

## **Cyclomatic Number of National Highways in India : A Geographical Analysis**

**Dr. Prem Pal Singh**  
**Assistant Professor (Geography)**  
**Pyarelal Smarak Mahavidyalay, Simariya, Kannauj, (U.P)**  
**Chhatrapati Shahu Ji Maharaj University (C.S.M.U, Kanpur)**

### **Abstract**

Roads are one of the major sources of development of any country. The internal economy of the country is advanced in the country where the road network is more developed. National highways are the most important of the road routes. The major cities of the country are connected by national highways.

Just as the road network is essential, so is its connectivity. Because if the roads are connected to each other, the connectivity is high and both time and distance factors are saved.

In the present research paper connectivity of National Highways in India is studied with the help of Cyclomatic Number.

### **Keywords**

National Highway, Cyclomatic Number, Connectivity, edges, vertices

### **Introduction**

India has a network of more than one and a half lakh kilometers of national highways. National highways are more or less developed in almost all the states of the country. The national highway network is developed mainly in the north central and southern parts of the country. Also, almost the main cities of the country are connected by national highways.

In the present research paper, a comparative study of the connectivity of national highways in India has been done with the help of Cyclomatic Number index.

### **Objectives**

The main objective of the present research paper is to calculate and evaluate the cyclomatic number of national highways in India.

## Data Source and Methodology

Present discussion is based on the secondary data and graph theory method. Related data and base map is compiled from 'National Highway Authority of India' The analysis is based on connectivity index of cyclomatic number suggested by K.J. Kansky (1963),

$$\mu = (e - v)$$

$\mu$  - Cyclomatic Number,

$e$  - edges

$v$  - vertices

Calculated values are shown in table and connectivity is shown in the map. The analysis is based on the state wise discussion.

## Study Region

India is situated in Asia and it is one of the important countries in this continent. India is a famous nation all over the world. Geographically, nation is situated in the southernmost region of Asia. India is a very populous nation which is naturally protected from all sides. It is famous all over the world for its rich culture and traditional values.

Geographically the nation is located in between latitudes  $8^{\circ} 4' N$  to  $37^{\circ} 6' N$ , and the longitudes  $68^{\circ} 7' E$  to  $97^{\circ} 25' E$ . The Tropic of Cancer passes through the country, dividing it into nearly two equal parts.

The world's highest peak, the Himalayas, is nearby. It is surrounded on three sides by the Indian Ocean to the south, the Bay of Bengal to the east and the Arabian Sea to the west. India, the second most populous democratic nation, is a democracy. Although the majority language of India is Hindi, there are around 22 other officially recognized languages.

## Edges and Vertices of National Highway

The center point where any two main roads meet are called 'vertices' and the roads leading from that center point are called 'edges'. Connectivity is calculated based on these two factors. The more the roads are connected to each other, the more the edges and vertices increase and the connectivity increases.

The following table no.1 shows the number of edges and vertices in the national highways of India state wise.

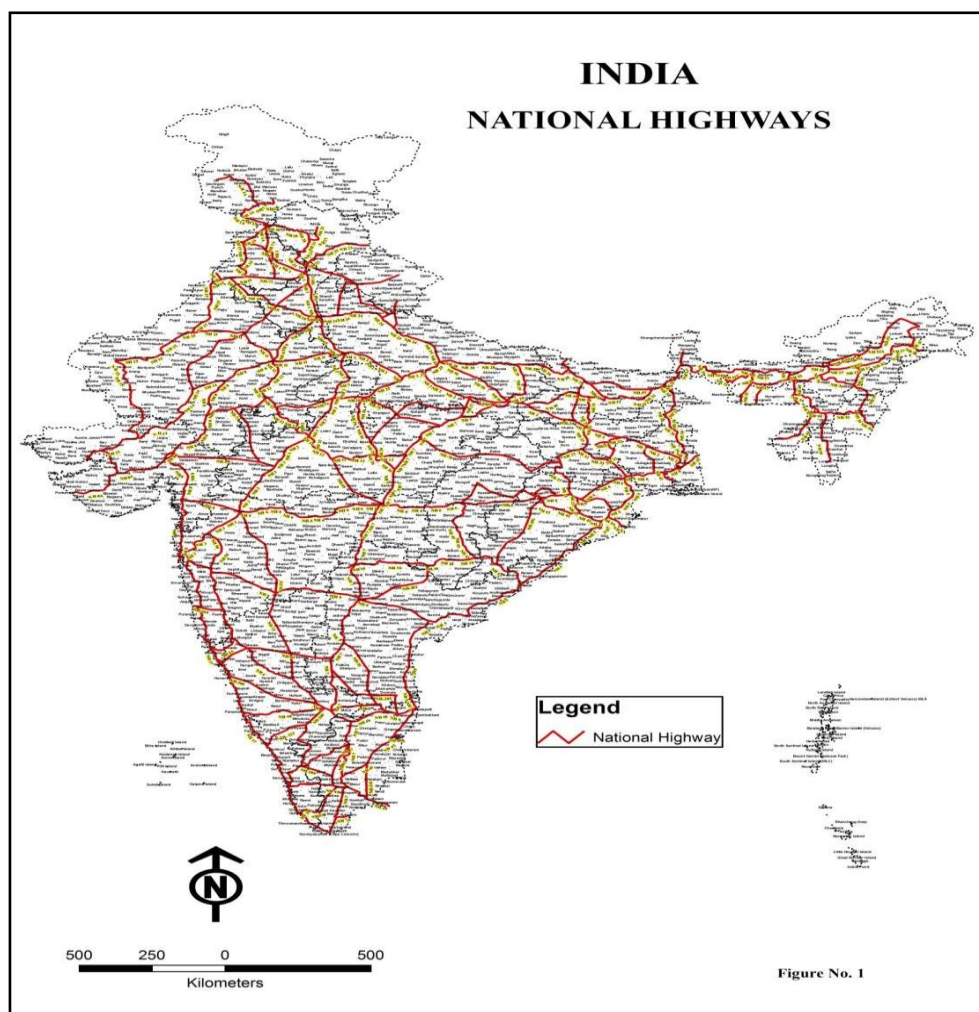
**Table No 1**  
**Edges and Vertices of National Highways in India (Year – 2014)**

States	Vertices	Edges
Andhra Pradesh	9	15
Arunachal Pradesh	1	1
Assam	12	20
Bihar	9	15
Chhattisgarh	3	9
Goa	2	4
Gujarat	7	15
Haryana	3	7
Himachal Pradesh	3	4
Jammu & Kashmir	3	3
Jharkhand	6	13
Karnataka	10	22
Kerala	5	11
Madhya Pradesh	12	27
Maharashtra	11	19
Manipur	2	3
Meghalaya	1	5
Mizoram	1	1
Nagaland	1	1
Orissa	12	23
Punjab	8	18
Rajasthan	8	17
Sikkim	1	1
Tamil Nadu	14	30

Tripura	1	1
Uttar Pradesh	14	29
Uttaranchal	1	5
West Bengal	8	16
<b>India</b>	<b>168</b>	<b>335</b>

Source – Calculated by Author

In India there are total 168 vertices and 335 edges are available in the existing network of national highway. Tamil Nadu, Uttar Pradesh state found the 14 vertices on nation highway in their entire boundary. Assam, Madhya Pradesh, Orissa state has found 12 vertices, while Maharashtra has 11 and Karnataka has found 10 vertices in national highway network in the state. Number of edges in is more than 20 in all states except Assam and Maharashtra state. The geographical area of these states is more and the number is less in comparison.



The other states have found less than 10 vertices in national highways network. The states of Arunachal Pradesh, Mizoram, Nagaland, Sikkim and Tripura have vertices in the national highway network. So each has a branch of national highway, i.e., a national highway passes through this state, but they are not connected to each other within the boundaries of that state. This state is mainly in the north and has a small area. Also, since it is a hilly area, it has an impact on road development. Vertices in these states are known as ‘end vertices’ or ‘end node’, means there is no further connection between them.

Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, and Uttarakhand state found 1 vertex in their national highway network. These states are also located in north part of India and physiography of this region impacts on the road network.

### **Cyclomatic Number of National Highways**

Cyclomatic number is one of the important indicators of road connectivity. It is produced the number of fundamental circuits in existing road network in any region. Cyclomatic number of road network is directly impact on the socio-economic development of the region. Areas with more Cyclomatic numbers have more access to main roads from one place to another. This saves both time and fuel.

The following Table No. 2 shows the state wise number of Cyclomatic numbers on National Highways in India.

**Table No 2**

**Cyclomatic Number of National Highways in India (Year – 2014)**

<b>States</b>	<b>Cyclomatic Number</b>
Andhra Pradesh	6
Arunachal Pradesh	0
Assam	8
Bihar	6
Chhattisgarh	6



Goa	2
Gujarat	8
Haryana	4
Himachal Pradesh	1
Jammu & Kashmir	0
Jharkhand	7
Karnataka	12
Kerala	6
Madhya Pradesh	15
Maharashtra	8
Manipur	1
Meghalaya	4
Mizoram	0
Nagaland	0
Orissa	11
Punjab	10
Rajasthan	9
Sikkim	0
Tamil Nadu	16
Tripura	0
Uttar Pradesh	15
Uttaranchal	4
West Bengal	8
<b>India</b>	<b>167</b>

Source – Calculated by Author

If we consider the entire country as a whole, there are a total of 167 fundamental circuits of national highways in the country. Major cities of the country from North to South and East to West are connected by these routes. If considered according to the state boundaries, there is a difference in the amount in each state.

Cyclomatic number is divided into four categories to describe the connectivity of nation highway. Cyclomatic number more than 10 as high connectivity, 5 to 10 as moderate, 1 to 5 as poor and cyclomatic number '0' as no connectivity between national highway.

### **High Connectivity (Cyclomatic Number more than 10)**

Tamil Nadu (16), Madhya Pradesh (15), Uttar Pradesh (15), Karnataka (12) and Orissa (11) states has found more than 10 fundamental circuits in the entire state national highway network. The state is large in area and more than 5 national highways pass through the state. The states of Karnataka and Tamil Nadu in the south have the most developed national highway network. Major cities of South India are connected by national highways that pass through the state. Also, the main cities of the north are connected by these main routes from the two states of Madhya Pradesh in Central India and Uttar Pradesh in North India.

### **Moderate Connectivity (Cyclomatic Number 5 to 10)**

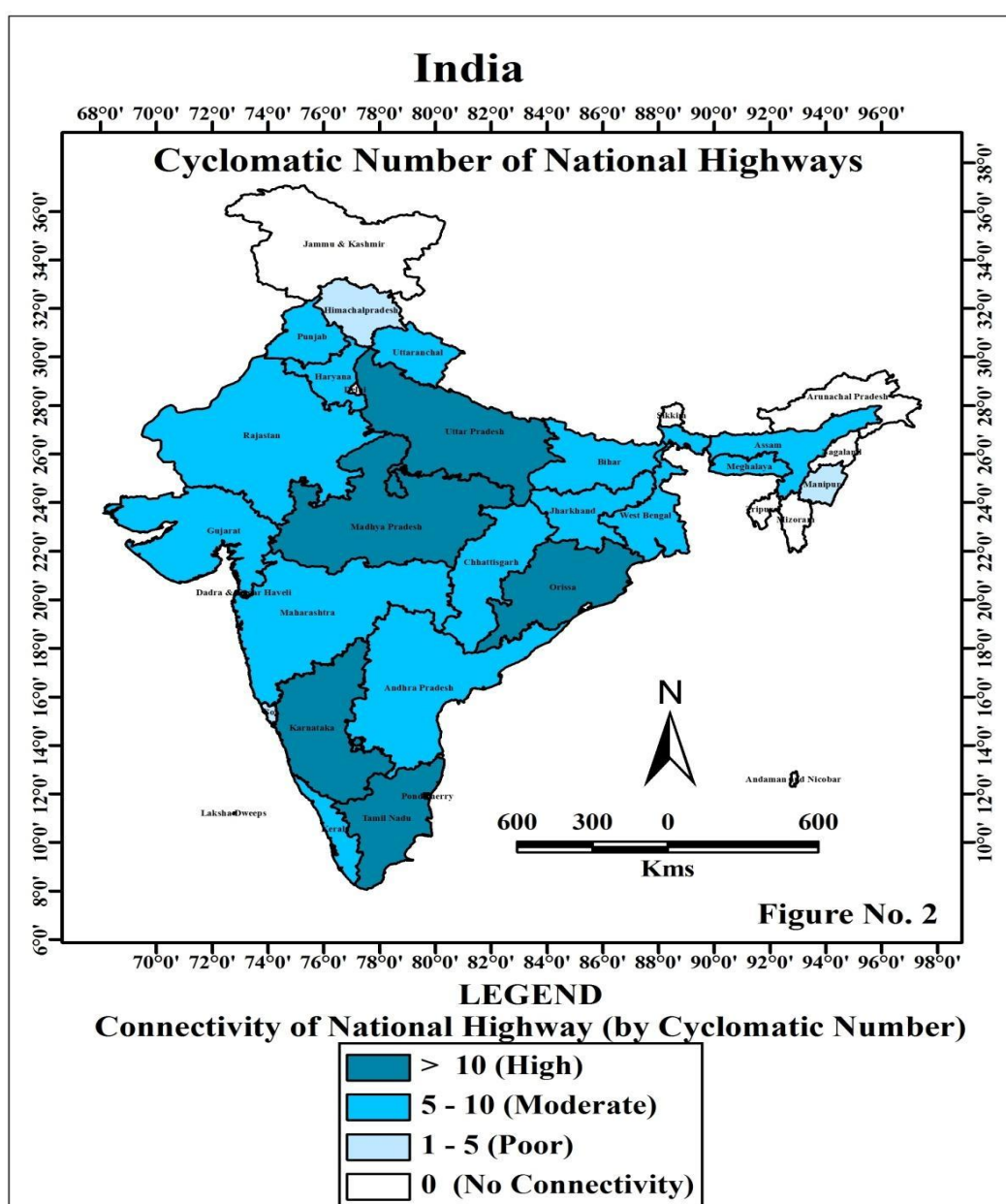
Punjab (10), Rajasthan (9), Assam (8), Gujarat (8), Maharashtra (8), West Bengal (8), Jharkhand (7), Andhra Pradesh (6), Bihar (6), Chhattisgarh (6), and Kerala (6) state has found the moderate connectivity of national highways in the entire state boundary.

There are 6 to 10 fundamental circuits are available in national highways network. Compare to the population, geographical area of these states this connectivity is not enough. More than three national highways pass through this state and some major cities are connected to the state capital by national highway.

### Poor Connectivity (Cyclomatic Number 1 to 5)

In the nation Haryana, Meghalaya, Uttaranchal state has found 4 and Himachal Pradesh, Jammu and Kashmir and Manipur state has found 1 fundamental circuits. But the cycle of national highways completed in this state is completed from another nearby state.

All these states are located in the north and connectivity in these states is very less. Other main roads connect the main cities of this state. The development of national highways has slowed down due to uneven topography.





## **No Connectivity of National Highways (Cyclomatic Number '0')**

Arunachal Pradesh, Mizoram, Nagaland, Sikkim and Tripura states has no found fundamental circuits in national highway network in their entire state boundary. The vertices in the national highways in these states are 'end node' type and no further connected. Therefore the road transport circuit within national highway is not completed within state and near state region.

These all states are located in northeast region and slope of this region is high. The socioeconomic developments of these states are also lower compare to the other states in the nation.

### **Conclusions and Suggestions**

India has an extensive network of national highways, but this highway network is not uniform in all the states. The national epidemic network is less developed in the northeast and north parts of the country. National highways are less developed in this area as the topography is not level. Therefore, the connectivity of national highways with each other is also less.

In India, states which have larger area, the basic circuit of national highways is completed under that state. But in some states these circuits are completed from a short distance. Although a state like Rajasthan is large in area, the state has only 9 fundamental circuits in the national highway network.

National highways must be developed for large and heavy vehicles as well as fast transportation. If these national highways are more connected to each other, the connectivity will increase and if the distance between connecting roads is less, time, distance and fuel will be saved. In the country, these national highways carry both domestic and inter-state travel, but intra-state travel is more prevalent. Therefore, it is necessary to increase the network of national highways in the interior parts of the state.

Jammu & Kashmir in the north of the country and Arunachal Pradesh, Mizoram, Nagaland, Sikkim and Tripura in the north-east of the country do not have a basic circuit of national highways. In the state of Jammu & Kashmir, one or two circuits may be formed, requiring the addition of a middle road.

In the state of Rajasthan, Uttar Pradesh, Bihar, Karnataka, Maharashtra, Tamil Nadu, there is scope for connecting many national highways and it is possible. This will help in the development of roads by increasing connectivity in this state.

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