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An Assessment of Accessibility and Connectivity of Some Important Places in Kolhapur City of Maharashtra: A Road Network Analysis

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Abstract

There are various methods to find out the accessibility and connectivity of road networks. The method that used to determine the accessibility and connectivity is quantitative or qualitative; sometime it includes both quantitative and qualitative aspects of transportation network. The degree to which any place is served by transportation network (on which it stands) defines the accessibility of that place. And the connectivity is the ratio between total number of arcs and total number of nodes in transportation network. The connectivity is directly proportional to the total number of arcs and inversely proportional to the total number of nodes. If the degree of connectivity within a transportation network is higher; then it means that transportation system will be more efficient. Therefore, the present paper attempts to access the accessibility and connectivity of road networks in Kolhapur city. The accessibility of study area is determined by the shortest path matrix. The connectivity is determined by the beta (β) index given by K.J. Kansky. After analyzing the accessibility and connectivity of study area, easily accessible and shortest paths are also suggested in order to reach the important centers very easily.

Key words: Road transportation network, accessibility, connectivity, shortest path matrix.

1. Introduction

A Transport network is established with a view to facilitate economic and social interaction in space- both at the intra and inter regional levels. But once it is established, it plays an important role in shaping the space economy itself. The maximum possible limit to the amount of interaction between the nodes and the hinterland is determined by the availability of network facility. Once a transport network comes to be established in an area, it

is considered as a neutral agency providing equal accessibility to all the nodes connected by it. The differentials in accessibility are brought out by the relative location of the nodes with references (Raza and Aggarwal, 1986). The transport structure in the Kolhapur district is composed mainly of railways, roadways and airways. The roadways are more important than other modes of intraregional transportation especially on micro-level, because of high flexibility and low expenditure involved in their constructions. The schematic linkage plans were prepared that suggested a number of measures for quantitative improvements of various road sections as well as proposing some new roads (Singh and Pathak, 2001). The degree to which any place is severed by a transportation network on which it stands is reflected in its relative accessibility to other places with which it interacts (Berry and Marble, 1968).

The interaction between places is determined by the presence of total nodes and arcs in their road network. If all the nodes are connected by sufficient number of arcs then it denotes highest degree of connectivity and accessibility. Therefore, the present paper attempts to access the accessibility and connectivity of road networks in Kolhapur city. The degree to which any place is served by transportation network on which it stands defines the accessibility of that place. The accessibility of study area is determined by the shortest path matrix. The connectivity means the degree of completeness of the links between nodes. The connectivity is determined by the beta (β) index given by K.J. Kansky. After analyzing the accessibility and connectivity of study area, easily accessible and shortest paths are also suggested in order to reach the important centers very easily.

2. Objectives

- To determine the connectivity and accessibility of Road Networks in study area.
- To suggest easily accessible and shortest path to reach the important centers in study area.

3. Materials and Methods

The present paper is based on secondary sources of data. Secondary data is collected from district census handbook, socio-economic review of Kolhapur district, gazetteers of Kolhapur district, Website of Kolhapur Municipal Corporation and available published and unpublished material, internet, books and maps of Kolhapur city.

For the present study, the connectivity and accessibility is determined by using the various statistical methods. The connectivity means the degree of completeness of the links between nodes.

The connectivity is determined by the Beta (β) index given by K.J. Kansky.

$$\text{Beta Index } (\beta) = \frac{\text{Arcs}}{\text{Nodes}}$$

Where, Arcs are total number of linkages between nodes

Nodes are the total number of link points in a network

The accessibility of study area is determined by the shortest path matrix. The ten important places in Kolhapur city are randomly selected for the present study and accessibility is determined by counting the road linkages between them. After analyzing the accessibility and connectivity of study area, easily accessible and shortest paths are also suggested in order to reach the important centers very easily.

4. Study Area

The present study is restricted to Kolhapur city. The Kolhapur city is located in northern part of Karveer tehsil and Karveer tehsil is situated in the northern part of Kolhapur district of Maharashtra. The city is well connected by rail and road with the major cities of India viz. Mumbai, Bangaluru, New Delhi and other important cities of Maharashtra like Pune, Sangli, and Miraj. Besides that, at the local level a city is also well connected with its surrounding villages. For the present investigation road network of Kolhapur city is taken into consideration.

4.1. Absolute Location

It lies between 16^{o} 42’ 50” north to 16^{o} 43’ 55” north latitude and 74^{o} 10’ 52” east to 74^{o} 11’ 57” east longitude.

4.2 Relative Location

Kolhapur is situated on the flood plain of Panchganga river. The distance of Kolhapur city from Pune is 240 km, while it is situated at a distance of 395 km to the south of Mumbai. The Pune –Bangalore National Highway No.4 plays an important role in developing the connectivity and accessibility of study area.

5. Discussion

5.1 Determination of Accessibility and Connectivity of Study Area

Transportation is not a science, but a field of inquiry and application. As such, it tends to rely on a set of specific methodologies, since transportation is a performance driven activity

and this performance can be measured and compared. Transportation planning and analysis are interdisciplinary by nature, involving among others, civil engineers, economists, urban planners and geographers. Each discipline has developed methodologies dealing with their respective array of problems. Still, transportation is an infrastructure intensive activity, implying that engineering has been the dominant methodological paradigm for transportation studies. Two common traits of transportation studies, regardless of disciplinary affiliation, are a heavy reliance on empirical data and the intensive use of data analytic techniques, ranging from simple descriptive measures to more complex modeling structures (www.routledge.com).

There are various methods to find out the accessibility and connectivity of road networks. The flow analysis can be done by analyzing the commute flow, commodity flow and migration. The method that used to determine the accessibility and connectivity is quantitative or qualitative; sometime it includes both quantitative and qualitative aspects of transportation network.

5.2 Connectivity of Road Networks in Study Area

The degree of connectivity is explained with the help of beta index devised by K.J. Kansky. The Beta index is determined by dividing total number of arcs in a network by the total number of nodes. The table 1 denotes the connectivity between the selected places. All the beta index values of selected places are more than 1, which means all the places are well connected to each other and have greater complexity.

The highest connectivity is found between CBS to Timber Market path because this path has highest index value (1.60) as compared to other paths. It is followed by the highest connectivity between CBS to Shahu Stadium (1.54), CBS to Mahalaxmi Temple (1.50) and CBS to Kapiltirth Market (1.50) path. On the contrary, CBS to Shivaji University (1.29), CBS to Market Yard (1.32) and CBS to Ramanand Nagar (1.32) path has slightly less connectivity than other paths.

The CBS to New Palace path has very less connectivity with index value of 1.28. The overall connectivity of the selected places with 785 arcs and 545 nodes is 1.44 that means all the above mentioned roads have the efficient transportation network with greater complexity (Table 1).

5.3 Accessibility of Road Networks in Study Area

Accessibility is another important characteristic of transportation network. It is one of the location features. The total number of nodes and arcs define the accessibility of area; if the every node is well connected or linked by arcs then it represents the greater accessibility.

Accessibility is higher in case of urban area because more nodes are linked with efficient road network than rural area. The degree to which any place is served by a transportation networks on which it stands is reflected in its relative accessibility to other places with which interacts. The accessibility and connectivity of the road network is analyzed by reducing the road networks into point and line form by using graph theory.

The degree of connectivity is explained with the help of beta index determined by dividing total number of arcs in a network by the total number of nodes. The table 1 denotes the connectivity between the selected places. All the beta index values of selected places are more than 1, which means all the places are well connected to each other and have greater complexity. In case of the present investigation, accessibility is determined by the shortest path matrix. The ten important places in Kolhapur city are taken into consideration for the present study and accessibility is determined by counting the road linkages between them. Above selected places have more complexity because of presence of more number of nodes. Besides that total number of arcs that links these nodes is also grater. For the shortest path matrix analysis (Table 2), there is a counting of total number of linkages that links the different nodes. The highest numbers of the arcs are found in between Bhosalewadi to Timber Market (1435). The number of arcs separating Bhosalewadi from CBS, Shivaji University, Mahalaxmi Temple, Shahu Stadium, New Palace, Market Yard, Kapiltirth Market, Ramanand Nagar, and Timber Market respectively is 59,145, 118, 184, 104, 81, 280 and 257. While the lowest numbers of arcs (785) are found between CBS to Timber market (Table 2). The total number of arcs separating CBS from Shivaji University, Mahalaxmi Temple, Shahu Stadium, New Palace, Market Yard, Kapiltirth Market, Bhosalewadi, Ramanand Nagar, and Timber Market respectively is 61, 131, 91, 77, 50, 113, 59, 89, and 114. In this way, the additions of each row give an aggregate (785) number. The lowest total indicates the most accessible path (CBS) and highest total indicates (Bhosalewadi) less accessible path. So, as per the above analysis the CBS is most accessible node from all other nodes. Therefore, it is very easier to reach the CBS from all remaining nodes. And Bhosalewadi is very less accessible from the remaining places.

6. Results and Suggestions

6.1 Results

- All the beta index values of selected places are more than one, which means all the places in study area are well connected to each other and have greater complexity.
- The highest connectivity is found between CBS to Timber Market path, because this path has highest index value (1.60) as compared to other paths.

- CBS to Shivaji University path has very less connectivity with index value of 1.29 as compared to other paths.
- The overall connectivity of the selected places with 785 arcs and 545 nodes is 1.44 that means all the above mentioned paths have the efficient transportation network with greater complexity.
- The lowest total (785 arcs) as per the shortest path matrix indicates that CBS is most accessible from all remaining selected places. So, as per the above analysis the CBS is most accessible node from all other nodes.
- The highest total (1435 arcs) indicates that Bhosalewadi is less accessible from all remaining selected places.

6.2 Suggestions

- It should be needed to increase the number and frequency of public transport vehicles (KMT) during the peak hours (11am to 12 noon and 4 pm to 6 pm) to avoid crowdedness.
- It should be essential to create one way on few congested roads. Especially the roads, which having the highest connectivity and highest resulting congestion, needed to be converted into one way.
- Timing of traffic signals should be adjusted from time to time as per increase or decrease in commute flows.
- To avoid the congestion during the accidents, proper system should be required to remove the affected vehicle immediately.
- To avoid the traffic jams during peak hours, there should be separate roads for the heavy vehicles.
- It should be needed to create separate footpaths for non-motorized transportation.
- There should be diversion of heavy vehicles transport flows and commute flows to avoid burden on congested roads.

7. Conclusion

The beta index values of all the selected places are more than 1, which means all the places are well connected to each other and have greater complexity. The highest connectivity is found between CBS to Timber Market path, because this path has highest index value (1.60) as compared to other paths. It is followed by the highest connectivity between CBS to Shahu Stadium (1.54), CBS to Mahalaxmi Temple (1.50) and CBS to Kapiltirth Market (1.50)

paths. On the contrary, CBS to Shivaji University (1.29), CBS to Market Yard (1.32) and CBS to Ramanand Nagar (1.32) path have slightly less connectivity than other paths. CBS to New Palace path have very less connectivity with index value of 1.28 (Table 1). The overall connectivity of the selected places with 785 arcs and 545 nodes is 1.44 that means all the above mentioned roads have the efficient transportation network with greater complexity.

The highest numbers of the arcs are found in between Bhosalewadi to Timber Market (1435 arcs) path. The number of arcs separating Bhosalewadi from CBS, Shivaji University, Mahalaxmi Temple, Shahu Stadium, New Palace, Market Yard, Kapiltirth Market, Ramanand Nagar, and Timber Market respectively are- 59,145, 118, 184, 104, 81, 280 and 257. While the lowest number of arcs (785) are found between CBS to Timber market (Table 2) path. The total number of arcs separating CBS from Shivaji University, Mahalaxmi Temple, Shahu Stadium, New Palace, Market Yard, Kapiltirth Market, Bhosalewadi, Ramanand Nagar, and Timber Market respectively are- 61, 131, 91, 77, 50, 113, 59, 89, and 114 (Table 2). In this way, the additions of each row give an aggregate (785) number. The lowest total indicates the most accessible path (CBS) and highest total indicates (Bhosalewadi) less accessible path. So, as per the above analysis the CBS is most accessible node from all other nodes. Therefore, it is very easier to reach the CBS from all remaining nodes. And Bhosalewadi is very less accessible from the remaining places.

8. Bibliography

1) Berry, Brian, J. L. and Marble, D. F., 1968, Spatial Analysis: A Reader in Statistical Geography, Northwestern University, Prience -Hall Inc. Englewood Cliffs, New Jersey.
2) Chaudhuri, M.R., 1976, An Economic Geography of India, Oxford and IBH Publishing Co., New Delhi.
3) Fenelon, K. G., 1925, The Economics of Road Transport, Printice hall, London.
4) Gentilcore, R. L., 1971, Geographical Approach to Canadian Problems, McMaster University, Hamilton and Prience -Hall of Canada Ltd. Scarborough, Ontario.
5) Raza, M. and Aggerwal, Y., 1986, Transport Geography of India, Concept Publishing Company, New Delhi.
6) Robinson, H. and Bamford, C.G., 1978, Geography of Transport, Macdonald and Evans, USA.
7) Saxena, H. M., 1975, Geography of Transport and Market Centers, Chand and Co. Pvt. Ltd. Ram Nagar, New Delhi-110055.

8) Singh, R. B. and Singh, R. L., 1966, Transport Geography of Uttar Pradesh, Banaras Hindu University, Varanasi-5.
9) Tisweell, W. V. and Barker, S. M., 1971, Quantitative Methods: An Approach to Socio- Economic Geography, University Tutorial Press Ltd. 9-10 Great Sutton Street, London, E.C.I.
10) White, H.P. and Senior, M.L., 1983, Transport Geography, Longmaninc, United State of America, New York.
11) Patil, P., Mane, B., 2012, An Appraisal of Gravity Model for Kurundwad Town and Its Surrounding Villages in Kolhapur District (Maharashtra: India). Mathematical Theory and Modeling, 2(7), 1-9.

Table 1: Connectivity of Road Networks in Study Area: Beta Index (β)

Sr. No.	**Connectivity between Various Paths**	**Beta Index (β)**
1.	CBS to Shivaji University	1.29
2.	CBS to Mahalaxmi Temple	1.50
3.	CBS to Shahu Stadium	1.54
4.	CBS to New Palace	1.28
5.	CBS to Market Yard	1.32
6.	CBS to Kapiltirth Market	1.50
7.	CBS to Bhosalewadi	1.34
8.	CBS to Ramanand Nagar	1.32
9.	CBS to Timber Market	1.60

Source: Surve Consultancy Services Pvt. Ltd.

Table 2: Accessibility of Road Networks (Using Arcs) in Study Area: Shortest Path Matrix

	CBS	Shivaji University	Mahalaxmi Temple	Shahu Stadium	New Palace	Market Yard	Kapiltirth Market	Bhosale wadi	Ramanand Nagar	Timber Market	Total (arcs)
CBS	00	61	131	91	77	50	113	59	89	114	785
Shivaji University	61	00	145	117	202	102	160	145	63	85	1080
Mahalaxmi Temple	131	145	00	111	53	164	130	118	139	104	1095
Shahu Stadium	91	117	111	00	110	149	114	184	107	93	1076
New Palace	77	202	53	110	00	130	140	104	235	218	1269
Market Yard	50	102	164	149	130	00	179	81	250	281	1386
Kapiltirth Market	113	160	130	114	140	179	00	207	90	93	1226
Bhosalewadi	59	145	118	184	104	81	207	00	280	257	1435
Ramanand Nagar	89	63	139	107	235	250	90	280	00	51	1304
Timber Market	114	85	104	93	218	281	93	257	51	00	1253

Source: Surve Consultancy Services Pvt. Ltd

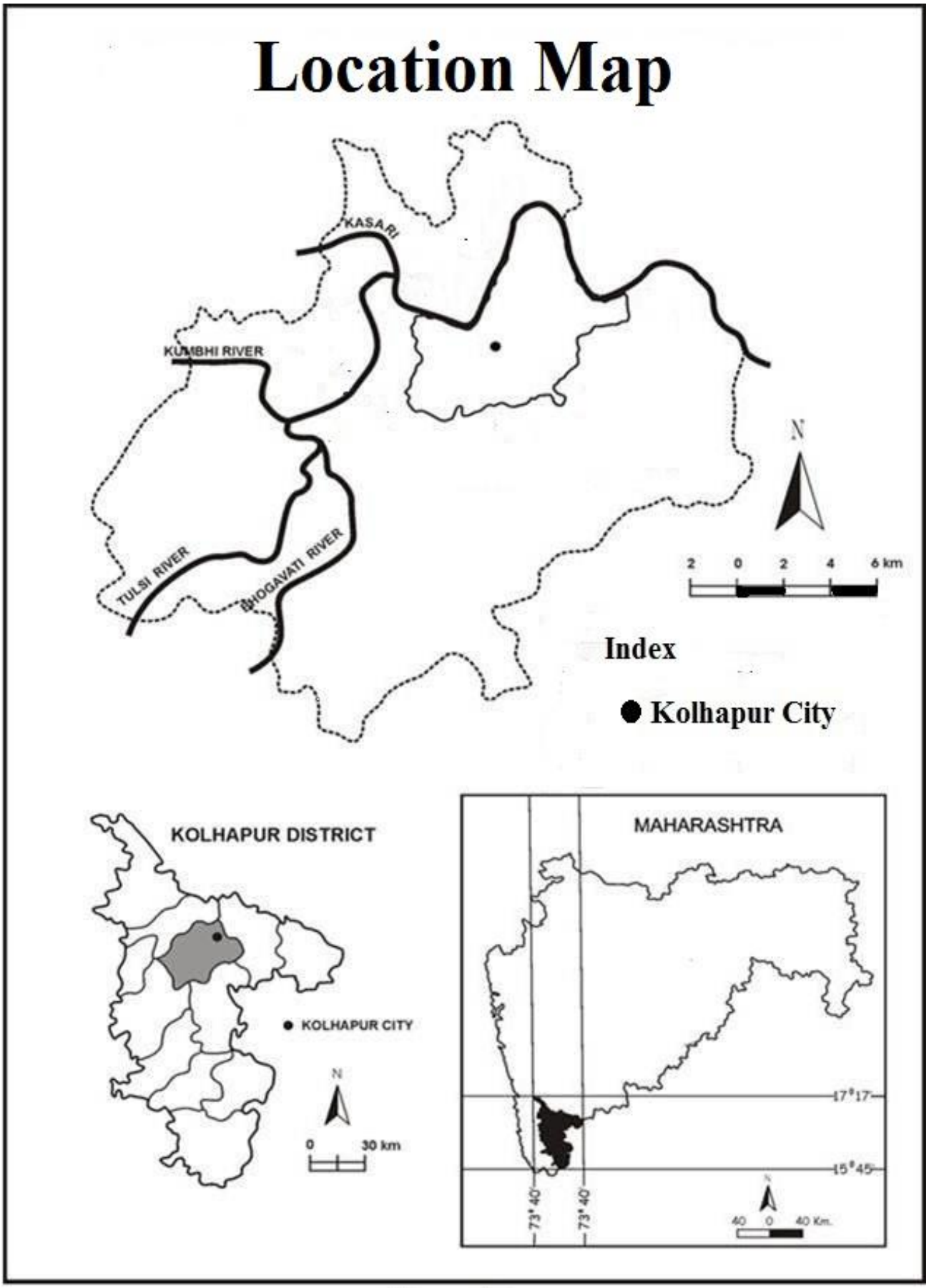

Location Map
KASARI
KUMBHI RIVER
TULSI RIVER
BHOGAVATI RIVER
N
2 0 2 4 6 km
Index
Kolhapur City
KOLHAPUR DISTRICT
KOLHAPUR CITY
N
0 30 km
MAHARASHTRA
17°17'
15°45'
73° 40'
73° 40'
40 0 40 Km.

Figure- 1

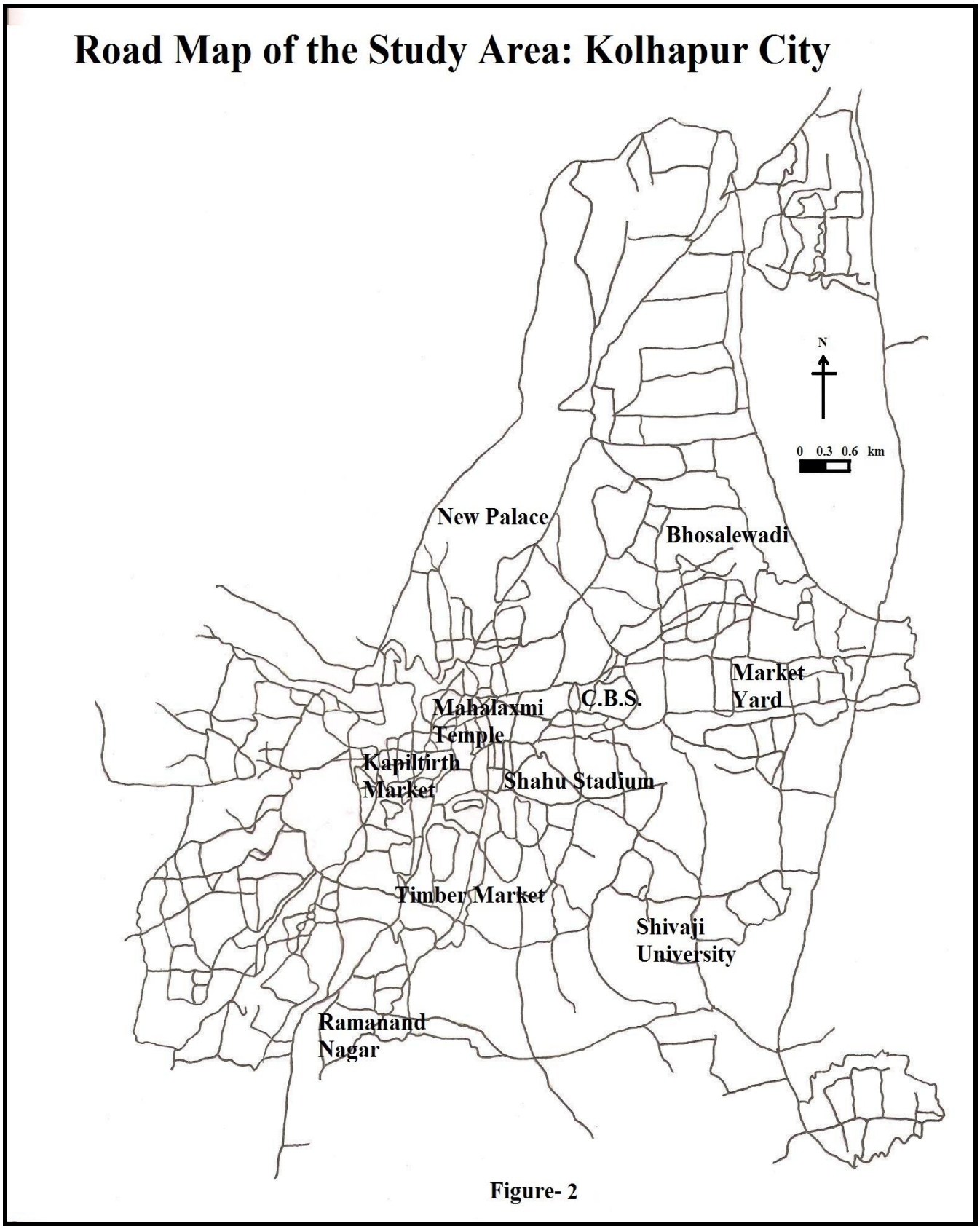
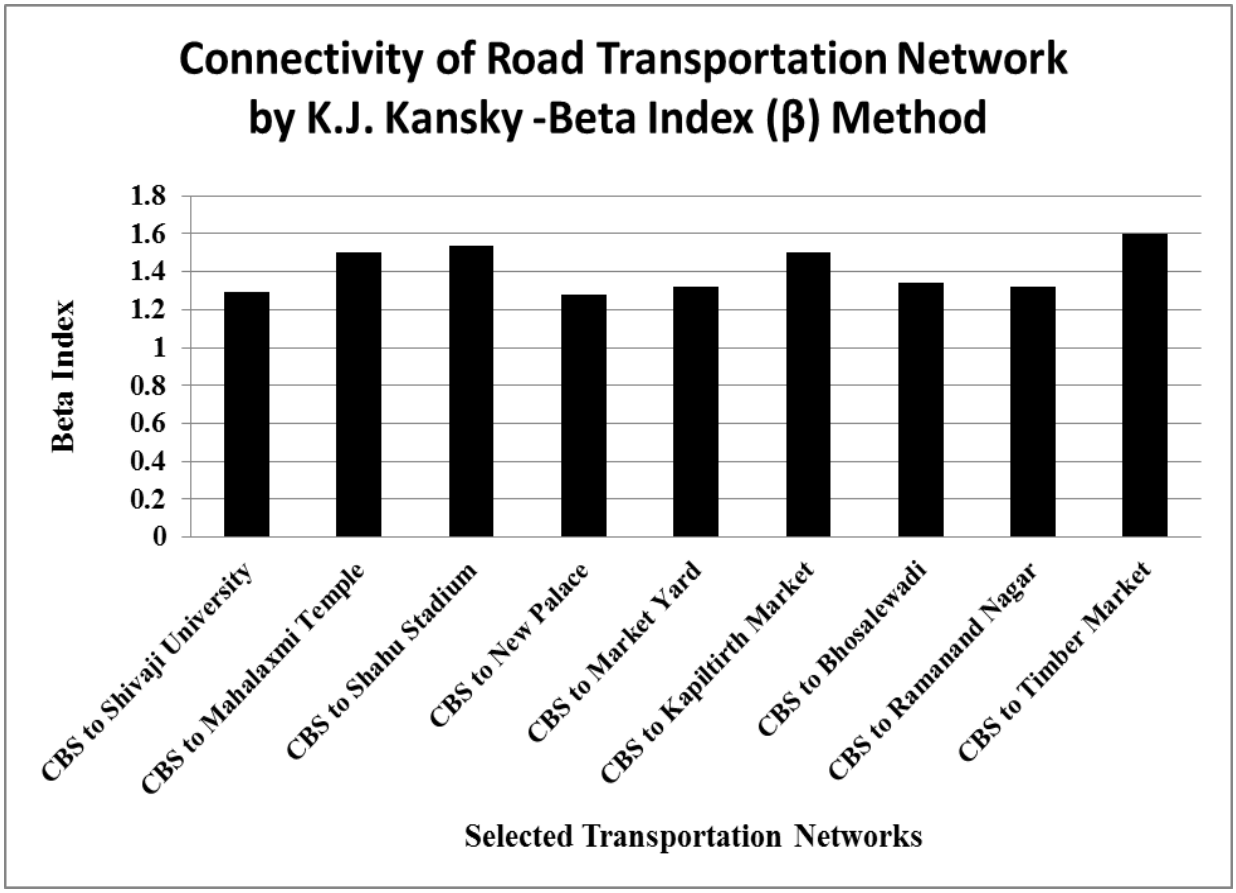


Figure- 2

Source: Surve Consultancy Services Pvt. Ltd.



Source: Based on Table 1

Figure- 3

Maps of Selected Road Networks in Study Area