

Structural Analysis of Existing Road Networks of Assam: A Transport Geographical Appraisal

Bharati Gogoi

Abstract - Road has been described as the life-blood of human civilization. Social interaction and economic prosperity in space have been shaped by the road networks both at intra and inter regional levels. Consequently, it is regarded as one of the most important indices of economic, social and commercial progress of any region. According to IHDR (2011), the study area Assam ranked 16 (0.444) out of 23 states of India in human development indices in spite of its immense historical background, rich human resources and abundant mineral resources. The state does not have any remarkable industrial establishments with the population engaged in subsistence agriculture marked by low yield and productivity. An attempt has been made through the present study to explore the existing pattern and spatial variations of road networks of the study area with the help of structural measures of transportation network. Structural analysis of transport networks is getting utmost important in geographical studies because it involves the description of the disposition of nodes and their relationships and linkage of distribution. The study reveals that districts of Assam had minimum road density and most of the districts are characterized by minimum efficiency of road network in terms of connectivity. The efficiency of road network is very low and higher spatial imbalance.

Index Terms - Accessibility, connectivity, efficiency, economic prosperity, road network, social interaction, spatial variation

1 INTRODUCTION

THE movement and exchange of people, goods and services is an obligatory feature of modern life (Umoren et al., 2009) because of its multi-dimensional functions and importance keeping relations and making integrations among every aspect of a society ranging from an individual to a nation. Road that act as key for transportation of people and materials from one place to another have spread like veins and arteries throughout the country and brought substantial development (Badigar and Badigar, 2003). The improvement of transportation through road networks in between any two points leads to increasing regional specialisation reducing the transport costs. Agglomeration economies at not only the large cities but also in rural areas accelerate their growth, expand the markets and increase the dominance of transportation system. The impact of technological change in transport sector since the late 19th century has been as theatrical as in every sphere of life (Simon, 1996). While rebuilding any region or nation or country, roads always play a dynamic part. In essence, transport network is considered as a set of interconnected route linking with numerous destinations within and the outside the region and provides a pace for

proper utilization of

resources. Transportation is not only a resource factor rather; it is a catalyst for the true development of various resource characters. No other transportation system is able to provide such a comprehensive door to door services nor any other mode have such extensive route network. 'Transportation and Spatial Structure' dealt with some characteristics features of the processes in which the transport networks are evolved (Taaffe and Gauthier, 1973). These features play vital role in the development of a region. In Assam, where other means of transport are yet to be developed, a well planned programme of the study of road network for its role in the development processes is urgently needed.

2 OBJECTIVES

1. To provide an idea about the existing road network of the district.
2. To find out the overall status of development of road network of the study area.
3. To find out the spatial variation of road network development of the study area.
4. To suggest some relevant strategies for the policy makers.

3 DESCRIPTION OF STUDY AREA

Assam is a northeastern state of India. Its capital is Dispur, located within the municipal area of Guwahati city. Located south of the eastern Himalayas, Assam comprises the Brahmaputra and the Barak river valleys along with the

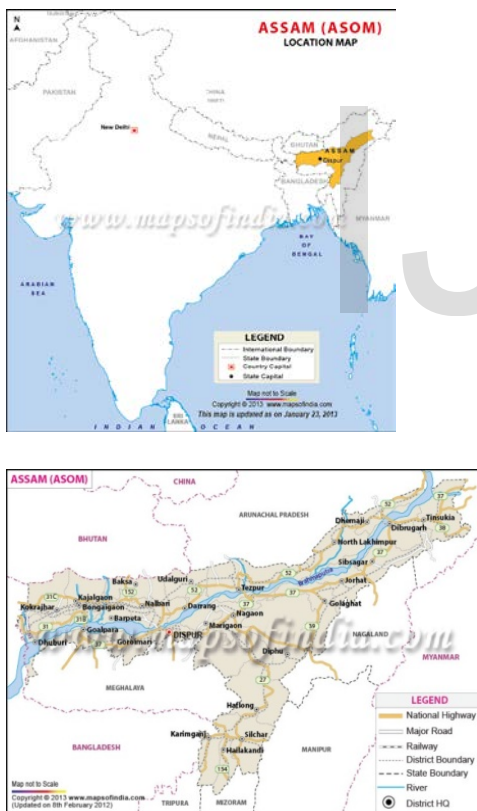
• Bharati Gogoi is currently pursuing Doctor of Philosophy in Geography in Dibrugarh University, India, PH-09859353977. E-mail: bharati_gogoi@rediffmail.com

movement of people and commodities. Practically, it performs manifold functions for the regional development reducing the spatial disparities and it brings equilibrium among societal, economic, political phenomena through the

Karbi Anglong and the North Cachar Hills with an area of 30,285 square miles (78,438 km²). Assam is surrounded by six of the other Seven Sister States: Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya. Geographically Assam and these states are connected to the rest of India via a narrow strip of land in West Bengal called the Siliguri Corridor or "Chicken's Neck". Assam shares international borders with Bhutan and Bangladesh.

Assam, extending from 89° 42' E to 96° E longitude and 24° 8' N to 28° 2' N latitude. The total geographical area of Assam is 78,438.08 km² with the total population of 31169272 persons including 15954927 males and 15214345 females in 2012 with a density of 397 persons per Sq. Km. The total rural population is 26780516 and total urban population is 4388756 in 2012. Assam comprises 27 districts, 56 sub - division, 219 Community Development Blocks, 184 circles, 214 towns, 26395 villages, 2202 gaon panchayat.

LOCATION MAP OF ASSAM



With the "Tropical Monsoon Rainforest Climate", Assam is temperate (summer max. at 95–100 °F or 35–38 °C and winter min. at 43–46 °F or 6–8 °C) and experiences heavy rainfall and high humidity. The average annual rainfall is 2296 mm. The climate is characterized by heavy monsoon

downpours reducing summer temperatures and affecting foggy nights and mornings in winters, frequent during the afternoons. Spring (Mar–Apr) and Autumn (Sept–Oct) are usually pleasant with moderate rainfall and temperature.

Comprising of valleys, hills and the perennial River of Brahmaputra, Assam Geography presents a fact file of the locational traits of the state. The forest lands occupy a major part of Assam's area. The agricultural fields of Assam are specially blessed by the River of Brahmaputra. Being divided into several rivulets and streams, the River as a whole makes the lands of Assam suitable for agricultural production. Adding the qualities of alluvial soil, Brahmaputra indirectly helps in increasing the crop growth of Assam state. The topography of Assam is also featured through many quaint hills that existed in the land from ancient periods. Placed on the foothills of the majestic Himalaya, Assam is adorned by beautiful valleys, rivers and plains. From Meghalaya, Nagaland and Mizoram to West Bengal, Arunachal Pradesh, Manipur and Bangladesh, the Assam area is a rich reserve of natural treasures. The area of Assam is known for its wide-spread tea plantation farms. Since the Assam topography comprises of various geographical traits hence the place resembles the varied landscapic characteristics of the North Eastern Region.

4 EXISTING ROAD NETWORKS OF THE STUDY AREA

After independence, the roads networks of the state have been extended a large. In 2012, the state had total 47448 km road length including 45500 Km. PWD roads and 1948 Km. National Highway. That accounts for approximately 60% of the total road length in the North-east. The major towns in the state are connected by National Highways. During the next five years, the Government will strive for the development of roads specifically in the industrial areas. Roads of the state have been maintained by different sectors of the Government like Public Works Department, Zilla Parisad, Gram Panchayet, Panchayet Samity and PMGSY. The total amount of road maintained by PWD is 45500 Km. Out of which 3134 Km. is State Highways, 4413 Km. is Major District road, 36544 Km. is Rural road and remaining 1409 Km. is Urban road. The total surfaced (Black topped) road network length is 21200 Km. and Unsurfaced road length is 24300 Km. On the other hand 4413 Km. road networks are maintained by Zilla Parisad. Gram Panchayet and Panchayet Samity maintain surfaced road networks of 36544 Km. in the rural areas; while PMGSY bears the responsibility of habitation connectivity by connecting 7416 villages by surfaced road networks. The roads of the study area can be classified in four categories i.e. National High way, State High way, District High way, Rural Roads and Urban Road.

TABLE – 1
DISTRICTS COVERED BY NATIONAL HIGHWAYS

National Highway No.	Area/places connected	Districts covered
31	Guwahati to Barahi (Bihar) via Siliguri and Koch Bihar	Kamrup, Nalbari, Barpeta, Kokrajhar, Bongaigaon and Dhubri
31. B	North Salmara to Jogighopa	Bongaigaon
31.C	Chapaguri via Srirampur to West Bengal	Kokrajhar
36	Nagaon via Dabaka to Dimapur	Nagaon, Morigaon and Karbi Anglong
37	Pancharatna via Guwahati, Nagaon, Jorhat, Sivasagar to Saikhowaghat (Dibrugarh)	Dhubri, Goalpara, Kamrup, Nagaon, Jorhat, Sivasagar, Dibrugarh, Tinsukia
38	Makum, Jaipur to Lekhapani	Tinsukia
39	Numaligarh via Golaghat, Dimapur to Kohima	Golaghat and Karbi Anglong
40	Guwahati to Shillong	Kamrup
44	Shillong via Badarpur, Karimganj to Agartala	Kachar and Karimganj
51	Paikan (Goalpara) to Tura	Goalpara
52	Baihata Chariali via Mangaldoi, Tezpur, Lakhimpur to Jonai	Kamrup, Darrang, Sonitpur, Lakhimpur and Dhemaji
53	Silchar via Lakhimpur to Imphal	Cachar
54	Silchar to Aizawl	Cachar

Baksa	97	43	961	0	1101
Darrang	143	119	785	20	1066
Udalguri	56	125	1639	9	1828
Assam	3134	4413	36544	1409	45500

Source: Statistical Handbook of Assam, 2012

5 METHODOLOGY

Topological map of 27 districts of the study area Assam were prepared. 1,085 centres or nodes from 27 districts related to the structural analysis of existing road networks of Assam were identified on the basis of following characteristics-

1. Urban centres
2. Administrative head quarters
3. Regional and local market centres
4. Centres for education
5. Location point of health centres

To describe the road network quantitatively and to compare the network of a district exactly with the other networks of different districts following indicators have been analyzed.

TABLE – 3
FORMULA FOR STRUCTURAL ANALYSIS OF EXISTING ROAD NETWORKS

Sl. No.	Indices	Formula	Correlation with Connectivity
1.	Road Density	$\frac{\text{Road length}}{\text{Area Sq. Km.}}$	Higher the density higher the development
2.	Beta Index	$\beta = \frac{e}{v}$	Higher value indicates more connectivity
3.	Alpha Index	$\alpha = \frac{e-v+1}{2v-5}$	Higher value indicates more connectivity
4.	Gamma Index	$\gamma = \frac{e}{3(v-2)}$	Higher the value indicates more connectivity
5.	Cyclomatic Number	$\mu = e - v + 1$	Higher value indicates more connectivity
6.	Grid Tree Pattern	$GTP = \frac{e-v+1}{(\sqrt{v}-1)^2}$	Higher the value greater is the connectivity of network
7.	Aggregate Transportation Score	$ATS = \beta + \alpha + \gamma + \mu + GTP$	Higher value indicates more connectivity and efficiency

TABLE – 2

DISTRICT WISE AND CATEGORY – WISE LENGTH OF ROADS UNDER PWD IN ASSAM, AS ON 31-03-2012 (IN KM.)

District	State Highway	Major District Road	Rural Road	Urban Road	Total
Kokrajhar	61	131	1632	16	1841
Dhubri	56	53	1007	38	1154
Goalpara	137	48	1354	10	1550
Barpeta	158	171	1463	31	1824
Morigaon	142	86	909	13	1150
Nagaon	297	327	2409	88	3120
Sonitpur	55	402	2132	59	2648
Lakhimpur	121	97	828	44	1091
Dhemaji	45	42	1168	86	1340
Tinsukia	63	171	1479	52	1765
Dibrugarh	155	163	1357	63	1738
Sivasagar	100	310	2425	40	2874
Jorhat	162	89	1714	86	2051
Golaghat	160	157	2131	33	2480
Karbi Anglong	337	561	3341	70	4309
Dima Hasao	380	199	1237	60	1876
Cachar	107	165	848	42	1163
Karimganj	35	343	539	19	936
Hailakandi	17	99	351	6	473
Bongaigaon	41	16	712	36	805
Chirang	0	223	429	8	660
Kamrup	89	230	2916	0	3235
Kamrup Metro	0	0	0	457	457
Nalbari	119	45	779	22	965

6 RESULT AND DISCUSSION

Structural Analysis of Existing Road Networks of Assam

Structure in transport geography refers to a system of arrangement consisting of a number of edges and vertices

in a plain surface in terrestrial surface by making a nexus of spatial activities of people in order to get the connectivity.

6.1 Road Density

Density of road network indicates the length of road per unit of geographical area which discerns the degree of connectivity and accessibility of the road network system. The length of roads per lakh of population in Assam (2012) is 152.23 Km. The average density of the road network system per 00 Sq. Km. of geographical area in Assam is 60.49 Km / 00 Sq. Km. The state has been classified into three regions on the basis of road density. Thirteen districts namely Sonitpur (50.15), Lakhimpur (47.91), Dhemaji (41.40), Tinsukia (46.57), Dibrugarh (51.40), Karbi Anglong (41.29), Dima Hasao (38.38), Cachar (30.72), Karimganj (51.74), Hailakandi (35.64), Bongaigaon (46.66) Chirang (33.42) and Baksa (54.84) belong to the lower road density region. On the other hand, nine districts namely Kokrajhar (58.16), Dhubri (69.35), Barpeta (68.13), Marigaon (74.15), Nagaon (78.53), Jorhat (71.94), Golaghat (70.82), Kamrup Metro (72.87) and Darrang (57.60) belong to the moderate road density region while only five districts namely Goalpara (84.98), Sivasagar (107.72), Kamrup (92.86), Nalbari (95.59) and Udalguri (109.20) belong to high road density region (Table 4).

TABLE – 4
SUMMARY FOR ROAD DENSITY

Low Density	30 – 55	Sonitpur (50.15), Lakhimpur (47.91), Dhemaji (41.40), Tinsukia (46.57), Dibrugarh (51.40), Karbi Anglong (41.29), Dima Hasao (38.38), Cachar (30.72), Karimganj (51.74), Hailakandi (35.64), Bongaigaon (46.66) Chirang (33.42) and Baksa (54.84)
Moderate Density	55 – 80	Kokrajhar (58.16), Dhubri (69.35), Barpeta (68.13), Marigaon (74.15), Nagaon (78.53), Jorhat (71.94), Golaghat (70.82), Kamrup Metro (72.87) and Darrang (57.60)
High Density	80 – 110	Goalpara (84.98), Sivasagar (107.72), Kamrup (92.86), Nalbari (95.59) and Udalguri (109.20)

6.2 Beta Index (β)

One of the simplest measures of connectivity is beta index (β) which can be found dividing the total number of arcs of a network by the total number of the nodes. Beta index ranges from 0.0 to network which consist just of nodes no arcs. If the value of beta index is greater than 1, the networks are well connected and higher values indicate higher the complexities of the networks. In the study area of Assam, out of 27 districts Karimganj, Baksa and Darrang have the lowest beta index value i.e. 1. On the other hand, Cachar district has the highest beta index value i.e. 1.297 enjoyed the most complex road network. The entire district has been divided into three regions on the basis of obtained beta values. In Assam, there are only five districts namely Sivasagar (1.25), Jorhat (1.295), Golaghat (91.24), Dima Hasao (1.22), Cachar (1.30) and Kamrup Metro

(1.25) have the most complex and well connected road networks. While nine districts namely Kokrajhar (1.14), Goalpara (1.14), Morigaon (1.125), Nagaon (1.20), Sonitpur (1.19), Tinsukia (1.17), Karbi Anglong (1.14) and Chirang (1.18) have moderate well connected road network and rest districts namely, Dhubri (1.06), Barpeta (1.08), Lakhimpur (1.09), Dhemaji (1.09), Dibrugarh (1.09), Karimganj (1), Hailakandi (1.05), Bongaigaon (1.06), Kamrup (1.07), Nalbari (1.06), Baksa (1), Darrang (1) and Udalguri (1.05) have the lowest well connected road network (Table – 5).

TABLE – 5
SUMMARY FOR BETA INDEX (B)

Lower Value	1 – 1.1	Dhubri, Barpeta, Lakhimpur, Dhemaji, Dibrugarh, Karimganj, Hailakandi, Bongaigaon, Kamrup, Nalbari, Baksa, Darrang, Udalguri
Moderate Value	1.1 – 1.2	Kokrajhar, Goalpara, Morigaon, Nagaon, Sonitpur, Tinsukia, Karbi Anglong, Chirang
Higher Value	1.2 – 1.3	Sivasagar, Jorhat, Golaghat, Dima Hasao, Cachar and Kamrup Metro

6.3 Alpha Index (α)

The alpha index is a ratio measure of the number of the actual circuits, to the maximum of in a given network. The range of the index is from a value of 0 for a minimally connected network to a value of 1 for a maximally connected one. The district has been divided into four regions on the basis of obtained alpha values. Tables 6 indicates that Karimganj, Hailakandi, Bongaigaon, Baksa and Udalguri districts have minimally connected road network having the alpha index value 0. Eight districts namely, Dhubri (0.017), Barpeta (0.028), Marigaon (0.046), Lakhimpur (0.031), Dhemaji (0.031), Dibrugarh (0.037), Kamrup (0.023) and Nalbari (0.017) belong to the lower alpha index region having lower connected road network. While Kokrajhar (0.058), Goalpara (0.059), Nagaon (0.098), Sonitpur (0.089), Tinsukia (0.081), Karbi Anglong (0.062), Chirang (0.069) belong to the moderate alpha index region having moderate connected road network. On the other hand only five districts namely, Sivasagar (0.12), Jorhat (0.145), Golaghat (0.12), Dima Hasao (0.11) and Cachar (0.14) and Kamrup Metro (0.11) belong to comparatively higher connected road network.

TABLE – 6
SUMMARY OF ALPHA INDEX

Lowest Value	0	Karimganj (0), Hailakandi (0), Bongaigaon (0), Baksa (0) and Udalguri (0)
Lower Value	0.01 – 0.05	Dhubri (0.017), Barpeta (0.028), Marigaon (0.046), Lakhimpur (0.031), Dhemaji (0.031), Dibrugarh (0.037), Kamrup (0.023) and Nalbari (0.017)
Moderate Value	0.05 – 0.10	Kokrajhar (0.058), Goalpara (0.059), Nagaon (0.098), Sonitpur (0.089), Tinsukia (0.081), Karbi Anglong (0.062), Chirang (0.069)
Higher	0.10 – 0.15	Sivasagar (0.12), Jorhat (0.145),

Value	Golaghat (0.12), Dima Hasao (0.11), Cachar (0.14) and Kamrup Metro (0.11)
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Since the number of faces is equivalent to the number of blocks, it is possible to judge that regions where the value of the alpha index is high have many blocks. This indicates that if the area of a region is fixed, the number of blocks is higher, and the average area of a block is smaller.

6.4 Gamma Index (Y)

Connectivity as measured by the Gamma index is expressed in terms of a graph theoretic range, that varies from a set of nodes having no interconnection of one centre to a set of nodes in which every node has an edge connecting it to every other node in the graph (Shing, 2003). The Gamma index is the ratio of the actual number of links to the maximum number of links that can be made according to the number of nodes on a graph. Simply Gamma index is a ratio between the observed number of edges and vertices of a given transportation network. The numerical range for the Gamma Index is between 0 and 1. Higher the value indicates higher the development of network. The Gamma index focuses on the connectivity of road networks. Tables 7 indicates that seven districts viz. Sivasagar (0.43), Jorhat (0.44), Golaghat (0.425), Dima Hasao (0.425), Cachar (0.45), Chirang (0.44) and Kamrup Metro (0.43) belong to the higher gamma index region. In the context of city planning, the road networks with a high value of the gamma index are well laid out in terms of the abundance of roads to choose from. Also, from the point of view of the possibility of a two-way escape, we can say that road networks with high value of the gamma index are well laid out. On the other hand ten districts namely Kokrajhar (0.41), Goalpara (0.40), Morigaon (0.41), Nagaon (0.41), Sonitpur (0.41), Tinsukia (0.40), Karbi Anglong (0.39), Bongaigaon (0.40), Darrang (0.40) and Udalguri (0.39) belong to the moderate beta index region. Rest districts namely Dhubri (0.37), Barpeta (0.38), Lakhimpur (0.38), Dhemaji (0.38), Dibrugarh (0.38), Karimganj (0.36), Hailakandi (0.38), Kamrup (0.37), Nalbari (0.37) and Baksa (0.36) belong to lower gamma index region.

TABLE – 7
SUMMARY FOR GAMMA INDEX

Lower Value	0.36 – 0.39	Dhubri (0.37), Barpeta (0.38), Lakhimpur (0.38), Dhemaji (0.38), Dibrugarh (0.38), Karimganj (0.36), Hailakandi (0.38), Kamrup (0.37), Nalbari (0.37) and Baksa (0.36)
Moderate Value	0.39 – 0.42	Kokrajhar (0.41), Goalpara (0.40), Morigaon (0.41), Nagaon (0.41), Sonitpur (0.41), Tinsukia (0.40), Karbi Anglong (0.39), Bongaigaon (0.40), Darrang (0.40) and Udalguri (0.39)
Higher Value	0.42 – 0.46	Sivasagar (0.43), Jorhat (0.44), Golaghat (0.425), Dima Hasao (0.425), Cachar (0.45), Chirang (0.44) and Kamrup Metro (0.43)

The difference between alpha and gamma indices is whether the focus is on the number of blocks or on the strength of connectivity of the road networks. As Okuno (1977) points out, while the alpha index does not accurately indicate the strength of connectivity of road networks, the gamma index overcomes this disadvantage.

6.5 Cyclomatic Number (μ)

Cyclomatic number is based upon the condition that as soon as a connected network has enough arcs or links to form a tree, then additional arcs will result in the formation of circuits. The cyclomatic number 0 indicates a tree type graph, whereas the graph closer and closer to the completely connected state, the cyclomatic number increases. A disadvantage of this method is that networks with very different forms may have the same cyclomatic number (Waugh, 1995). Tables 8 indicates that the cyclomatic number 0 of Karimganj, Hailakandi, Bongaigaon, Baksa, Darrang and Udalguri indicate a tree type graph while districts namely Sivasagar (17), Jorhat (20), Kamrup Metro (15) and Golaghat (15) having the highest cyclomatic number represents its more closeness and more connected state of road network. On the other hand only six districts namely Nagaon (13), Sonitpur (11), Tinsukia (9), Karbi Anglong (8), Dima Hasao (10) and Cachar (10) belong to the moderate cyclomatic index region having moderate value. Rest twelve districts namely Dhubri (1), Kokrajhar (3), Goalpara (4), Barpeta (2), Morigaon (2), Lakhimpur (3), Dhemaji (2), Dibrugarh (3), Chirang (2), Kamrup (2), Nalbari (1) have low value of cyclomatic number and belong to the low cyclomatic number region.

TABLE – 8
SUMMARY OF CYCLOMATIC NUMBER

Lowest Value	0	Karimganj, Hailakandi, Bongaigaon, Baksa, Darrang and Udalguri
Lower Value	1 – 7	Dhubri (1), Kokrajhar (3), Goalpara (4), Barpeta (2), Morigaon (2), Lakhimpur (2), Dhemaji (2), Dibrugarh (3), Chirang (2), Kamrup (2), Kamrup Metro (5), Nalbari (1)
Moderate Value	7 – 14	Nagaon (13), Sonitpur (11), Tinsukia (9), Karbi Anglong (8), Dima Hasao (10) and Cachar (10)
Higher Value	14 - 21	Sivasagar (17), Jorhat (20), Golaghat (15) and Kamrup Metro (15)

6.6 Grid Tree Pattern

The GTP index is derived by considering both typical types of road network patterns: the grid pattern and the tree pattern, and general road network patterns that are not classified as belonging in either the grid pattern or the tree pattern category. Thus the GTP index is considered as a new index combining the alpha and the gamma index. The GTP index is applied for evaluating road network patterns. The fact have to be consider that a square lattice pattern is considered to be an ideal pattern. The GTP is one of the most important measures

for identifying pattern of network and connectivity. The value of GTP ranges from 0 to 1. The value of '0' indicate that the existing network has tree pattern with poor connectivity & the value approaching towards '1' represents grid pattern with highest network connectivity. The districts which have a GTP value of 0 are Karimganj, Hailakandi, Bongaigaon, Baksa, Darrang and Udalguri with tree pattern of road network and the poorest network connectivity. The poor connectivity of road network represented by hub and spoke pattern include the districts of Kokrajhar (0.16), Dhubri (0.1), Goalpara (0.16), Barpeta (0.1), Morigaon (0.13), Sonitpur (0.1), Lakhimpur (0.1), Dhemaji (0.1), Dibrugarh (0.12), Karbi Anglong (0.16), Kamrup (0.1), and Nalbari (0.1). Six districts namely Nagaon (0.24), Tinsukia (0.21), Golaghat (0.29), Dima Hasao (0.27) and Chirang (0.20) have hexagonal pattern which indicate moderate road network connectivity. The remaining three districts Sivasagar (0.30), Jorhat (0.36), Cachar (0.38) and Kamrup Metro (0.30) have grid pattern with highest connectivity of transport in Assam.

TABLE – 9
SUMMARY OF GTP

Lowest value	0	Tree Pattern	Karimganj, Hailakandi, Bongaigaon, Baksa, Darrang, Udalguri
Lower Value	0.1 – 0.2	Hub & Spoke Pattern	Kokrajhar (0.16), Dhubri (0.1), Goalpara (0.16), Barpeta (0.1), Morigaon (0.13), Sonitpur (0.1), Lakhimpur (0.1), Dhemaji (0.1), Dibrugarh (0.12), Karbi Anglong (0.16), Kamrup (0.1), Nalbari (0.1)
Moderate	0.2 – 0.3	Hexagonal Pattern	Nagaon (0.24), Tinsukia (0.21), Golaghat (0.29), Dima Hasao (0.27), Chirang (0.20)
Higher value	0.3 – 0.4	Grid Pattern	Sivasagar (0.30), Jorhat (0.36), Cachar (0.38) and Kamrup Metro (0.30)

6.7 A.T.S (Aggregate Transportation Score)

It is clear that the districts namely Kokrajhar (4.77), Dhubri (2.50), Goalpara (5.76), Barpeta (3.56), Morigaon (3.71), Lakhimpur (3.59), Dhemaji (3.59), Dibrugarh (4.61), Karimganj (1.37), Hailakandi (1.43), Bongaigaon (1.46), Chirang (3.89), Kamrup (3.52), Kamrup Metro (6.97), Nalbari (2.50), Baksa (1.36), Darrang (1.4) and Udalguri (1.44) have almost equal and lower level of connectivity ranging from 1 to 8.10. Again, the districts like Nagaon (14.98), Sonitpur (12.70), Tinsukia (10.86), Karbi Anglong (9.74), Dima Hasao (12.03) and Cachar (12.28) have slightly better level of connectivity if compared with the previous category. Moreover, three districts i.e. Sivasagar (19.10), Jorhat (22.24), Golaghat (17.07) have higher A.T.S value which results higher degree of connectivity (Table 10). Therefore the overall picture of connectivity in the region under study is more or less uniform with little regional variations.

TABLE – 10
SUMMARY OF A. T. S.

Lowest Value	1 – 8.1	Kokrajhar (4.77), Dhubri (2.52), Goalpara (5.76), Barpeta (3.56), Morigaon (3.71), Lakhimpur (3.59), Dhemaji (3.59), Dibrugarh (4.61), Karimganj (1.37), Hailakandi (1.43), Bongaigaon (1.46), Chirang (3.89), Kamrup (3.5), Nalbari (2.50), Baksa (1.36), Darrang (1.4) and Udalguri (1.44)
Moderate Value	8.1 – 15.2	Nagaon (14.98), Sonitpur (12.70), Tinsukia (10.86), Karbi Anglong (9.74), Dima Hasao (12.03) and Cachar (12.28)
Higher Value	15.2 – 22.3	Sivasagar (19.10), Jorhat (22.24), Golaghat (17.07) and Kamrup Metro (16.98)

TABLE – 11
DISTRICT WISE ROAD DENSITY AND COMPOSITE SCORE OF ROAD TRANSPORTATION IN ASSAM

District	Road Density Per 100 Sq. Km. of Geographical Area	β	α	γ	μ	GTP	ATS
Kokrajhar	58.16	1.14	0.06	0.41	3	0.16	4.77
Dhubri	69.35	1.06	0.02	0.38	1	0.05	2.50
Goalpara	84.98	1.14	0.06	0.40	4	0.16	5.76
Barpeta	68.13	1.08	0.03	0.38	2	0.08	3.565
Morigaon	74.15	1.12	0.05	0.41	2	0.13	3.71
Nagaon	78.53	1.2	0.10	0.41	13	0.24	14.98
Sonitpur	50.15	1.19	0.09	0.41	11	0.20	12.70
Lakhimpur	47.91	1.09	0.03	0.38	2	0.08	3.59
Dhemaji	41.40	1.09	0.03	0.38	2	0.08	3.59
Tinsukia	46.57	1.17	0.08	0.40	9	0.20	10.86
Dibrugarh	51.40	1.09	0.04	0.38	3	0.10	4.61
Sivasagar	107.7	1.25	0.12	0.43	17	0.30	19.1
Jorhat	71.94	1.29	0.14	0.44	20	0.36	22.24
Golaghat	70.82	1.24	0.12	0.42	15	0.29	17.07
Karbi Anglong	41.29	1.14	0.06	0.39	8	0.16	9.745
Dima Hasao	38.38	1.22	0.11	0.42	10	0.28	12.03
Cachar	30.72	1.29	0.14	0.46	10	0.38	12.28
Karimganj	51.74	1	0	0.37	0	0	1.37
Hailakandi	35.64	1.05	0	0.38	0	0	1.43
Bongaigaon	46.66	1.06	0	0.4	0	0	1.46
Chirang	33.42	1.17	0.07	0.44	2	0.21	3.89
Kamrup	92.86	1.06	0.02	0.37	2	0.06	3.52
Kamrup Metro	72.87	1.25	0.11	0.43	15	0.30	16.97
Nalbari	95.59	1.06	0.02	0.37	1	0.04	2.50
Baksa	54.84	1	0	0.36	0	0	1.36
Darrang	57.60	1	0	0.4	0	0	1.4
Udalguri	109.2	1.05	0	0.39	0	0	1.44

7 MAJOR FINDINGS

1. Assam has 40.49 Sq. Km road density per 100 Sq. Km. of geographical area, which is not satisfactory in position. Inter district variation of road density is very low.

2. There is a little variation among the blocks in terms of Beta Index and Gamma Index.
3. Three districts namely Goalpara, Kamrup, Nalbari and Udalguri have minimally connected road networks in spite of its higher density of road networks.
4. Karinganj, Hailakandi, Bongaigaon, Baksa, Darrang, Udalguri have tree type of graph which represents the least close road networks.
5. Inter district variation of cyclomatic number is very high.
5. Cachar has higher close and connected state of road networks in spite of its lower road density.
7. In case of all the connectivity indices (road density, beta, alpha, gamma, cyclomatic number, GTP and ATS) only four districts Golaghat, Sivasagar, Kamrup Metro and Jorhat represent highest value and highest degree of road connectivity and efficiency in the state.
8. Seventeen districts namely, Kokrajhar, Dhubri, Goalpara, Barpeta, Morigaon, Lakhimpur, Dhemaji, Dibrugarh, Karimganj, Hailakandi, Bongaigaon, Chirang, Kamrup, Nalbari, Baksa, Darrang and Udalguri have lower development of transportation in terms of connectivity and have the least efficient road network in Assam.
9. Karimganj, Hailakandi, Bongaigaon, Baksa, Darrang and Udalguri have lowest development in terms of road connectivity and efficiency in the state in spite of their strategic location.

8 CONCLUSION

The study reveals that in 2012, no districts of Assam had road density more than 150 km per 100 square km and most of the districts characterised by minimum efficiency of road network in terms of connectivity. Therefore, it is clear and evident from above discussion that the study area has been experiencing lack of spatial efficiency due to shortage road length. The consequence of which is very uneven spatial development when only a few parts of the study area is equated with well road network. As movements of people, goods and services are highly associated with efficiency of places, naturally the districts of the study area deprived of attaining this facility. Thus, nature of developmental efficiency is also poorer in the study area experiencing a large scale deprivation from every aspect of developmental issues in spite of its immense potentiality from different perspectives like forest resource, mineral resource, agriculture, tourism, agro based industries. These local facilities cannot be utilized properly without radical improvement of existing transportation (Cooley, 1894). Physical constraints like flood and monsoonal rainfall hinder transport development but at the same time it is also true that lack of transparency in between different Governmental organizations is another important factor for this. The progress of transportation is also necessarily dependent upon the consolidation of political power (Cooley, 1894). Number of roads in all blocks of the district should be increased to achieve the better connectivity and accessibility as improvement of transportation, including rural roads, is said to form the most valuable aspect of rural development (Hodder,; William, 1978). Efficiency of road network should be enriched in all

aspects for proper utilisation of available resources. Not only the quantity but also the quality of the road network should be developed to achieve enough efficiency. Therefore, due attention should be paid by making required number of road to enhance mobility and efficiency in Assam, otherwise transport optimacy and its related development never be attained.

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