



## Spatial Pattern of Road Transport Connectivity in Pancha Block, Puruliya District, West Bengal

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### Abstract

*Movement of man and material across spaces is accomplished through some definite channels of transport network. These channels consist of nodes and routes connecting these nodes. On the efficiency and fluency of linkages between the places the advancement of a region depends. The present paper is a humble submission to measure the connectivity pattern with the help of cyclomatic number, alpha, beta, gamma index and Aggregate Transportation Score. At the same time it opts to explore the most vulnerable areas with regard to connectivity at Pancha Block of Purulia District, one of the backward Districts of West Bengal. Most of the pockets of the Block represent a very disappointing figure with respect to Connectivity measures. The areal networks are found to be branching. For the upgradation of accessibility the existing tree sort of network should be enhanced into a circuitry network implying maximum connections.*

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### Introduction

Movement of man and material across spaces is accomplished through some definite channels of transport network. These channels consist of nodes and routes connecting these nodes. Network implies the spatial pattern of transportation facilities in a given region. Most of the measurement techniques of network are based upon the graph theory. Graphs are defined as systematically organized points and lines. It enables us to look at the entire transport network, as well as its parts in terms of the whole (Raja and Aggarwal, 1999, p. 23). It is to be noted that the points that form the basic elements of a graph are called vertices or sometimes designated as nodes. The lines connecting the nodes are known as edges. The graph that can be mapped on a plane such that no two edges have a point in common that is not a vertex is known as a planar graph. A circuit is defined as a finite, closed path wherein the initial node of linkage sequence coincides with the terminal node.

### Objectives

The paper opts to diagnose the followings, viz,

- To examine the existing linkage

system through the evaluation of areal accessibility by metalled and unmetalled roads;

- To find out the areal accessibility.
- To find out connectivity status and its spatial variations.

To accomplish these objectives, the paper has been divided into three parts, Section I depicts the existing linkage system. Section II is an attempt to explore areal accessibility status, section III opts to scrutinize the connectivity domain.

### Methodology

Connectivity represents the quantum of connections between all the vertices (Nodes) and edges (Linkage). It may be defined as the degree of compactness of the links between nodes. The degree of connection between all vertices is defined as the connectivity of the network. Kansky (1963) developed several descriptive indices for measuring the connectivity of network, i.e., Beta, Index, Gamma Index and Cyclomatic Number.

The cyclomatic number is defined as the count of number of basic circuits existing in the graph and is

given by:

$\mu = e - v + p$  (where  $e$  = number of edges;  $v$  = number of vertices or nodes;  $p$  = number of non connected sub graphs).

The alpha index is an adjusted form of the cyclomatic number and is defined for non planer graph as the ratio of observed number of fundamental circuits to the maximum number of circuits that may exist in the system. For a non planer graph it is given by:

$$\alpha = e - v + 1/2v - 5.$$

The beta index is a very simple measure of connectivity, that can be found by dividing the total number of arcs in a network by the total number of node, i.e.,  $\beta = \text{arcs} / \text{nodes}$  (Saxena, 2005).

The gamma index is a ratio between the observed number of edges and vertices of a given transportation network. The gamma index for a non planer graph may be defined as  $\gamma = e / 3(v - 2)$ .

The aggregate transportation score (ATS) as developed by Mukherjee (1974) is simply the summation of cyclomatic number, alpha, beta and gamma indices and is computed in the following manner:

Each of the indices are first arranged in an ascending order and is divided into three groups as high, medium and low class (Table - 1). The values are then given score appropriate to the class they belong to.

### The Study Area

The rainfed Purulia district (from 22°42'35"N to 23°42'00"N latitudes and from 85°49'25"E to 86°54'37"E longitudes) is a part of the Chhotanagpur plateau in India consisting of "succession of rolling uplands with intervening hollows" and infertile lateritic soil. The physical landscape, quite unique, having distinctive topography, soil, terrain, drainage, forest can be characterized as poorly suited to agriculture and a high incidence of severe poverty. Like the topography of the district, its population structure (Area = 6259 km<sup>2</sup>; Population = 2536516 as per 2001 Census of India) is unique having the highest concentration of Scheduled Tribe population (18.27%) in West Bengal. The bulk of its population consists of Hindu and Semi-Hinduized communities who still preserve some of the life style of their tribal forefathers. Economically also, the district is one of the poorest among the sixteen districts of West Bengal.

Puncha Block (Lat. 23°10'N 23°16'N and Long. 86°40'E 86°55'E) lies in the eastern part of Purulia District (Fig.1). It is under P.S. Puncha and Kenda. The block stretches over an area of 330.1 sq. km and has a population of 108129 persons inhabiting 98 villages out of 109 villages (Table 2). Single cropped agriculture is the mainstay of economy here. About 53% of total area is cultivable and 18.43% cultivable area is irrigated. Regarding educational facilities, middle, secondary, and H.S. schools are found only in 22, 17 and 4 villages respectively. The area under scrutiny witnesses

inadequacy in every means of transport linkages. Seventy one villages are out of preview of bus service till today.

## Results and Discussion

### Section - I: The Existing Road Network

With a view to facilitate the movement of men and material from one discrete node to another across space some definite channels of transport are required. These channels consist of nodes and routes connecting these nodes. The term network may, thus, be considered as referring to spatial pattern of transportation facilities in a given region.

The block suffers from all sorts of linkage system. It is 43 kms away from the nearest railway station. So no question of railway service arises in the block under scrutiny. The only way of communication is through road transport which is also disappointing. The western part of Kasai river, comprising the Kenda Circle, all weather motorable road concentration is insignificant. One state highway traversing from Manbazar to Purulia touches Kenda and Panipathar Gram Panchayet. This is the only metalled road passing through Panipathar gram panchayet. In Kenda Gram panchayat, apart from the state highway, there are two metalled road connections: one that runs from Konapara through Balakdi meets the state Highway near Kenda 'Thanagora' and another road which radiates from Kenda to Noagarh. From Kenda another road runs towards Koira to link Jambad and Puncha, the block headquarters of the Puncha Block.

The metalled road density is found to be very worrisome so far as the Pirrah gram panchayet is concerned. Only one motorable road passes through the gram panchayet bordering Kenda and Puncha in its two sides. The road is also frequented by hallows, broken here and there, and resembles an unmetalled road. Three metalled roads are found to be radiating in the direction of Noagarh, Keshra and Kadma, but both the length and condition are very frustrating. In the western half within the Kenda P.S. the density and state of all season motorable roads are disappointing. Most of the villages are connected through unmetalled roads and cart tracks. That makes most parts of the villages remote and inaccessible.

The picture is a little bit better in the eastern part of Kasai. Gram panchayat-wise all weather motorable road density varies from 0.15 km/sq. km in the Chandra Gram Panchayet to 0.60 km/sq. km in the Puncha Gram panchayet (Fig.2). One important metalled road from manbazar to Purulia Via Lalpur runs through Napara. The other metalled road in the gram panchayet progresses from Napara to Shyamakata, Napara to Koira, Bhutam to Gagda, Kanandi, Koira, Koira-suridih to Kenda, Napara and Puncha. The metalled road density in Bagda Gram panchayet is to the tune of 0.38 km/sq.km. The road that flows from Manbazar to Purulia also traverses through Bagda. Apart from this,

Ramkundi to Sargara, Napara, Gopalpur, Baragram and Gopalpur to Chirudih, Baragram are other metalled roads in this gram panchayet.

In so far as the Chirudih Gram panchayet is concerned, two nodes, namely, Tusooria and Laharia are diagnosed. In Tusugoria, the road from Chirudih to Bankura are seen to converge with all season Bankura-Manbazar road. From Laharia, three metalled road in the direction of Gopalpur, Poradi and Arali-Chirudih are noticed. Lakhra Gram panchayet suffers from paucity of metalled road. Barring the Bankura-Manbazar road that passes through Badra of the Lakhra Gram panchayet, no significant metalled road are there. Another road from Dhadki to Lakhra also exists in this gram panchayet. In Puncheda Gram Panchayet, three major nodes are distinguished. One is Block Headquarters from where three metalled roads in the direction of Manbazar, Purulia and Koira are found to be radiating whereas roads from Manbazar to Purulia, from Manbazar to Bankura, from lakhra to Dhadki traverse through the Dhadki node of the Puncheda Gram Panchayet.

The road density map based on the length of metalled road divided by Gram Panchayet area follows the connectivity pattern. It depicts high road density in Napara, Kenda and Puncheda Gram Panchayats (more than 0.53 km / sq. km). The Gram panchayets located in the western and south western part embracing Panipathar, Pirrah, Chandra Gram panchayet register low density of roads (<0.345 km/sq.km) with Chandra being the lowest of only 0.15 km road/ sq. km. The remaining gram panchayets have a moderate nature of road concentration. The road density map testifies to the paucity of metalled road in the western half of the block under survey.

### **Section -II: Areal accessibility**

Governed basically by the terrain and state of transport web of an area, areal accessibility implies physical access to any transport facility and clarifies the ease and comfort one feels in journeying from one place to another.

It is a relative term showing a complementarity (Shukla, 1981) between the place of origin and destination. Puncheda suffers from tremendous paucity of transport web. Scarcity of metalled road makes most part of the undulating terrain inaccessible. Scarcity of metallic road coupled with poor socio-economic status designates this block as 'Backward'.

On both side of an all weather motorable road up to 1.5 km, in a plateau fringe with undulating topography, the area has been considered to be easily accessible, from 1.52.5 km accessible and beyond 2.5 km hardly accessible. The area under scrutiny witnesses inadequacy in every means of transport linkages. It has been found from the survey that 52 villages can access metallic road within 1.5 km, comprising mostly the south eastern part of kenda circle

and north eastern side of the Puncheda circle. Within 1.5-2.5 km distances from the motorable road 44 villages are there (Fig.3). There are 13 villages that have to cross > 2.5 km to access the metalled road. The maximum value being more than 8 km.

The unmetalled roads and cart tracks are insufficiently scattered all over the block. Very few villages can access unmetalled road within 1 km from their villages. Most of the village roads are footpaths and cart tracks. The villages in the extreme western margin consisting of Panipathar Gram panchayet, south western part and southern part of Chandra and Pirrah gram panchayet, in the Kenda circle the villagers can have a touch of unmetalled road after travelling through one to two kms from their villages (Fig.4). Similar observations are also having in all parts of the Puncheda circle. In a mountaneous and plateau track, if we can consider location of villages beyond 1 km from metalled road to be inaccessible. Against this consideration most villages in the Block are found to be poor accessible.

### **Section -III: Patterns of Connectivity and Accessibility**

Connectivity represents the quantum of connections between all the vertices (Nodes) and edges (Linkage). It may be defined as the degree of compactness of the links between nodes. The degree of connection between all vertices is defined as the connectivity of the network. Kansky (1963) developed several descriptive indices for measuring the connectivity of network, i.e., Beta, Index, Gamma Index and Cyclomatic Number.

The value of cyclomatic number registers lowest values in chadra and Pirrah gram panchayets, immediadly followed by Panipathar Gram panchayet. Maximum value is found to occur in Puncheda Gram Panchayet. Napara, Bagda, Kenda. Lakhra, Gram panchayet embrace moderate nature of this variable. Coupled with cyclomatic number, the alpha index provides a more sensitive measure. The lower value of alpha indices is observed in Chandra and Pirrah Gram panchayet whereas higher value prevails in puncheda. Kenda and jambad gram panchayet. Napara, lakhra, Panipathar gram panchayet witness moderate value so far as the alpha indices are concerned.

The beta index ranges from 0.0 for network that consist of node with no areas, through 1.0 and greater where networks are well connected. The value of beta index in the study area varies from 0.75 to 1.00. Lakhra, Chirudih, Panipathar Gram panchayet, Chandra and Pirrah gram panchayet has beta index to the tune of 0.71 to .80, whereas for Kenda, napara and puncheda gram panchayet the value range between 0.91 to 1.0, with Kenda possessing the maximum value of 1. Remaining gram panchayets like Baga and Jambad observe a modetate beta index value of 0.81 to 0.90 range.

It needs mentioning that in all the areas barring Kenda gram panchyhet, the values are found to be

greater than 0 but less than unity. This emphasizes that some routes are there along which goods can flow. Another aspect to note is that the areas possessing beta index value equals to unity (such as Kenda) can be described as a simple connected graph (Fig.5) as all vertices are connected by minimum number of edges required complete network connection. But no Gram panchayet has been found to observe beta index of connectivity more than unity, thereby implying less degree of interconnection between them.

The gamma index (Table - 3) as measured from gamma index varies from a set of nodes having no interconnection to the one in which every node has an edge connected to every node in the graph. The numerical range varies between 0 to 1. The value in Puncha Block ranges from 0.33 to 0.42. The values are found to be low in all places barring some places of Puncha, napara and kenda gram panchayets. The connectivity of the network is evaluated in terms of the degree to which the network deviates from an unconnected graph and approximates maximally connected one

In the context of Puncha, the ATS score varies from the minimum of 40 in pirrah and Chandra gram panchayet to the maximum of 77 in Kenda followed by Puncha (68) gram panchayet. The values are found to be high in Napara (61) also. Jambad gram panchayet performs moderately in this aspect whereas Bagda, Chirudih, Lakhra and Panipathar Gram panchayet embrace very low values in terms of ATS Scores. The higher the value of the A.T.S., the greater the level of connectivity (Fig.6, Table 4). Barring Puncha, Kenda and Napara, no other region found to perform satisfactory in this respect. Puncha, the Block Headquarter, is an area marked by high road network, an area of convergence and divergence of number of roads, the confluence of producers and consumers. The block is situated in both sides of Kasai in such a way that the areas in the eastern part rely heavily on Puncha and the other sides consider Kenda as the most influential area. The higher beta value for both Puncha and Kenda are generally the result of higher amount of roads. The other Gram Panchayats that have lower beta values generally have very few number of roads which itself is a result of lack of capital for investment, terrain handicaps, engineering difficulties and regional imbalances in resource allocation created by political vicissitudes.

The ATS values are positively correlated (Table 5) with Beta, Alpha, Cyclomatic number and Gamma Indices. It is found to have a strong positive co relation with Beta (0.94) and Alpha (0.92) indices while weakly correlated with gamma index. The gamma index is weakly correlated with all the variables, the lowest being 0.06 with cyclomatic number. The co-relation does suggest that the four structure indices are correlated with each other, although the strengths of co-relations vary.

### Conclusion

In conclusion it can be said that the existing tree sort of network should be enhanced into a circuitry network implying maximum connections. This can be achieved by increasing number of lower order tributary linkages to the existing linkage system. All the market centres should be interlinked with one another and with their surrounding rurality and deviousness of lower order tributary linkages should possibly be removed to enhance the level of interaction.

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Table – 1: Score Table

Class/Indices	Alpha	Beta	Gamma	Cyclomatic	A.T.S.
High	29	27	25	19	100
High	17	16	15	12	60
Low	13	11	9	7	40

Source: Mukherji, 1974



Table - 2: Ranking of Puncha Block

Ranking	District	State	National
Area	8	64	2460
Population	13	287	3207
Sex Ratio	3	220	2073
Child Sex Ratio	8	96	1460
Literaracy Rate	3	249	3265
Pop. Density	12	50	3294
Work Participation Rate	17	322	2893

Source: Census Of India, 2011.

Table - 3: Calculated Value of Structure Indices, 2013

Gram Panchayat	Edges (e)	Vertices (v)	Beta Index	Gamma Index	Alpha Index	Cyclomatic Number
Napara	13	14	0.93	0.36	0.26	6
Puncha	14	15	0.93	0.36	0.36	9
Lakhra	7	9	0.78	0.33	0.24	3
Chirudih	6	8	0.75	0.33	0.18	2
Bagda	7	13	0.85	0.33	0.14	3
Kenda	10	10	1.00	0.42	0.40	6
Panipathar	3	4	0.75	0.33	0.20	1
Chadra	3	4	0.75	0.30	0	0
Pirrah	3	4	0.75	0.30	0	0
Jambad	8	9	0.89	0.34	0.31	4

Source: Field Survey and Computed by Author, 2013

Table – 4: Aggregate Transport Score and Structural Indices, 2013

Gram Panchayat	Cyclomatic No.	Alpha Index	Beta Index	Gamma Index	A.T.S. Score
Napara	12	13	11	25	61
Puncha	19	13	11	25	68
Lakhra	07	13	11	15	46
Chirudih	7	13	11	15	46
Bagda	07	13	11	15	46
Kenda	12	13	27	25	77
Panipathar	7	13	11	15	46
Chadra	7	13	11	09	40
Pirrah	7	13	11	09	40
Jambad	12	13	11	15	51

Source: Field Survey, and Computed by Author 2013

Table – 5: Correlation Matrix of Indexes

	ATS	Beta Index	Alpha Index	Cyclomatic No.	Gamma Index
ATS	1				
Beta	0.94	1			
Alpha	0.92	0.78	1		
Cyclomatic No.	0.81	0.74	0.72	1	
Gamma	0.49	0.39	0.38	0.06	1

Source: Field Survey and Computation by Author, 2014

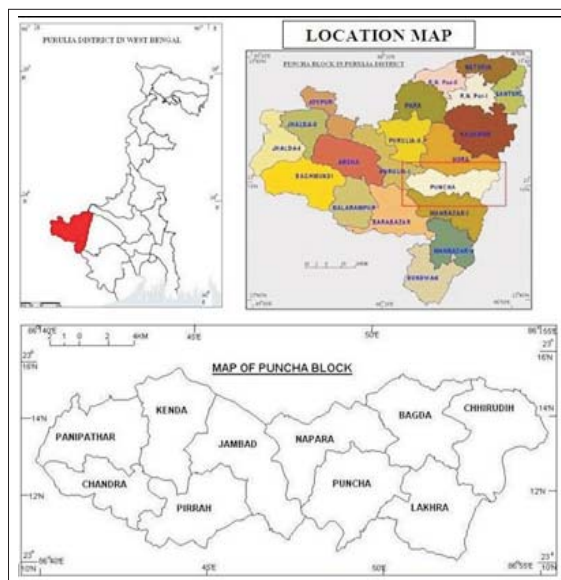


Fig. 1: Location Map of the Study Area

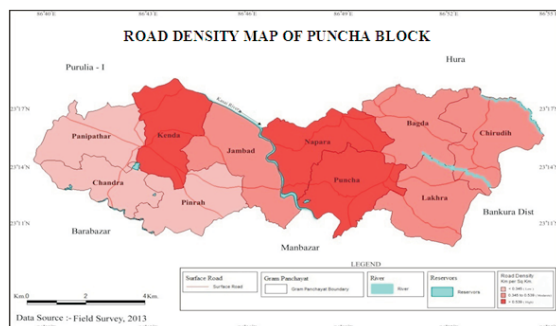


Fig. 2: Road Density Map

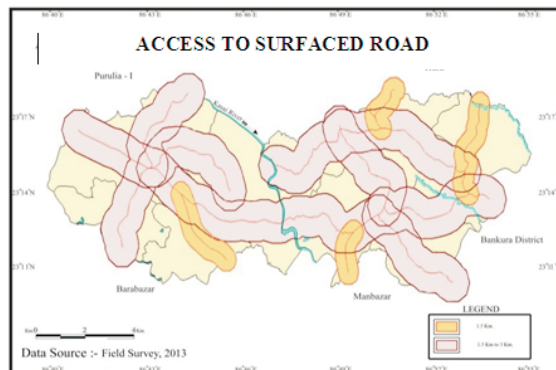


Fig. 3: Access to Surfaced Road

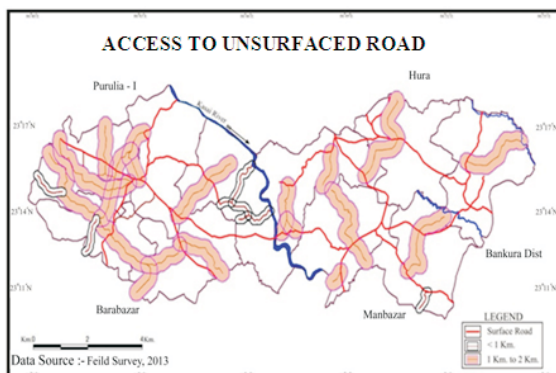


Fig. 4: Access to Unsurfaced Road

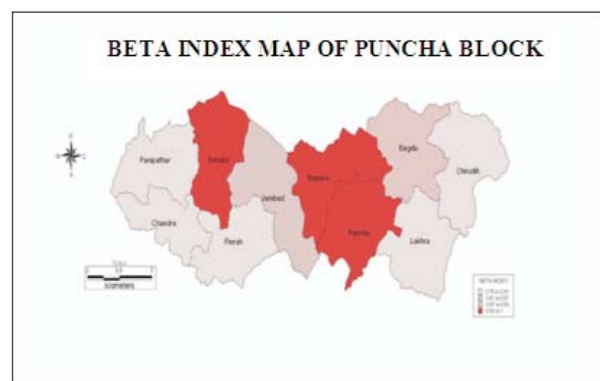


Fig. 5: Beta Index Map

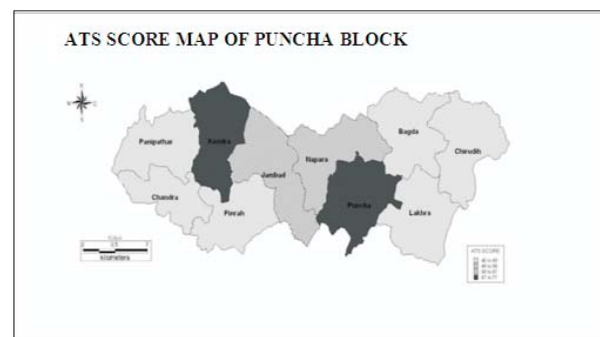


Fig. 6: ATS Score Map



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