, Indian Journal of Regional Science, **42**(2), pp. 40–53.
- Kumar, S. (2009), *Inter Regional and Inter District Disparities in Agricultural Development: A Study of Uttar Pradesh*, Indian Journal of Regional Science, **41** (1), pp. 22–36.
- Landis, J.D. (1995), *Imagining land use futures: applying the California urban futures model*, Journal of the American Planning Association, **61**, pp. 438–57.
- Mallikarjun, M. (2000), *Inter-Regional Disparities in Economic Development – A Study of Andhra Pradesh*, Indian Journal of Regional Science, **32** (2), pp. 1–10.
- Masser, I., Campbell, H. (1991), *Conditions for the effective utilisation of computers in urban planning in developing countries*, Computers, Environment and Urban Systems, **15**, pp. 55–67.
- Mathur, A. (1983), *Regional development and Income Disparities in India – A Sectoral Analysis*, Economic Development and Cultural Change, **31** (2), pp. 475–505.
- Mondal, S.M., Garg, R.D. (2007), *Urban Utility Facility Mapping and Assessment of Ward-Wise Infrastructure Development of Rishikesh – A Geoinformatics Approach*, Indian Journal of Regional Science, **39** (1), pp. 111–123.
- Nishanth, T., Prakash, M.N., Vijith, H. (2010), *Suitable site determination for urban solid waste disposal using GIS and Remote sensing techniques in Kottayam Municipality, India*, International journal of geomatics and geosciences, **1**(2), pp. 197.
- Paul, S. (2012), *Factors and Dimensions of Inter-Ward Disparities in Urban Facility-Utility Services in Burdwan City, India*, Archives of Applied Science Research, **4** (3), pp. 1376–1388.
- Paul, S., Dasgupta, A. (2008), *Urban Facility-Utility Mapping of Krishnagar Municipality – An Appraisal of Ward-wise Infrastructure Development*, Indian Journal of Landscape Systems and Ecological Studies, **31** (2), pp. 91–98.
- Rao, Hemlata (1984), *Regional Disparities and Development in India*, Ashish Publishing House, New Delhi.

- Rao, Hemlata (1985), *Inter-State Disparities in Development in India*, in Mishra, G. P. (ed.), *Regional Structure of Development and Growth in India*, New Delhi, **1**, pp. 68–101.
- Saini, Vipin (2008), *Growth of Towns in Different Size Classes: Study of a Less Developed Region*, *Indian Journal of Regional Science*, **40** (1), pp. 93–97.
- Singh, Yogeshwar, Dr. M.S., Chauhan, Dr. S.K., Katiyar (2012), *SWM of Kolar Municipality Using Remote Sensing and GIS Techniques*, *International Journal of Advance Technology & Engineering Research*, **2** (1), pp. 30–33.
- Shiffer, M.J. (1995), *Interactive multimedia planning support: moving from standalone systems to the World Wide Web*, *Environment and Planning B: Planning and Design*, **22**, pp. 649–664.
- Veldhuisen, K., Timmermans, H., Kapoen, L. (2000), *Ranblas: A regional planning model based on the microsimulation of daily travel patterns*, *Environment & Planning A*, **32**, pp. 427–443.
- Williamson, J., G. (1965), *Regional Inequalities and the Process of National Development: A Description of Patterns*, *Economic Development and Cultural Change*, **12** (4), pp. 121–129.
- Wray, C., Van Olst, R. (2012), *Enabling g-government in the Gauteng City-Region*, *The African Journal of Information and Communication*, **12**, pp. 65–83.
- Yeh, A. (1990), *A land information system in the programming and monitoring of new town development*, *Environment and Planning B: Planning and Design*, **17**, pp. 375–84.
- Yeh, A., Li, X. (1996), *Urban growth management in the Pearl River Delta: an integrated remote sensing and GIS approach*, *ITC Journal*, **5**, pp. 77–85.
- Annual Administrative Report of Rajarhat-Gopalpur Municipality (2008–2009), Bureau of Urban Affairs, Govt. of West Bengal, India.
- Rajarhat-Gopalpur Municipality (2012), *Draft Development Plan Main book for 2007–12, Overview of the Municipality*, CMU, KUSP, pp. 24.

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