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Geo-spatial Appraisal of existing road network Assessment: A case Study in lower and Hill division of Assam, India.

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ABSTRACT
The development of the transport and road network plays an important role in the economic development of a country. These road networks create the Social interaction and economic prosperity both at intra and inter regional levels. Consequently, it is regarded as one of the most important indices of socio-economic and commercial development of any region. In the study area most of the populations are engaged in subsistence agriculture by low yield and does not have any remarkable industrial establishments. 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 more 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 the districts of lower Assam as well as hill 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 between lower and hill Assam division is found.

KEY WORDS - Road network, accessibility, connectivity, efficiency, spatial variation.

I. INTRODUCTION

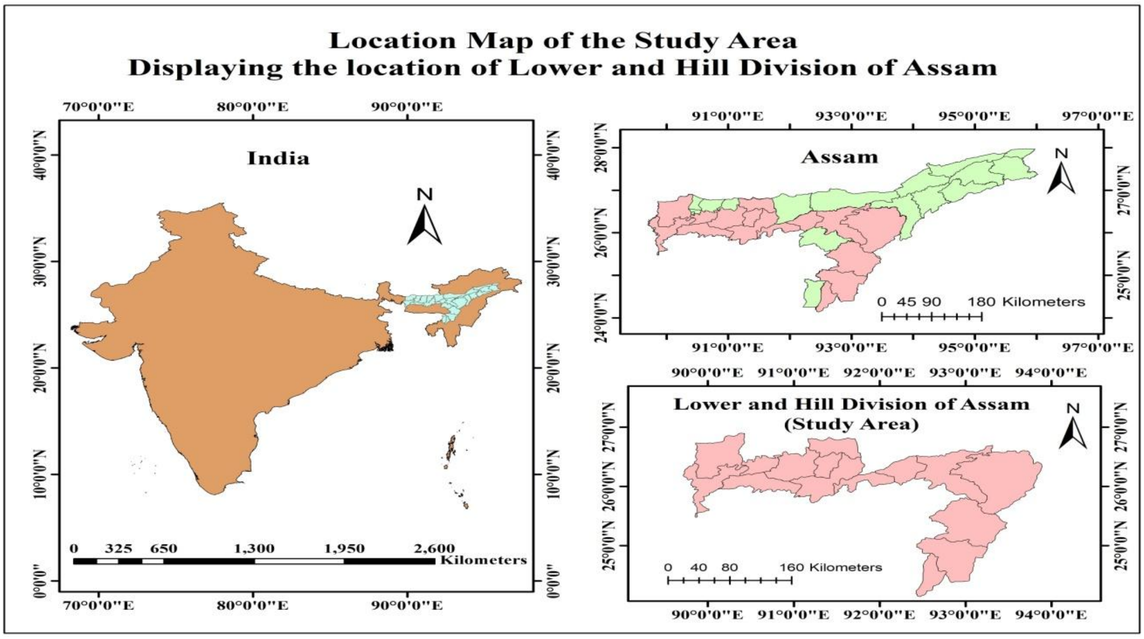
Transport has become an important subject matter for geographers for two main reasons. Firstly, transport is a significant human activity with a strong spatial component. Secondly, it is an important factor influencing the spatial variation of many other social and economic activities (Sarkar et al., 2013). The movement and exchange of people, goods and services is a compulsory feature of modern life 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 (Umoren et al., 2009). 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). Improvements in transportation via road networks between any two places result in increased regional specialisation and lower transportation costs. (Gogoi, 2013). Agglomeration economies accelerate expansion, expand markets, and strengthen the dominance of transportation systems not only in large cities but also in rural areas. (Gogoi, 2013). Since the late nineteenth century, the influence of technological progress on the transportation industry has been as tremendous as it has been in every other aspect of existence. (Simon, 1996). At the local scale existing the hydrographical and geomorphologic characteristics are strong factors in transport development, particularly in terms of the technical challenges (bridge, gradients) they present to construct and maintain infrastructure (Gogoi, 2013). Hence the study about structural analysis of transport network in lower and hill region is very crucial for understanding the spatial variation road network in that region.

II. OBJECTIVES

2.1 To study about the existing road network in the study area.
2.2 To analysis the spatial variation of road network development between lower and hill division of Assam.
2.3 To find out the overall status of development of roadnetwork of the study area.

III. STUDY AREA

The Assam state Located in south of the eastern Himalayas, extending from 89° 42′ E to 96° E longitude and 24°8′ N to 28° 2′ N latitude. Assam comprises with five administrative divisions such as Barak valley, Hill and central Assam, Lower Assam, Upper Assam, and North Assam. Geographically Assam and the northeastern 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". The lower division of Assam comprises with Dhubri, Goalpara, Barpeta, Kokrajhar, Bongaigaon, Nalbari, Kamrup Metro, Kamrup and Baksa. Whereas, the Hill division of Assam comprises with Dima Hasao, Cachar, Nagaon, Morigaon, Karbi Anglong and Hailakandi.



IV. METHODOLOGY

Urban centres, administrative head quarters, regional and local market centres, centres for education, location point of health centres, and other characteristics were used to identify nodes or vertices from 15 districts related to the structural analysis of existing road networks in hill and lower Assam. The following indicators were evaluated to quantitatively describe the road network and to compare the network of a district to the networks of other districts.

Table- 1 Road network assessment index

Sl. No.	Indices	Formula	Correlation with Connectivity
1	Road Density	$\frac{Road\ lengt\square}{Area\ sq.km.}$	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		Higher value indicates more connectivity

	Number	$\mu = e - v + 1$	
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

V. RESULT AND DISCUSSIONS

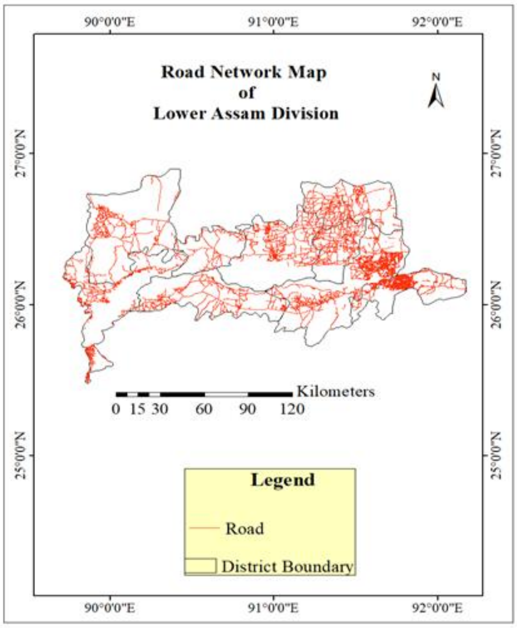
5.1 Existing scenario of Road Network in the Study area:

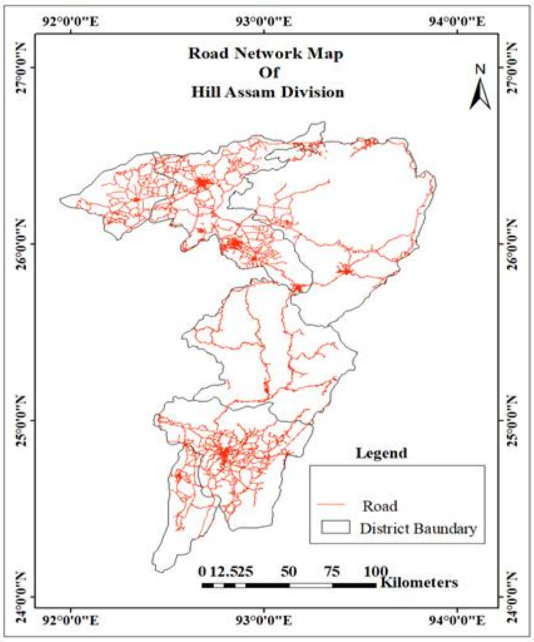
Science independence, the roads networks of the state have been extended a large. In 2016-17, the state had total 49454.44 km road length including 45554 Km. PWD roads and 3900.44 Km. National Highway. The surfaced road is 27003 km and unsurfaced road is 18551 km (Table-2). The major towns in the state are connected by National Highways. 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 length in lower Assam division is 13242 km and in the Hill division the amount is 11779 km, which is quite less in compare with lower division.

Table-2 Existing Road Network of the Study area in 2017, as on 31-03-2017 (in Km)

District	State Highway	Major District Road	RuralRoad	UrbanRoad	Total
Dima Hasao	223	199	1237	60	1719
Cachar	107	165	848	42	1162
Nagaon	260	326	2409	88	3083
Morigaon	134	86	909	13	1142
Karbi Anglong	228	561	3341	70	4200
Hailakandi	17	99	351	6	473
Dhubri	55	53	1007	38	1153
Goalpara	137	48	1354	10	1549
Barpeta	120	171	1663	31	1985
Kokrajhar	23	131	1632	16	1802
Bongaigaon	41	16	712	36	805
Nalbari	70	45	876	22	1013
Kamrup (Metro)	0	0	0	664	664
Kamrup	52	230	2916	0	3198
Baksa	71	43	959	0	1073

Source: Office of the chief Engineer, P.W.D (Road), Assam.





5.2 Assessment of Road Network

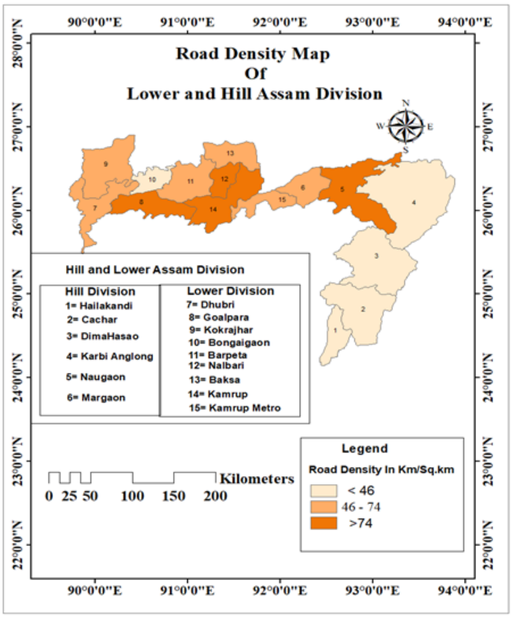
5.2.1 Road Density

Density of road network indicates the length of road per unit of geographical area which explains the degree of connectivity and accessibility of the road network system. The study area has been classified into three regions on the basis of road density. Six districts namely Karbi Anglong (41.29), Dima Hasao (38.38), Cachar (30.72), Hailakandi (35.64), Bongaigaon (46.66) and Baksa (54.84) belong to the lower road density region. On the other hand, the districts namely Kokrajhar (58.16), Dhubri (69.35), Barpeta (68.13), Morigaon (74.15), Nagaon (78.53), Kamrup Metro (72.87) belong to the moderate road density region while only three districts namely Goalpara (84.98), Kamrup (92.86), Nalbari (95.59) belong to high road density region (Table-3).

Table-3 Road density

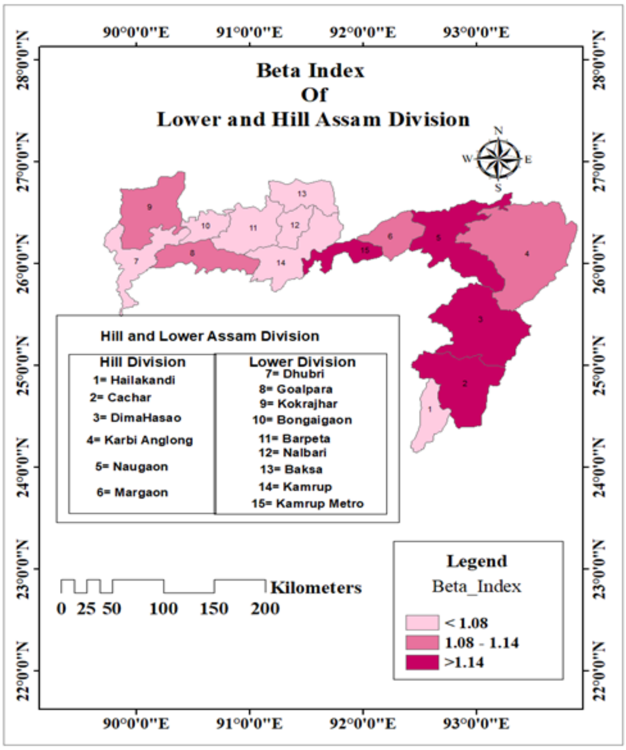
Lower Assam	
District	Road Density
Dhubri	69.35
Goalpara	84.98
Barpeta	68.13
Kokrajhar	58.16
Bongaigaon	46.66
Nalbari	95.59
Kamrup (Metro)	72.87
Kamrup	92.86
Baksa	54.84
Hill Assam	
District	Road Density
Dima Hasao	38.38
Cachar	30.72
Nagaon	78.53
Morigaon	74.15
Karbi Anglong	41.29
Hailakandi	35.64

Source: Computed by The author



5.2.2 Beta Index

The beta index (β) is a simple measure of connectedness that is calculated by dividing the total number of arcs in a network by the total number of nodes. If the beta index value is greater than 1, the networks are well connected, and higher values indicate that the networks are more complex. In the study area of Assam, out of 15 districts Baksa 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 three districts namely Dima Hasao (1.22), Cachar (1.30) and Kamrup Metro (1.25) have the most complex and well connected road networks. While five districts namely Kokrajhar (1.14), Goalpara (1.14), Morigaon (1.125), Nagaon (1.20), Karbi Anglong (1.14) have moderate well connected road network and rest districts namely, Dhubri (1.06), Barpeta (1.08), Hailakandi (1.05), Bongaigaon (1.06), Kamrup (1.07), Nalbari (1.06), Baksa (1), have the lowest well connected road network (Table-4).



Source: Computed by the author

Table-4 Beta Index

Lower Assam	
District	Beta Index
Dhubri	1.06
Goalpara	1.14
Barpeta	1.08
Kokrajhar	1.14
Bongaigaon	1.06
Nalbari	1.06
Kamrup (Metro)	1.25
Kamrup	1.07
Baksa	1.00
Hill Assam	
District	Beta Index
Dima Hasao	1.22
Cachar	1.30
Nagaon	1.20
Morigaon	1.13
Karbi Anglong	1.14
Hailakandi	1.05

5.2.3 Alpha Index:

The alpha index is a ratio that compares the number of actual circuits to the total number of circuits in a network. The index ranges from 0 for the most least connected network to 1 for the most fully connected network. The district has been divided into three regions on the basis of obtained alpha values. Tables-5 indicates that Hailakandi, Bongaigaon and Baksa districts have minimally connected road network having the alpha index value 0. Five districts namely, Dhubri (0.017), Barpeta (0.028), Morigaon (0.046), 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), Karbi Anglong (0.062), belong to the moderate alpha index region having moderate connected road network. On the otherhand only three districts namely Dima Hasao (0.11) Cachar (0.14) and Kamrup Metro (0.11) belong to comparatively higher connected road network.

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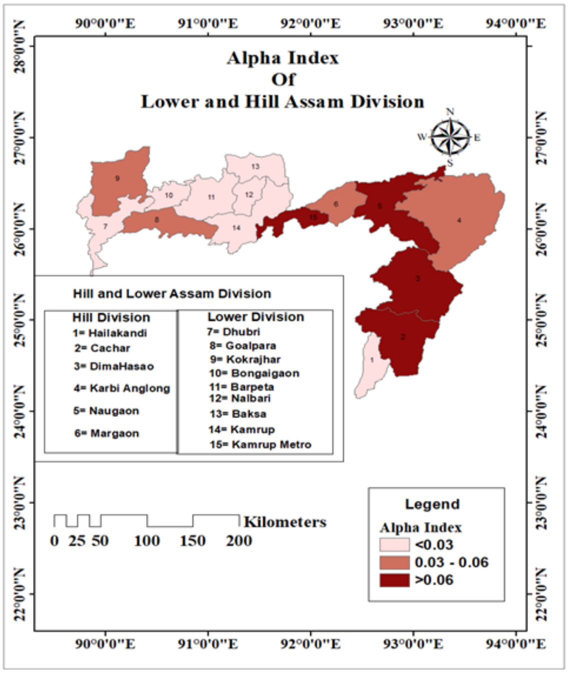
Table – 5 Alpha Index

Lower Assam	
District	Alpha Index
Dhubri	0.02
Goalpara	0.06
Barpeta	0.03
Kokrajhar	0.06
Bongaigaon	0.00
Nalbari	0.02
Kamrup (Metro)	0.11
Kamrup	0.02
Baksa	0.00
Hill Assam	
District	Alpha index
Dima Hasao	0.11
Cachar	0.14
Nagaon	0.09
Morigaon	0.05
Karbi Anglong	0.06
Hailakandi	0.00



Computed by the Author

5.2.4 Gamma Index

The Gamma index measures connectivity in terms of a graph theoretic range that ranges from a set of nodes with no interconnectivity of one centre to a set of nodes with an edge linking each node to every other node in the graph (Shing, 2003). The Gamma index is the ratio of the actual number of links to the greatest number of linkages possible given the number of nodes in a network. 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-6 indicates that three districts i.e. Dima Hasao (0.425), Cachar (0.45), 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 favorable. On the other hand six districts namely Kokrajhar (0.41), Goalpara (0.40), Morigaon (0.41), Nagaon (0.41), Karbi Anglong (0.39), and Bongaigaon (0.40), belong to the moderate beta index region. Rest of the districts namely Dhubri (0.37), Barpeta (0.38), Hailakandi (0.38), Kamrup (0.37), Nalbari (0.37) and Baksa (0.36) belong to lower gamma index region.

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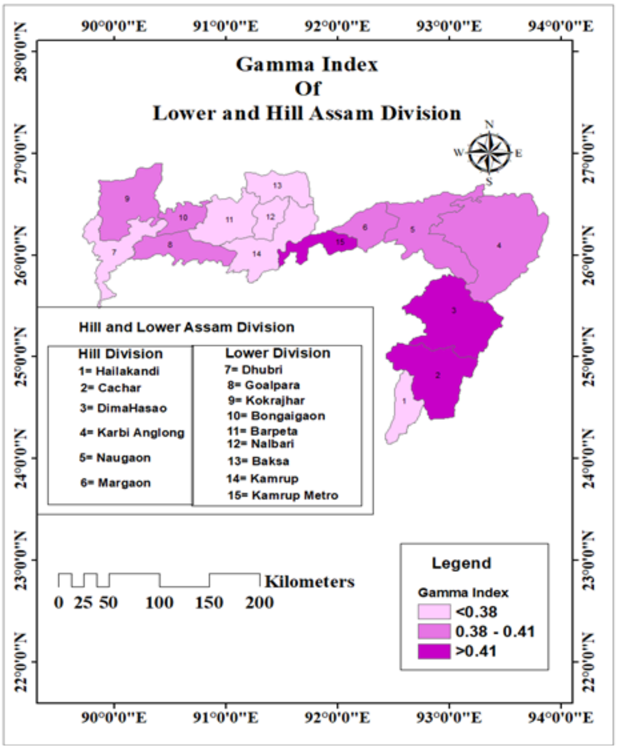

Table-6 Gamma Index

Lower Assam	
District	Gamma Index
Dhubri	0.37
Goalpara	0.40
Barpeta	0.38
Kokrajhar	0.41
Bongaigaon	0.40
Nalbari	0.37
Kamrup (Metro)	0.43
Kamrup	0.37
Baksa	0.36
Hill Assam	
District	Gamma index
Dima Hasao	0.43
Cachar	0.45
Nagaon	0.41
Morigaon	0.41
Karbi Anglong	0.39
Hailakandi	0.38

Source: Computed by the Author

5.2.5 Cyclomatic Number

The Cyclomatic number is based on the idea that once a connected network has enough arcs or links to create a tree, adding more arcs will result in circuit construction. The Cyclomatic number 0 implies a tree type graph, but the Cyclomatic number increases as the graph approaches the fully linked state. This approach has the drawback of having the same Cyclomatic number for networks of very different forms (Waugh, 1995). Tables-7 indicates that the Cyclomatic number 0 of Hailakandi, Bongaigaon, Baksa indicate a tree type graph while, districts namely Kamrup Metro (15) having the highest Cyclomatic number represents its more closeness and more connected state of road network. On the other hand only four districts namely Nagaon (13), Karbi Anglong (8), Dima Hasao (10) and Cachar (10) belong to the moderate Cyclomatic index region having moderate value. Rest seven districts namely Dhubri (1), Kokrajhar (3), Goalpara (4), Barpeta (2), Morigaon (2), Kamrup (2), Nalbari (1) have low value of Cyclomatic number and belong to the low Cyclomatic number region.

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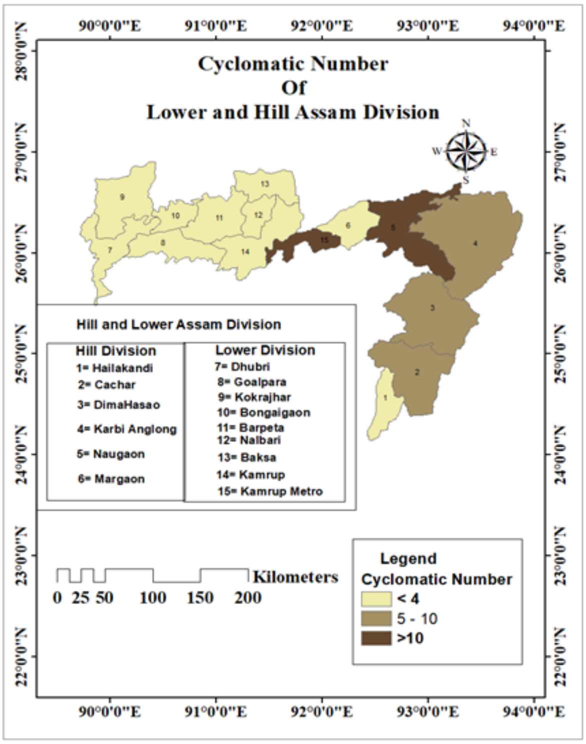
Table – 7 Cyclomatic Number

Lower Assam	
District	Cyclomatic Number
Dhubri	1
Goalpara	4
Barpeta	2
Kokrajhar	3
Bongaigaon	0
Nalbari	1
Kamrup (Metro)	15
Kamrup	2
Baksa	0
Hill Assam	
District	Cyclomatic Number
Dima Hasao	10
Cachar	10
Nagaon	13
Morigaon	2
Karbi Anglong	8
Hailakandi	0

Source: Computed by the Author



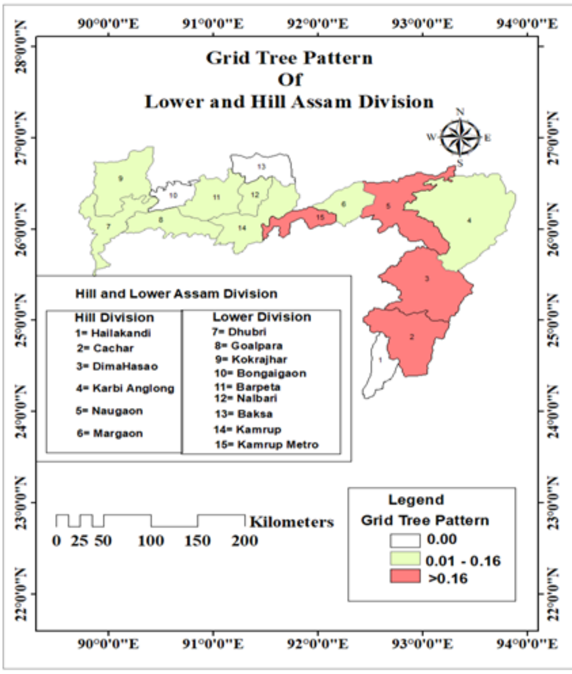
5.2.6 Grid Tree pattern:

The GTP index is calculated by taking into account both common types of road network designs: The grid pattern and the tree pattern, as well as basic road network layouts that aren't classed as grid or tree patterns. Thus the GTP index is considered as a new index combining the alpha and the gamma index. The GTP index is used to assess the patterns of road networks. The fact that a square lattice pattern is believed to be an ideal pattern must be addressed. 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 Hailakandi, Bongaigaon, Baksa with tree pattern of road network and the poorest network connectivity. The poor connectivity of road network represented by hub and spoke pattern includes the districts of Kokrajhar (0.16), Dhubri (0.1), Goalpara (0.16), Barpeta (0.1), Morigaon (0.13), Karbi Anglong (0.16), Kamrup (0.1), and Nalbari (0.1). Two districts namely Nagaon (0.24) and Dima Hasao (0.27) have hexagonal pattern which indicate moderate road network connectivity. The remaining two districts Cachar (0.38) and Kamrup Metro (0.30) have grid pattern with highest connectivity of transport in Assam.

Table – 8 Grid Tree Pattern

Lower Assam	
District	Grid Tree Pattern
Dhubri	0.10
Goalpara	0.16
Barpeta	0.10
Kokrajhar	0.16
Bongaigaon	0.00
Nalbari	0.10
Kamrup (Metro)	0.30
Kamrup	0.10
Baksa	0.00
Hill Assam	
District	Grid Tree Pattern
Dima Hasao	0.27
Cachar	0.38
Nagaon	0.24
Morigaon	0.13
Karbi Anglong	0.16
Hailakandi	0.00

Source: Computed by the Author



5.3 The overall status of the road network in the study area:

Aggregate Transportation Score (A.T.S) is defining as the sum of Beta, Alpha, and Gamma index with Cyclomatic number and Grid tree pattern. Higher the value indicates more connectivity and efficiency and lower the value indicates less connectivity and efficiency. It is clear from the above discussion (Table-8) that the districts namely Kokrajhar (4.77), Dhubri (2.50), Goalpara (5.76), Barpeta (3.56), Morigaon (3.71), Hailakandi (1.43), Bongaigaon (1.46), Kamrup (3.52), Kamrup Metro (6.97), Nalbari (2.50), Baksa (1.36), have almost equal and lower level of connectivity ranging from 1 to 8. Again, the districts like Karbi Anglong (9.74) have slightly better level of connectivity if compared with the previous category. Moreover, three districts i.e. Nagaon (14.98), Dima Hasao (12.03) and Cachar (12.28) have higher A.T.S value which results higher degree of connectivity. As a result, the overall image of connectedness in the research area is more or less uniform, with minimal regional variance between Assam's lower and higher regions.

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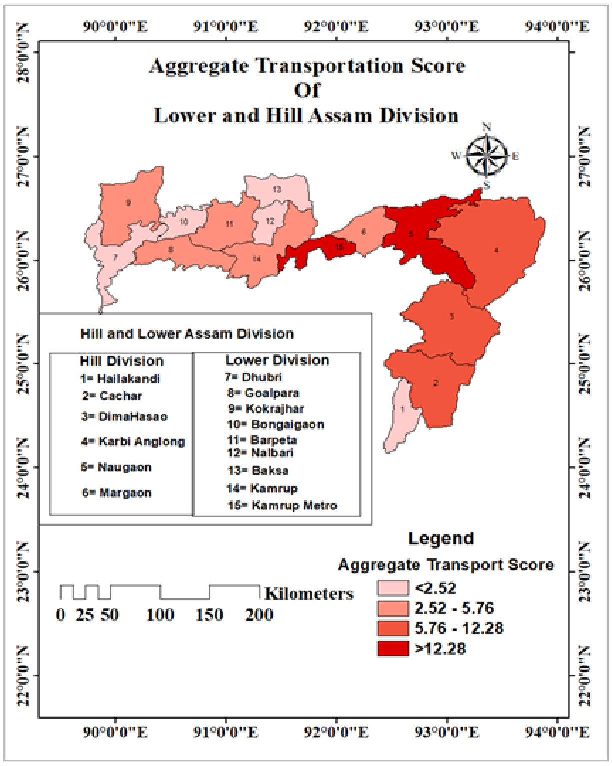

Source: Computed by the Author

Table – 10 Aggregate Transportation Score

Lower Assam	
District	A.T.S
Dhubri	2.52
Goalpara	5.76
Barpeta	3.56
Kokrajhar	4.77
Bongaigaon	1.46
Nalbari	2.50
Kamrup (Metro)	16.98
Kamrup	3.5
Baksa	1.36
Hill Assam	
District	A.T.S
Dima Hasao	12.03
Cachar	12.28
Nagaon	14.98
Morigaon	3.71
Karbi Anglong	9.74
Hailakandi	1.43

VI. MAJOR FINDINGS

Assam has 58.08 Km road length per 100 Sq. Km. of geographical area, which is not satisfactory in position. The variation in road density between districts is extremely low.

6.1 The district namely Baksa have minimally connected road networks in terms of density of road networks which is 54.84 in the lower Assam division. On the other hand the district i.e. Cachar have the minimum road density of 30.72 in the Hill Assam Division.

6.2 There is a little variation among the Beta Index and the Gamma Index.

6.3 The district such as Hailakandi, Bongaigaon, and Baksa has tree type of graph which represents the least close road networks.

6.4 The Cyclomatic number is very high in Kamrup metro district in lower Assam division and Nagaon in Hill division.

6.5 Though Cachar has lower road density but it is close and connected state of road networks.

6.6 In case of the entire connectivity indices such as road density, Beta, Alpha, Gamma, Cyclomatic number, GTP and ATS only one district in lower Assam i.e. Kamrup Metro and Nagaon in Hill Assam represent highest value and highest degree of road connectivity and efficiency in the study area.

6.7 The districts namely Kokrajhar, Dhubri, Goalpara, Barpeta, Bongaigaon, Kamrup, Nalbari, Baksa in lower Assam division and the districts namely Morigaon and Hailakandi have lower development of transportation in terms of connectivity and have the least efficient road network in the study area.

6.8 Though the district such as Hailakandi, Bongaigaon and Baksa has their strategic location but these districts have lowest development in terms of road connectivity and efficiency in the study area.

VII. CONCLUSION

The most valuable part of rural development, is improving transportation, including rural roads. (Hodder, William, 1978). The efficiency of places is strongly linked to the flow of people, products, and services. But naturally the districts of Hill division of the study area deprived of attaining this facility. As a result, the nature of developmental efficiency is poorer in the study area, which is suffering from widespread deprivation in every aspect of development, despite its enormous potential from various perspectives such as mineral resources, tourism, forest resources, agricultural activity, agro-based industries, and so on. These local resources can't be fully utilized unless present transportation is drastically improved (Cooley, 1894). Though the advancement of transportation development is closely linked to political power coordination, but the physical obstacles such as undulating topography in Assam's Hill division and flooding in the Lower division are the main roadblocks to transportation growth (Cooley, 1894). On the other hand, a lack of transparency between various government agencies is a significant component in this growth. The study reveals that in 2017, the number of roads in all the district of the study area should be increased to achieve the better connectivity and accessibility. Because no districts of the study area had road density more than 100 km per 100 square km and most of the districts characterised by minimum efficiency of road network in terms of connectivity. As a result of the preceding discussion, it is obvious that the research area has been facing a lack of spatial efficiency in transportation due to a lack of road length. As a result, spatial growth is quite uneven, except in a few portions of the study region where the road network is extensively developed.

REFERENCES

[1]. Aduory, R. (2010). Geographical Analysis of the Network of Roads in the Duor for 2008. Journal of Tikrit University for the humanities, University of Tikrit, Iraq, 17(3).
[2]. B. Sukla, "Mass Transport Services in Calcutta Metropolitan Area," Geography of Transport Development of India, B. C. Vaidya, New Delhi: Concept Publication Company, pp. 124 – 139, 2003.
[3]. Bharuri, S. (1992). Transport and Regional Development, A Case Study of Road Transport of WestBengal, Concept Publishing Company, New Delhi.
[4]. Eberts, R. (2005). Understanding the Impact of Transportation on Economic Development, Norman Foster, and Department of Transportation. pp. 1-5.
[5]. Gogoi, B. (2013). Structural Analysis of Existing Road Networks of Assam: A Transport Geographical Appraisal. International Journal of Scientific & Engineering Research, 4(12), 1817-1823.
[6]. H. M. Saxena, Transport Geography. New Delhi: Rawat Publication, pp. 9 – 35, 2010.
[7]. Li, T., Wu, J., Sun, H., & Gao, Z. (2016). Integrated co-evolution model of land use and traffic network design. Networks and Spatial Economics, 16(2), 579-603.
[8]. M. Yeats, An Introduction to Quantitative Analysis in Human Geography. Mc Graw Hill Publication: New York, pp 12 – 44, 1972.
[9]. Mitra, S., Das, B., Roy, S., & De, S. K. (2015). Transport network system in Namchi town of south Sikkim: a geographical appraisal. Geo-Analyst , ISSN 2249-2909.p1-9.
[10]. P. S. Gautam, Transport Geography of India. New Delhi: Mittal Publication, pp. 1 – 6, 1992.
[11]. Qtiashat, D., Makhmreh, Z., Taleb, H. A., & Khalaifat, A. (2018). Urban land use pattern and road network characteristics using GIS in Al Salt City, Jordan. Modern Applied Science, 12(4), 128-142.
[12]. Rodrigue J.P., Comtois C, & Slack B. (2006). The Geography of Transport Systems, Routledge, London, p. 12-13.
[13]. Sarkar, D. (2013). Structural Analysis of Existing Road Networks of Cooch Behar District, West Bengal, India: A Transport Geographical Appraisal, Ethiopian Journal of Environmental Studies and Management Vol. 6 No.1., pp. 74-81.
[14]. Sarkar, T., Sarkar, D., & Mondal, P. (2021). Road network accessibility analysis using graph theory and GIS technology: a study of the villages of English Bazar Block, India. Spatial Information Research, 29(3), 405-415.
[15]. Taran, A., & Makhamra, Z. (2015). Quantitative Analysis of Road Network in the Mafraq Governorate, the Dirasat journal (Humanities and social sciences). University of Jordan,(42).