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EXPLAINING SPATIAL VARIATION OF RURAL DEVELOPMENT CONCERNING ACCESSIBILITY PARAMETERS: A CASE STUDY IN BELDANGA-I BLOCK OF MURSHIDABAD DISTRICT IN WEST BENGAL

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Abstract:
Rural transport is essential and probably the most important part of rural development. It works as a physical linkage, which creates a couple of other linkages to ensure greater circulation within it. Developing rural areas means not only developing agriculture but also the transport infrastructure, which improves the level of accessibility Development can be equated with accessibility, and differences in accessibility within rural settlements might cause differences in development. The present paper is an attempt to look into the matter of the relationship between development and accessibility over space. For this purpose, Beldanga-1 Community Development Block of Murshidabad District has been chosen. Z-Score and Principal Component Analysis is used to determine the level of development using some selective demographic, household amenity, agricultural infrastructure, land use, and industrial criteria. For accessibility measurement distance from roads, service points, and nodal connectivity are used. The significant correlation coefficient of overall accessibility index with the level of development (Z-score) is found but has explained only 20% of the total variation of the development. So there may be other factors that control the level of development.

1.0. Introduction

Accessibility is the ease of access to place or service or closeness to services from the residence of people. It depends on many things like distance, time, and cost of travel (Martinez et al., 2012). Good all-weather road connections along with

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available transport service are important for this purpose because a good road creates pathways and transport service helps people moving to service location easily. From this standpoint, accessibility may be (a) physical, when determined based on physical distance from roads; (b) relative, when determined based on the travel time or cost; and (c) nodal, when determined based on connectivity matrix (L-Matrix as noted in Taffe et.al., 1996). Furthermore, there are other dimensions of accessibility, i.e. (d) public service accessibility and (e) social service accessibility, which are determined based on the ease of access (distance) to public offices and social service locations.

Accessibility directly impacts upon the overall development of any area because it determines the movement of people and goods in the area. Reaching social services is very important for human development, and better connectivity, physical and transport accessibility improves access to these services. The road transport services increase the accessibility to every corner of a region and thereby increase the scale and rate of mobility of the people (NRRDA, 2008) and help themselves to participate in the nation-building process by raising their livelihood. It is well acclaimed that isolation and remoteness limit the access of rural households to secure employment and income opportunities, health, and educational facilities, and above all, limit their participation in public affairs (NRRDA, 2006). It performs as a social service by facilitating access to healthcare, welfare, and cultural or artistic events. It is an industry by its right and creates viable links between producers and consumers and between demand and supply regions and thus performs economic services (Rodrigue et al., 2013). According to Pacione (1995), accessibility is used as a measure of spatial opportunity, and without it 'rural deprivation' is the inevitable outcome. It is experienced in both developed and developing countries with different forms, and in developing countries, it is more acute (Nutley, 1999). Jhonston (1989) mentioned that the relatively far-off and isolated habitations might experience limited mobility patterns than those are better connected. Poor public transport service to education, employment, and health care facilities (Hine and Mitchell, 2003) and inequality in the supply of transport service (Langford et al., 2012) can have a great impact on vulnerable people within society.

2.0. Objectives of the study

From the above discussion, it is now well understood how transport is essential for rural people to get access to their basic services. So keeping in mind the importance of transport connectivity and resultant accessibility on the overall development of rural people, the authors in their present research have set the following objectives:

- To evaluate the spatial variation of development at micro spatial level i.e., village level in the Block,
- To measure the spatial variation of accessibility within the Block in terms of physical, social, public and network accessibility, and finally
- To assess the relationship between the level of accessibility and level of development so that clear understanding becomes possible.

3.0. Scope and limitation of the study

The study has been built on a firm base where the relationship between accessibility and development is widely discussed and established both qualitatively and quantitatively on different socio-economic conditions in different parts of the world. In the present study, this relationship is examined on the Indian perspective quantitatively but in a simpler way using available secondary information. It is also tried to unfold the degree of relationship of the various indicators of development with the different accessibility indicators, which is the fresh attempt in this paper and thus can be said as indicator level study.

There are limitations too. The most important is the limited use of data. There is a large number of indicators to be utilized, but due to difficulty constraints, some of these data could not be utilized. Another limitation is the methods. There is a wide range of established methodology for this study, but here simple methodology is followed to establish the relationship.

4.0. Study area

Beldanda-1 Block of Murshidabad District, West Bengal is situated in Sadar Sub-Division of Murshidabad District, West Bengal, with a population of 319514 (Census of India, 2011). It has one urban center, the Beldanga Municipality, surrounded by 13 Gram Panchayats (Statistical Handbook, 2012). About 97% of people live in rural areas (Census of India, 2011). There are 66 Mouzas (revenue villages) out of which 55 are inhabited (Census of India, 2011). The total area of the Block is 168.75 sq. km (Census of India, 2001).

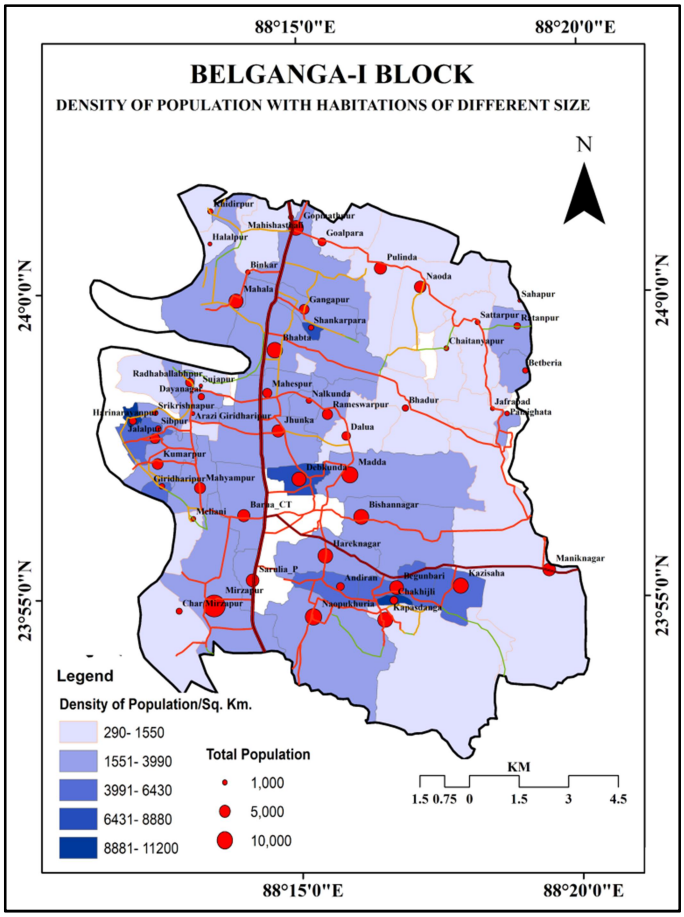


Fig. 1
Population Density and distribution in the study area

The total length of the road is about 452.73 km, out of which only 184.97 km is surfaced including National Highway, Major District Road, Other District Roads and Village Roads under PWD and PMGSY (District Statistical Handbook, 2012). National Highway No. 34 passes through this block from south to north, connecting the Block headquarter. There is one Major District Road connecting the different rural habitations. There are 5 bus routes originating/ terminating in the block (District

Statistical Handbook, 2012). This Block has been chosen for the present study due to its large base of the rural population (Fig. 2).

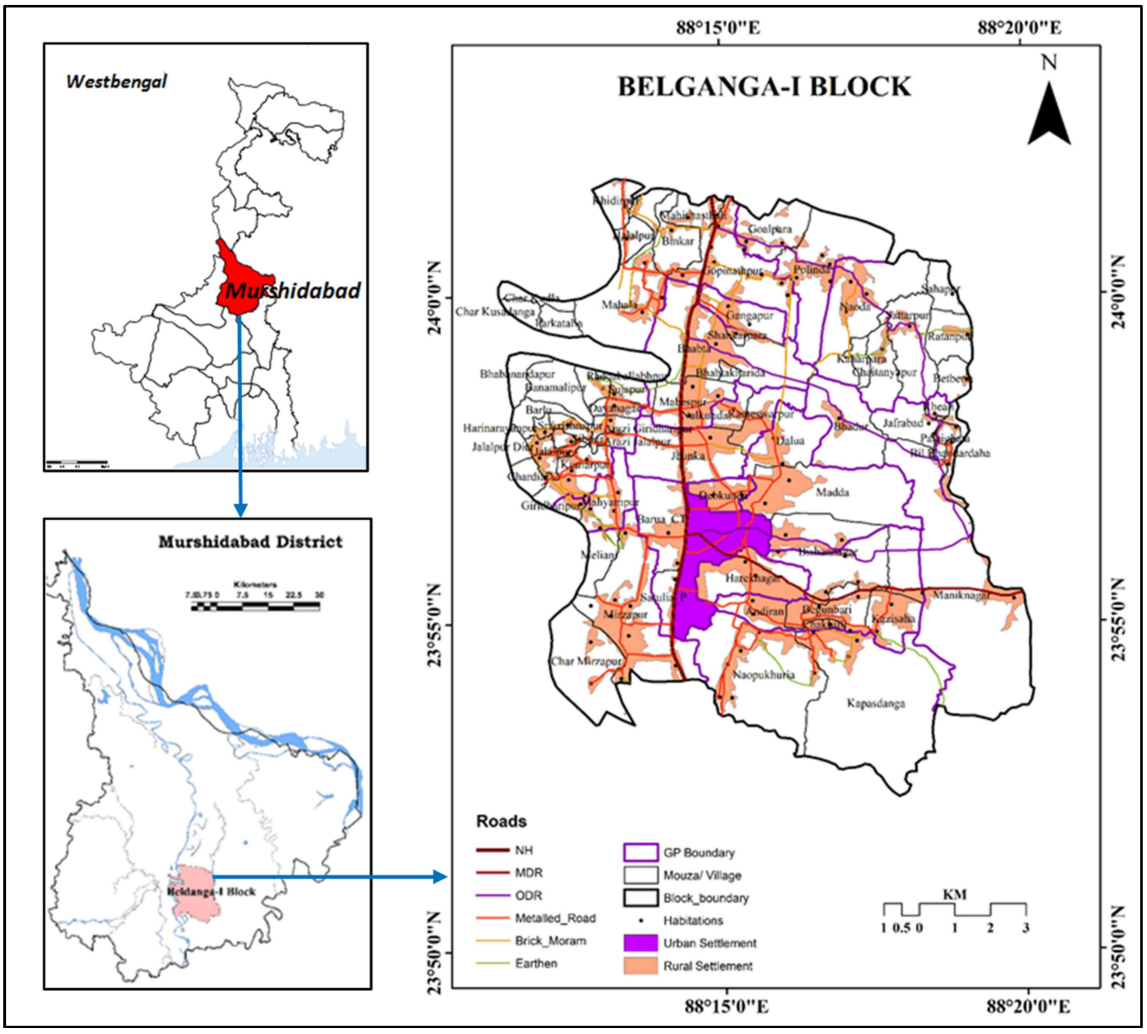


Fig. 2
Location of the Study Area

5.0. Database

The study is based on secondary data collected from different sources. For measuring the development Village directory of District Census Handbook of Murshidabad, the Census of India, 2011, has been used. For measuring accessibility, road network is prepared from Block land use map published by Land and Land Reform Department (L&LR), Government of West Bengal (2014). The information on categories of roads and the PMGSY roads are collected from the WBSRDA, Murshidabad (2016). The generated road network map is then verified thoroughly by Google Earth Satellite Images. Some field verification has also been done to confirm the type of road and the transport service points. Settlement patches are extracted from the Block land use map and later verified in Google Earth.

6.0. Methodology

Spatial variation of development can be measured in different ways, and the findings also vary along with them. Not only the method, but also the choice of variables is also an important determining factor of the success of any method. Level of socio-economic development of the villages is measured by composite indices and correlated with the accessibility indices. To develop a composite index, six indicators with 12 variables (Table 1) are chosen. Moreover, to do this first, all the 12 variables are converted into a standard score. Then two composite indices have been computed for assessing the level of development. Both the composite index has a high (0.949) mutual correlation coefficient value, which justifies its use (Fig. 3).

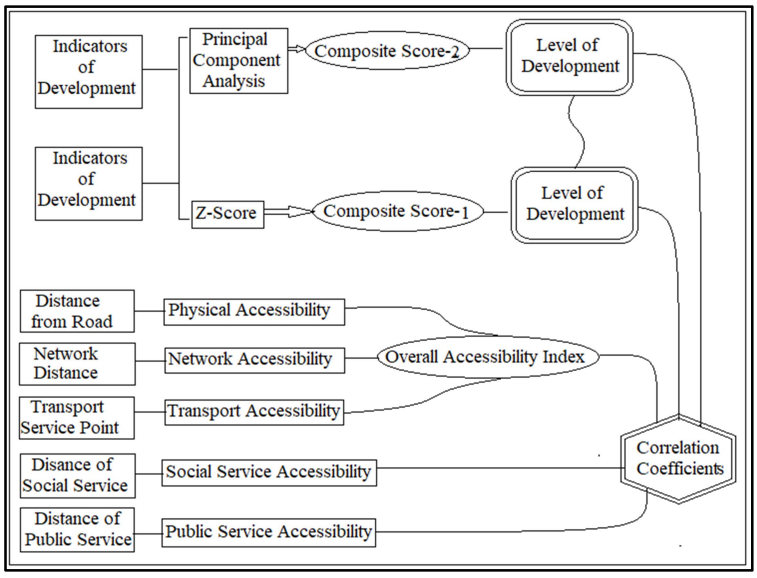


Fig. 3
Methodology flow chart

To compute the first composite index, the Z scores (Sarkar, 2013) of all the twelve variables are summed up using the following equation:

$$CDi = \frac{1}{k}\sum_{i=1}^{k} Xi - \mu$$

Equation (1)

Where, *CDi* is the composite development index of village *i*,
Xi= actual score,
μ is mean score of variable *X,* and
k is the no of variables under consideration

Principal Component Analysis has been deployed to get component scores, which are later, summed up to get the second composite index (Mahmood, 2013) using the following equation:

$$CDi = \frac{1}{n}\sum_{i=1}^{n} PCi\ (1...n)$$

Equation (2)

Where, *CDi* is the composite development index of village *i*,
PCi is the Principal Component Score, and
n is the no of Principal Components used.

Principal Component Analysis can mathematically be defined as an "orthogonal linear transformation" (Mahmood, 2013), which transforms the dataset into a new set of uncorrelated components in such a way that the highest

variance is experienced in the first component, the second most significant variance on the second component and so on. It is instrumental in grouping a large set of variables into few components, called principal component, which, in turn, helps in classifying the original variables. In the present work, it is used as a tool for measuring overall development as well as the correlation of the accessibility parameters with the components.

Table 1
Indicators and Variables of Socio-economic Development

Indicators	Variables
1. Demographic	i. Population density ii. Adult literacy rate
2. Economic	iii. work participation index- total worker to total effective population (excluding population below 06 year) ratio in % iv. % of other worker to total workers v. % of main workers to total workers
3. Household Amenities	vi. % of HH availing LPG connection vii. % of HH have full concrete house viii. % of HH have full concrete roof ix. % of HH have 2 wheeler x. % of HH have 4 wheeler xi. % of HH have electricity xii. % of HH avail banking service xiii. % of HH have latrine facility xiv. % of HH have 3 or more rooms
4 Industrial	xv. % household industry worker to total worker
5 Agricultural	xvi. % irrigated area
6 Land use	xvii. Area under non-agricultural use

Source: Census of India, 2011

Table2
Road layers for distance raster

Road Category	Distance band	Re-classification
Highways (NH/ SH)	0- 1km	1
Major Roads (NH/ SH/ MDR)	1- 2 km	2
Black Top Roads (NH/ SH/ MDR/ ODR/ VR)	2- 5 km	3
All-Weather Roads (NH/ SH/ MDR/ ODR/ VR/ BR)	5- 10 km	4
Only Earthen Roads (0-1 km= 1 and beyond= 0)	Beyond 10 km	5

Source: Prepared by authors

Table 3
Facility points for social & public service accessibility

Sl. No	Facility Category	Type of Facility
1	Education	Degree college; Higher Secondary school; Primary school.
2	Health	Rural Hospital/ Block Primary Health Centre; Primary Health Centre/ MBBS; Primary Health Sub Centre/ Maternity Centre/ Dispensary; other medical facility/ Medicine store
2	Banking and Market	Commercial/ cooperative Bank; ATM/CSP; Regular Market/ Weekly Market
4	Communication	Post office/sub-post office; Internet/ Private courier
5	Administrative	Block Development Office; GP & RI office.

Source: Compiled by authors

A single parameter is insufficient to depict the real picture of accessibility because accessibility depends on the distance from the metalled road, network connectivity, transport service provisions, and many more. Thus, in order to have a clear picture of accessibility in the study area a composite accessibility index (Overall Accessibility Index) has been devised combining three primary accessibility parameters like, physical accessibility, network accessibility and transport service accessibility using the following equation:

$$OAIi = \sum_{i=1}^{n} PAI, NAI, TAI$$

Equation (3)

Where, *PAI* is the Physical Accessibility Index,
NAI is the Network Accessibility Index, and
TAI is the Transport Service Accessibility Index

To get Physical Accessibility Index (PAI), distance rasters are generated from different categories of roads and reclassified (Table 2) by the 'Spatial Analyst' tool in Arc Map v10.2. To get the Network Accessibility Index (NAI), rasters are generated for both nodal accessibility and network diameter and reclassified into five equal classes with assigned values 1 to 5 in ascending order. In both cases, rasters are generated with the same pixel size to be compatible in 'raster calculator' and combined to get desired accessibility indices. For the Transport Service Accessibility Index (TAI), distance of habitations from nearest transport service points (Bus and Auto/Trekker) are computed using the 'Closest facility' tool of ArcMap 10.2 and averaged to villages.

Accessibility to public offices (Block Head Quarter; Gram Panchayat Headquarter and Revenue Inspector office), and accessibility to social service points (Table 3) are also computed by measuring the closest distance from the habitation to the facility locations using same way the transport service accessibility is measured. Finally, the scores are summed up, averaged to villages, and converted into unity to get desired accessibility indices. Accessibility is measured in terms of distance from the roads or service location based on this the indices are prepared, so more the distance and higher the index value, the more inaccessible the place will be.

7.0. Results and discussions

In this section, the findings of the methods applied in this study are discussed justified with valid explanations. The significant findings are as follows:

7.1. Physical Accessibility

The district has one National Highway, one Major District Road, and many village roads. Most of the villages are connected by metalled roads making good physical accessibility in the Block (Table 4). About 98% of the population and 93% of villages are within the range of 1km distance from any metalled road. This is very good in terms of physical accessibility.

Villages with JL no. 7, 9, 10, 11, 12, 13, 28, 29, 30, 31, 32, 48, 49, 52, 59, 60, which are located close to the National Highway and Major District Road, have a

high level of physical accessibility in contrast to villages with JL no. 16, 17, 18, 23, 24, located in the extreme north-east corner of the Block.

7.2. Network Accessibility

Central nodes always show the highest accessibility within a selected network, and in this paper, similar observation is received in case of network accessibility. But it is worthy of mention that the geographic area used for selecting network is crucial because with the change in the geographical area might change in the nodal accessibility value. This is even truer for a smaller area like a CD Block within a district because the road network is continuous and spread beyond the Block boundary or even the district and State boundary.

Table 4
Physical accessibility of village and population

Road/Distance	Object	Distance (Meter) from Roads				
		500	1000	2000	5000	10000
NH	Village	11%	26%	45%	89%	100%
	Population	12%	28%	45%	89%	100%
NH & MDR	Village	13%	28%	65%	92%	100%
	Population	24%	39%	66%	97%	100%
NH, MDR, ODR & VR	Village	85%	**93%**	100%	-	-
	Population	95%	**98%**	100%	-	-

Source: Prepared by the authors

7.3. Transport Service Accessibility

The most important component of accessibility is the transport service. It is well accepted that a distance of 10 km or more with good transport connectivity is more accessible than a place with a distance of 5km or even less but without any transport facility. In this Block, the Train, Bus, and Trekker services are available at different locations. However, the Buses as well as the Trekker/ Auto services are available only in the villages, which are located alongside the national highway and major district road. It is found that only trekker service is available on Sargachhi-Pulinda road in the northern part of the Block. The rail track passes through this Block from south to north and parallel to the National Highway, but only three railway stations are serving the Block. The map (Fig. 5) shows good transport service accessibility in the most part of the Block. However the villages

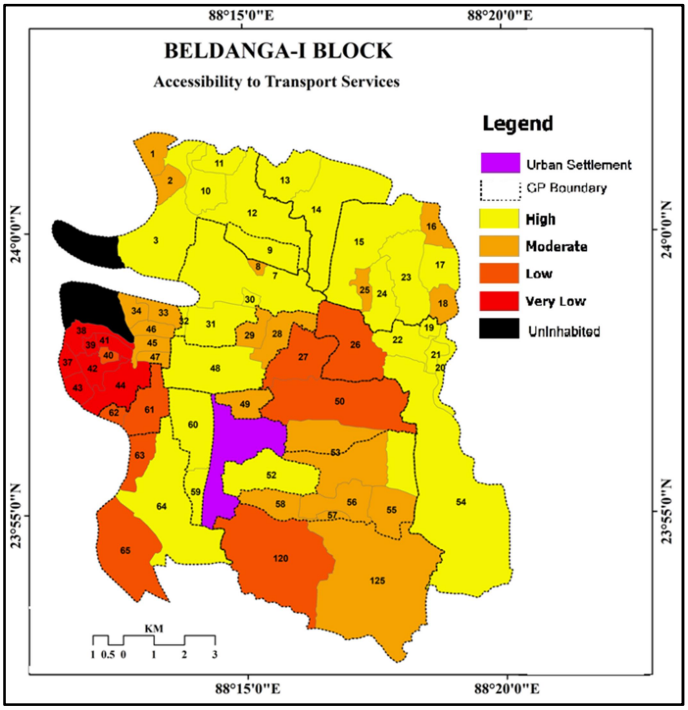
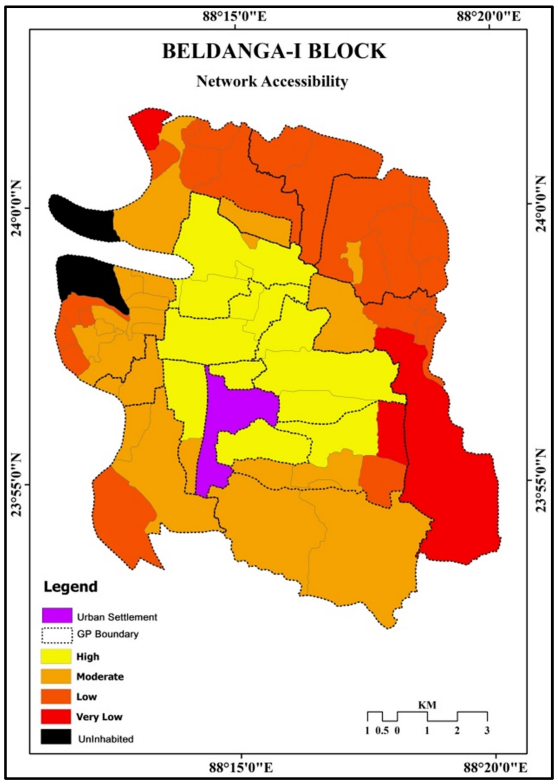
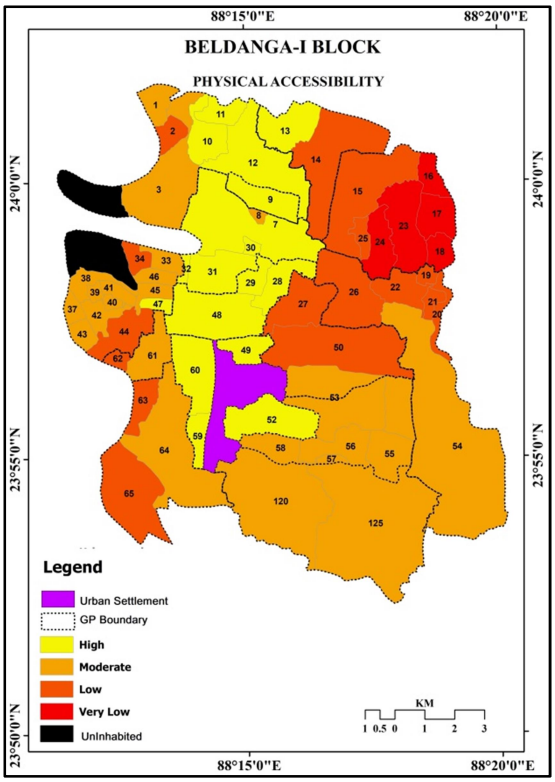


Fig. 5
Accessibility to transport service

in the extreme western part of the Block are worsely suffered from the unavailability of the transport service accessibility.



6(a)



6(b)

Fig. 6
(a) Physical and (b) Network Accessibility

7.4. Overall Accessibility Index (OAI)

The three accessibility parameters used to determine the overall accessibility index have a mutual correlation of more than 0.5, which is significant for this study. Villages located on either side of the national highway have a high level of accessibility. Mostly the villages, located in the north-eastern border area and western part have witnessed low accessibility (Fig. 6 & 7).

7.5. Accessibility to Public and social services

Accessibility to public service means ease of access to Block Development Office, Gram Panchayat Office, and Office of the Revenue Inspector. Within a distance of 2 km from Block office, only 3% village and

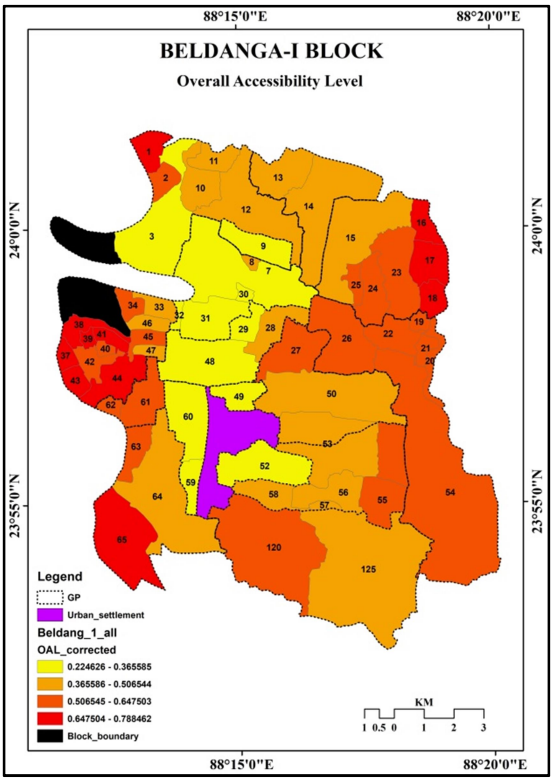


Fig. 7
Overall Accessibility Index

8% population live, which is increased to 21% and 43% respectively within 5 km. still, 26% of villages and 12% of total population live beyond 10 km distance from Block office. In the case of the Gram Panchayat office and Revenue Inspector office, the situation is quite satisfactory as about 91% of the village and 97% of the population in the block live within a distance of 5 km (Table 5).

Accessibility to higher educational institution *i.e.,* college is quite frustrating in the Block as only 18% village, and 35% population live within 5 km radius. For high school, the situation is quite acceptable because about 85% of the village and 98% of the population live within 5 km radius.

Health service accessibility is not satisfactory. Till now, about 73% of villages and 55% of the population live beyond 5 km distance from the Block hospital, although about 92% people live within 10 km distance. Banking and market service accessibility is quite good as within 5 km distance from any bank 77% of villages and 95% of the population live. For the market it is 92% and 100% respectively (Table 5).

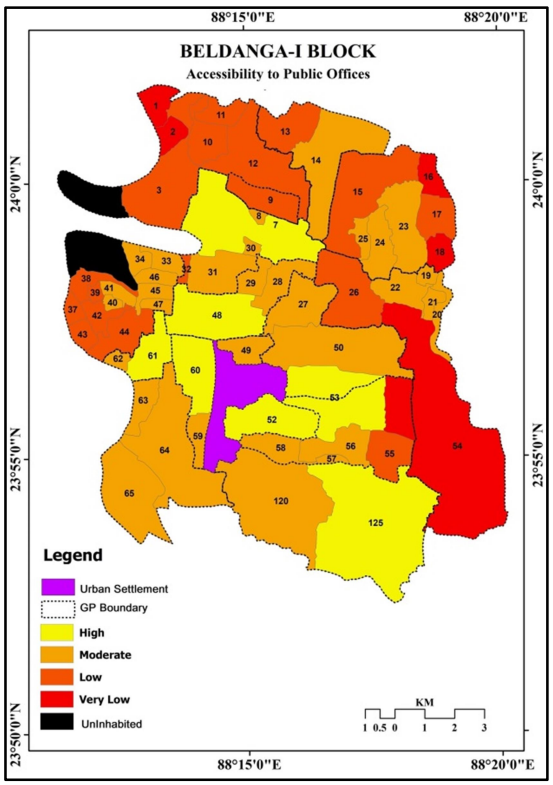


Fig. 8
Public service accessibility

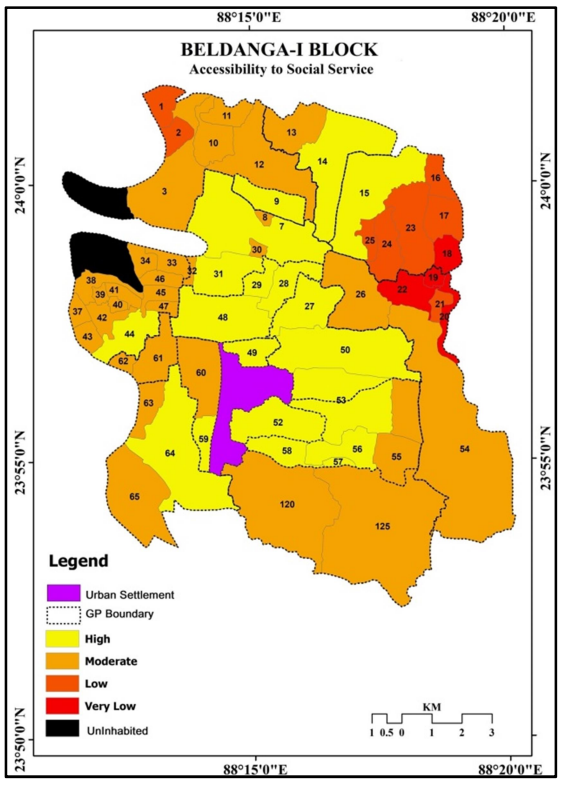


Fig. 9
Social services accessibility

Public service accessibility (Fig. 8) is high in villages around the central and southern part of the Block, which indicates the concentration of the administrative offices in the most accessible central part of the Block. High public service accessibility of these villages is influenced by the location of the BDO office in the Municipal area. The spatial pattern of accessibility, if high and moderately accessible villages are combined, is more defined, and the villages in the central and northern part enjoy good public service accessibility.

In the case of social services accessibility (Fig. 9) clearer pattern of accessibility is visible, and most villages are enjoying good social service accessibility except few numbers of villages in the North-eastern marginal part of the Block.

Table 5
Public and social service accessibility by habitation and population

Type of Public/ Social Service	Object	Distance from Roads				
		500	1000	2000	5000	10000
Block offices	Village	0%	0%	3%	21%	**74%**
	Population	0%	0%	8%	43%	**88%**
GP and RI offices	Village	11%	29%	**52%**	**91%**	100%
	Population	15%	36%	**55%**	**97%**	100%
College	Village	0%	0%	0%	18%	72%
	Population	0%	0%	0%	35%	88%
High School	Village	14%	29%	**55%**	**85%**	100%
	Population	23%	43%	**85%**	**98%**	100%
Block Hospital	Village	0%	0%	2%	23%	73%
	Population	0%	0%	3%	45%	92%
Bank	Village	3%	11%	38%	**77%**	92%
	Population	1%	8%	47%	**95%**	100%
Market	Village	26%	38%	**70%**	**92%**	100%
	Population	29%	43%	**80%**	**100%**	-

Source: Computed by the authors

7.6. Overall Accessibility Index and Other accessibility parameters

Transport is a significant contributing factor to development, and it enhances the various socio-economic components of any area with good transport. Transport also controls the growth of the settlement, and it develops in the densely and potential settlement areas. Important Public offices and various social services are also found in relatively more accessible areas, and thus a close link of the public and social services with the transport development is always noticed. In the present study, moderately strong dependence has been noticed between overall accessibility and public service accessibility (0.557) and social service accessibility (0.719) in this Block.

7.7. Level of Socio-economic Development in relation to accessibility parameters

The composite index-I and Composite index-II produce the almost identical result, and both the indices clearly depict the spatial variation of development in the Block. The strong correlation coefficient (0.95) between them (Table 7) is significant at 95% confidence level and validates both the variables selected as well as the methods chosen for.

From the map (Fig. 10 & 11) it is observed that the four villages, namely *Begunbari* (JL No 56), *Andrian* (JL No 58), *Chakhijli* (JL No 57) and *Barua-CT* (JL No 60) shows significant development and they are located along the peripheral part of the Beldanga Municipal town. Six villages in the northern part of the Block (JL No. 3, 7, 9, 11, 12, 31), four small villages in the western part of the Block (JL No. 33, 39, 42, 45) and ten villages in the south-central part of the Block (JL No. 26, 27, 49, 50, 52, 53, 55, 59, 120 and 125) has been identified as moderately developed.

Villages with high to moderate density (Fig. 1) and close to major roads (Fig. 6) and facilitated with good transport services (Fig. 4) and network connectivity (fig. 5) witness moderate to high level of development. Contrastingly, the villages located in the marginal areas of the Block show low to very low level of development. There is an exception also. The village *Sahapur* (JL No. 16) located in the north-eastern corner, surprisingly, shows moderate development, which may be due to its good relative accessibility to neighbour Block or some other factors not included in this analysis. Very low level of development is observed in the four extreme marginal villages, namely *Ratanpur* (JL No. 17), *Betberia* (JL No. 18), *Arazi Jalalpur* (JL No. 47), and Char *Mirzapur* (JL No. 65). The correlation coefficients are below 0.5, which indicates low causal relationships between accessibility indices and development indices. Thus it can be concluded that there are factors other than accessibility indicators responsible for the socio-economic development of people in the Block.

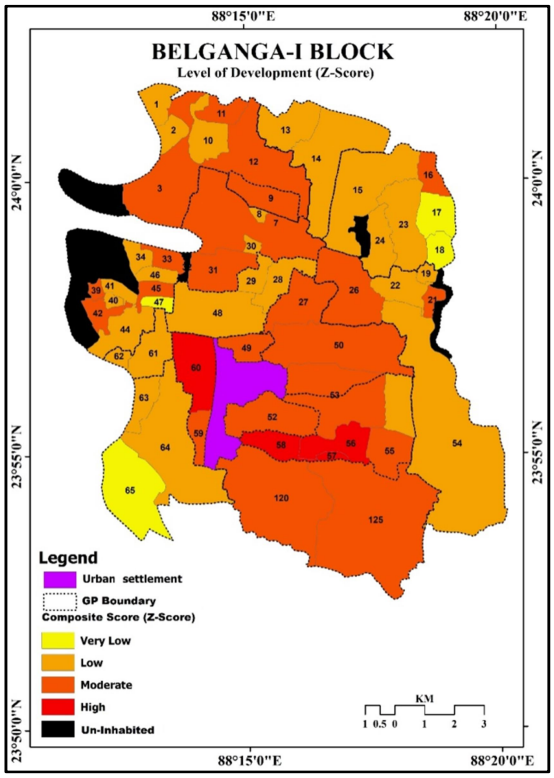


Fig. 10
Level of Development (Composite Index-I)

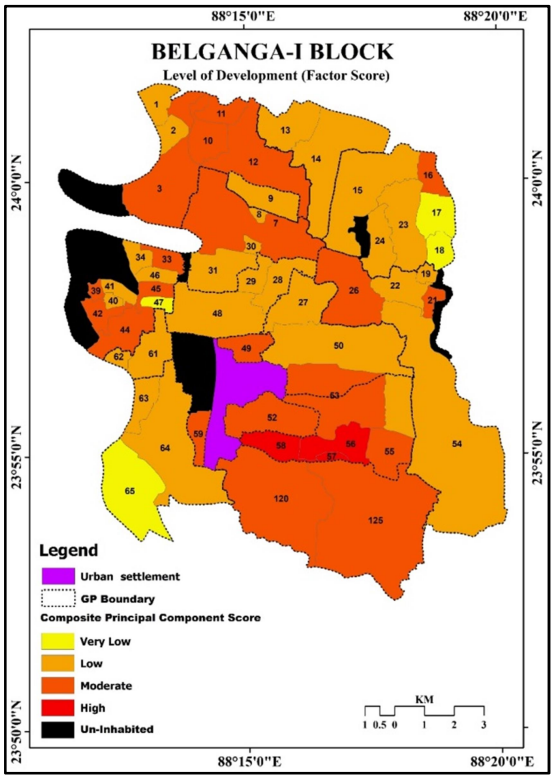


Fig. 11
Level of Development (Composite Index-II)

7.8. Principal Component Analysis and Level of Development

Principal Component Analysis (PCA) is done by incorporating the 12 development indicators. The PCA extracts five components (Table 6), contributing 72% of the total variance. The First Principal Component (PC-1) solely contributes 19% of the total variance, and it constitutes the '*demographic and household amenities component*' having positive factor loading with literacy, other workers, non-workers, LPG connections, electricity connections, four-wheelers, two-wheelers, three or more rooms and latrine (Table 6; Fig. 12).

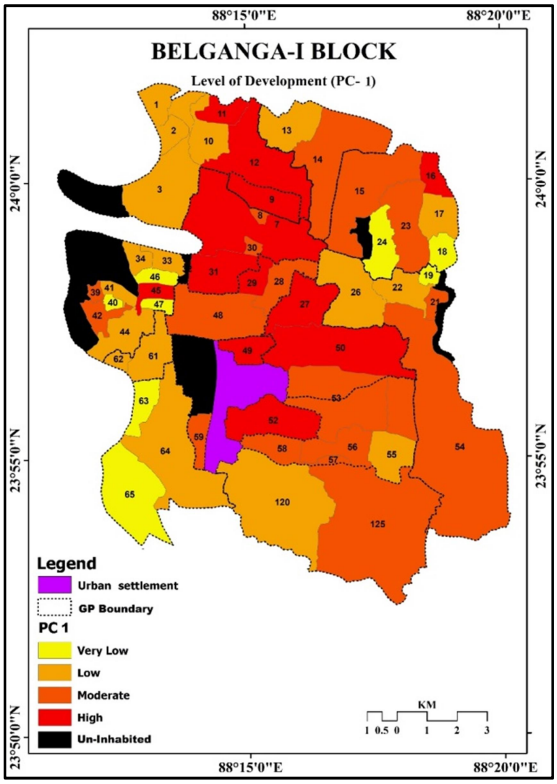


Fig. 12
PC-1: Demographic and household amenities

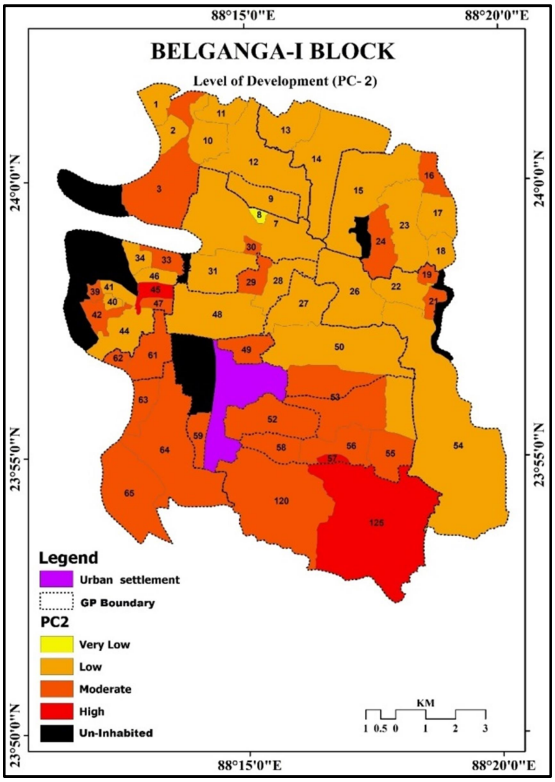


Fig. 13
PC-2: Occupation

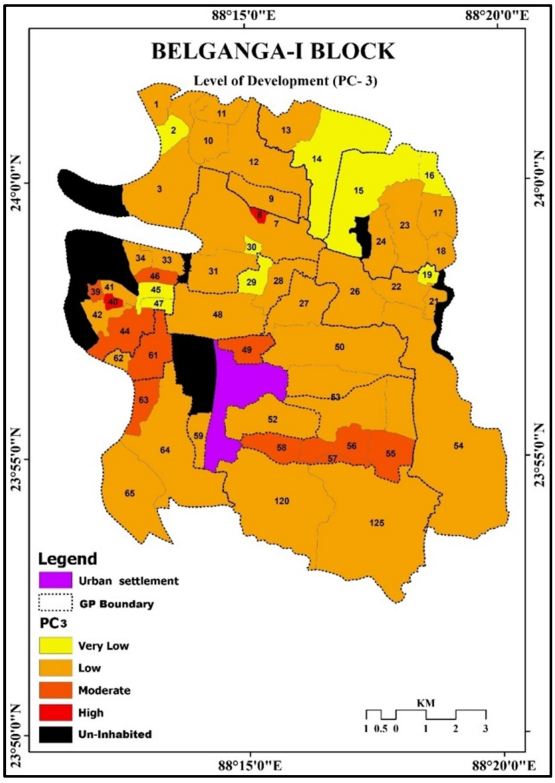


Fig. 14
PC-3: Demographic and employment

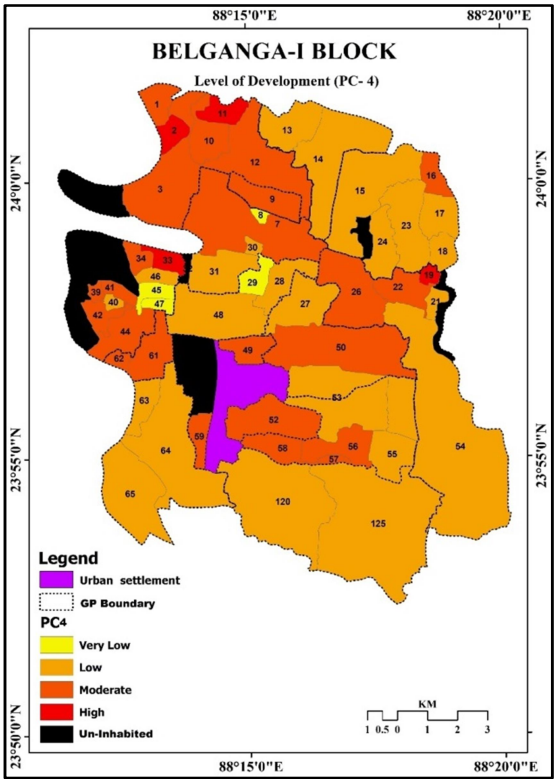


Fig. 12
PC-4: Household infrastructure component

Table 6
Principal Component Matrix

Indicators of Development	Components				
	1	2	3	4	5
Density of Population			0.727		
Adult literacy	0.606	-0.448		0.251	0.308
Work Participation Rate	-0.269	0.694	0.283		
Main Worker		0.306	-0.813	0.306	
Other Worker	0.639	0.412			
Non Worker	0.354		0.756		
Irrigated Area		0.798			
Non-Agricultural Workers		0.467	0.625		
Household Industry Workers		0.737			
Concrete House				0.921	
Concrete Roof				0.921	
Latrine	0.825				
Three or more rooms	0.830		0.332		
Two Wheelers	0.666				0.364
Four Wheelers	0.417	0.411		-0.276	0.413
Electricity connections	0.367	0.304		0.587	
LPG Connections	0.409				0.680
Banking					0.792

Source: Prepared by the authors

Table 7
Correlation coefficient between different indices

Indices	1	2	3	4	5
1. Social Accessibility Index	1				
2. Public Accessibility Index	0.494**	1			
3. Physical Accessibility Index	0.718**	0.362**	1		
4. Overall Accessibility Index	0.719**	0.557**	0.850**	1	
5. Composite Index by Z-score	-0.439**	-0.350**	-0.385**	**-0.440****	1
6. Composite Index by Factor score	-0.400**	-0.302*	-0.305*	**-0.310***	**0.949****
Principal Component-1	**-0.560****	-0.201	**-0.402****	**-0.543****	
Principal Component-2	-0.123	**-0.481****	-0.119	-0.108	
Principal Component-3	**-0.268***	-0.174	-0.094	-0.056	
Principal Component-4	0.054	0.212	-0.024	0.038	
Principal Component-5	0.004	-0.031	-0.043	-0.024	

** Correlation is significant at 0.01 level (2-tailed)
* Correlation is significant at 0.05 level (2-tailed)

Source: Prepared by the authors

The correlation coefficient value of PC-1 and the Physical accessibility, overall accessibility, and ease of access to social services are -0.40, -0.-0.53, and -0.56, which are significant at 95% confidence level (Table 6). The weak negative correlations are observed with the accessibility indicators (negative indices), which signify that the adult literacy, percentage of non-workers, and other demographic components and household amenities have improved with the accessibility indicators. However, there are other factors that are also influential on the indicators in the 1st principal components. A careful reading of the map (Fig. 12) shows that strongly developed villages with respect to the PC-1 are very close to the most accessible places in the Block. However, the moderate correlation is the result of a large number of moderate to low developed villages that have weakened the correlation.

The Second Principal Component (PC-2) contributes 15% of the total variance and constitutes the '*Occupational component*' having negative factor loadings with the literacy but positive factor loading with the work participation, main workers to total workers, other workers, percentage irrigated area, non-agricultural workers, household industry workers, Electricity connections and four-wheelers (Table 6; Fig. 13). The correlation coefficient is insignificant with the Overall Accessibility Index (OAI), which indicates that the occupation and workers do not depend on the accessibility indicators. Thus it can be concluded that accessibility has no significant impact on the occupation and workers in the Block.

ThirdPrincipal Component (PC-3) contributes 14% of the total variance and constitutes the '*demographic and employment component*' having positive factor loading with the density of population, non-workers, non-agricultural workers, and three or more rooms and negative factor loading with the main worker to total workers (Table 6; Fig. 14). It has no significant correlation with the Overall Accessibility Index (OAI) except with ease of access to social services (correlation coefficient -0.268. So it can be interpreted that demographic and employment-related attributes are independent of accessibility indicators.

Forth Principal Component (PC-4) contributes 13.7% of the total variance and constitutes '*household infrastructure component*' having high positive loading with the concrete house, concrete roof and moderate positive loadings with electricity connection, adult literacy and main worker and negative loading with households with four-wheelers (Table 6; Fig. 15). There is no significant relationship with any of the accessibility indicators, which indicates that the household infrastructure, more specifically the building conditions, is independent of the accessibility indicators.

8.0. Conclusion and recommendation

Accessibility is a comprehensive term but simple to understand. Several techniques are put forth to determine it. The techniques may vary to a great extent, but it solely depends on transport parameters. Any improvement in the transport sector improves the level of accessibility.

On the other hand, development is a comprehensive thing and more complex in nature. It is more difficult to measure as there is a long debate on the indicators and methods to be used for this purpose. As like as the measurement, the correlates of development are also broad and unclear. In this paper, an attempt has been made to understand the level of association between the development parameters and accessibility parameters. In some cases, correlation is significant, but, in some cases, it is not so.

Good transport connectivity leads to good physical accessibility, but the ease of access to public and social services, which is important for human and economic development, depends on many things like the location of those facilities and the type and availability of the transport services. So it is important to improve transport services in more villages to increase the level of accessibility and enlarge the impact of social services on the overall development.

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