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Analysis of Transportation Network and Spatial Economy – Network Influence on urban potentiality

Prem N Bastola [1], Ramesh Pokhrel [2], Rabindra Nath Shrestha [3]

[1, 3] *Department of Civil Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal*
[2] *Institute For Development and Policy Studies*
Corresponding Email: [1] pnbastola@ioe.edu.np

Abstract
This research work presents the analysis of the existing road network in connection to the urban economy, and relates this to the growth of urban centres as vital nodal points along the road network. The accessibility of existing network is worked out both in reference to network topology and distance between the locations. The accessibility is integrated with socio-economic parameters to reveal potential accessibility of urban centres, and a hierarchical setting has been derived.
The socio-economic characteristics is held responsible for economic activity and relative scenario for some ten urban centres is elaborated in detail. Finally intrusion of some other road links have been corroborated into the existing road network to see the changed effect if any. The SRN has been thought to be intruded by KKHT and NSFT and a notion on the effect of attractions and emissions of urban areas has been conceptualized. This analysis philosophy can serve as a tool for planning, upgrading and addition of new links to best suit the burgeoning urban economy and achieve regional balance.

Keywords
Road network – Connectivity – Accessibility – Spatial Economy – Potentiality

Introduction

Transportation infrastructures form the basis for all other infrastructures within the urban sprawl. The urban centers are connected via transport networks; primarily by road and the airways. The important road network form Strategic Road Network (SRN). So the connectivity of these centres are of prime factor for economic development. When transport systems are efficient, they provide economic and social opportunities and benefits that result in positive multipliers effects such as better accessibility to markets, employment and additional investments. When transport systems are deficient in terms of capacity or reliability, they can have an economic cost such as reduced or missed opportunities.

The development process and rate depends largely on policy and planning. Planning of efficient network and locations of urban centres, with considerations from macro-economic facet, what potentiality do these locations bear, since different locations specialize in different economic prospects can only address the poverty. Large volume talks and seminars are not to be blessed if we still not focus the deeply rooted theorems as to how developed countries have succeeded as they are. Increasing density of the urban areas and reinforcing the connectivity of these by strong network has been proved to enhance economy. Thus the two sides of economy for some major urban areas in Nepal, has been attempted here.

1. Literature Review

The average density of paved roads in high-income economies is 59 times that in the low-income group. Road conditions also seem to be associated with economic development: the density of paved roads in good condition varies from 40 km/million inhabitants in low-income economies to 470 middle-income and 8,550 in high-income economies [1]. The Strategic Road Network (SRN), existing National Highways and Feeder Roads falling under Bituminous/Blacktop,

Graveled and Earthen road categories has a total length of 11636 km out of which only 5574 km is black top, and is made up of national highways and feeder roads. The SRN consists of 3 main east west corridors and several north south corridors [2]. Transportation networks are commonly simplified as graphs with elementary components retained: nodes indicate centroids of human settlements (places), facilities, and intersections of routes; links represent segments of infrastructure [3]. Connectivity was first proposed by Mine and Kawai in 1982, which reflects the probability to maintain connectivity between nodes in transport networks Accessibility is a measure of the ease with which an individual can pursue an activity of a desired type, at a desired location, by a desired mode, and at a desired time. Once accessibility can be quantified, there are many potential uses for this measure. First, it succinctly captures the quality of the existing state of the transportation system at many spatial levels. Accessibility has several forms and can be integrated with attributes of locations to give core picture in relation to economy [4, 5].

Today more than half of the 7 billion inhabitants of the planet live in urban areas, with this share expected to keep rising. Whereas in developed countries urbanization has been a long and slow process, in developing countries this process is now characterized by a really fast pace and a high degree of urban concentration, with urban population tending to concentrate in one or few large metropolitan areas of disproportionate size. However, while urbanization is a universal phenomenon triggered by the sectorial shift from agriculture to industry and modern services, its speed seems to vary according to the level of development [6]. The 1961 census for the first time defined an urban area or a 'sahar' as "an area with a population cluster of 5,000 and over and having an urban environment such as high school, college, judicial and administrative offices, bazaar, communication facilities, mills, factories etc." but also indicated that the definition was not strictly followed [7]. The urbanization is reflected in 58 urban centres, and total population is 4525787, which is 17% of the total population of the country [8].

The World Development Report argues that some places are doing well because they have promoted transformations along the three dimensions of economic geography: density, distance and division [9]. The aggregate side of economic analysis, macroeconomics considering major variables of influence comprise population as the first basis [10]. An area which represents economic generation can be best defined by reference to its economic features such as employment and industry [11]. Harris showed that market potential is determined by the distance to and the size of market demand in alternative locations. Compared to travel cost measures, market potential accessibility measures take into account that destinations at greater distance provide diminishing opportunities [12].

The Technical Assistant carried survey of the route for fast track 2007/2008. The proposed preferred corridor option would result in significant benefits in terms of reducing travel time and vehicle operating costs between Kathmandu and the Terai and Indian border as well as increasing road capacity on this corridor. The survey team concluded that the project would result in a saving of 152 kilometres and over four hours of travel time [13]. The road length from Hetauda to Kathmandu is approximately 227 km with travel time of approx. 6-8 hrs. The alternative route - the Tribhuvan Highway, though only 133 km in length still requires travel time of approx. 7-8 hrs. Whereas the purposed KKHT Highway will connect Kathmandu with Hetauda via Kulekhani in an hour [14].

2. Methodology

The data pertaining to the study are categorically second order. These can be grouped into two section as

- The network data
- The socio-economic data

These data were gathered from secondary sources, Department of Road, and Central Bureau of Statistics as such to name.

The computation Procedure

Network Analysis

Connectivity analysis

$$C = \sum_{j}^{n} C_{ij} \tag{1}$$

Here C is degree of node , C_{ij} is the connectivity matrix.

Accessibility Analysis

$$AI = \frac{\sum_{j=1}^{n} D}{n} \tag{2}$$

Here AI is Accessibility Index, D is distance matrix obtained from d_{ij} graph, which is the distance between locations i and j, and n is number of locations.

Socio-Economic Analysis

$$A = f[P, PD, M, E] \tag{3}$$

Here, A is attribute, f is function of,P is Population, PD is population density,M is Manufacture value-added, and E is employment measure of respective urban areas. Recall that n is number of locations.

Integrated Analysis

Computation of Potential Accessibility Matrix

$$AP = \sum_{i}^{n} A_i + \sum_{j}^{n} A_j * \omega \tag{4}$$

where $\omega = d_{ij}^{-1}$ Here, A is Potential Accessibility,A_i and A_j are attributes of locations i and j, and ω is the cost of travel between locations i and j.

Intrusion Effect Analysis

Assuming the changes in the D matrix as a result of intrusion in the network, we derive the changes in the AP matrix. These changes are assumed to occur because of Kathmandu Kulekhani Hetauda Tunnel (KKHT) highway and North South Fast Track (NSFT).

Let us define **D'** as the new distance matrix. We again, make use of equation (4) but with transformed values ofω and write

$$AP = \sum_{i}^{n} A_i + \sum_{j}^{n} A_j * \omega' \tag{5}$$

3. Results and Discussions

Results from Network Analysis

The total connectivity/ the degree of the 10 selected urban centres unveil that these have high connectivity than other centres, high value indicating high connectivity, and the degree values are closely spaced ranging from 4 to 3. Within this frame, Kathmandu bears less connection than Butwal or Itahari, as such, the connectivity formulations exaggerate the importance of locations.

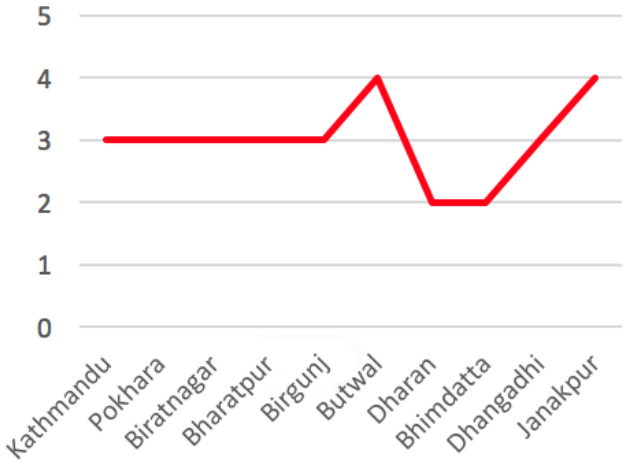

Figure 1: Degree

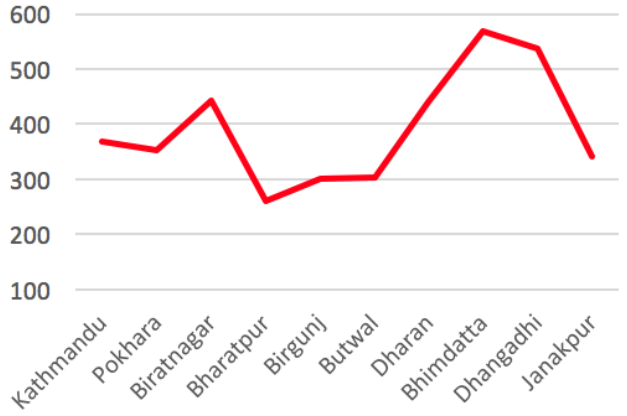

Figure 2: Accessibility Index

Bharatpur is the most accessible, first in its rank with Pokhara at fifth and Kathmandu at sixth position, whilst Bhimdatta is least accessible. The accessibility characteristics of the existing network, from the result

follows the centrality pattern of the connectivity. Least value of AI, hereafter provides the platform for future potentiality for development/ population concentration, other forces remaining constant.

Results from Socio-Economic Parameters

Kathmandu is the most populated centre with Butwal at sixth and Janakpur at tenth position. The valued graph utterly dominated by the Kathmandu has been associated with the consideration of Kathmandu to include the centres in the valley.

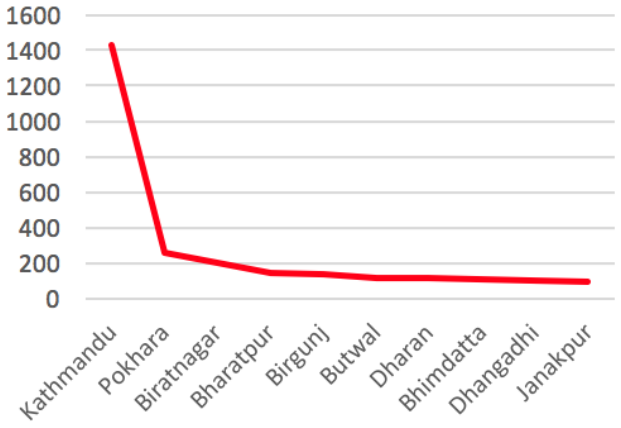

Figure 3: Population

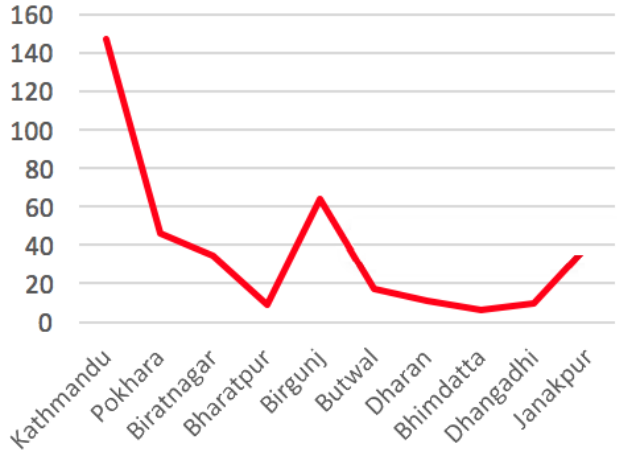

Figure 4: Population Density

In so far as other attributes are considered, though Kathmandu retains the same position for density, Bharatpur the most accessible location takes ninth position for density, and Birjunj is second most dense centre.

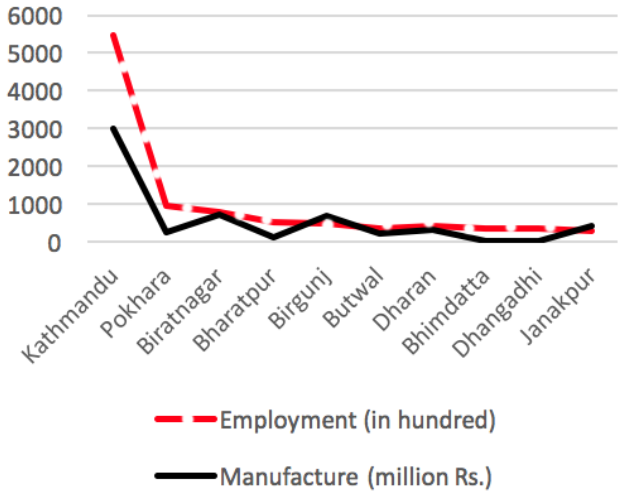

Figure 5: Employment & Manufacture output

From the facet of employment, Pokhara ranks second after Kathmandu the capital. Biratnagar parallels Pokhara, the rest urban centres have comparable employment.

Biratnager surpasses the rest except the valley in manufacturing output. Birgunj, Janakpur and Dharan have high manufacturing output than other locations. As revealed by the graph, some possess too low output. Different locations therefore specialize in different attributes. The most accessible is almost least dense and disparity among attributes from network property alone cannot suppress the valley from top rank.

Results from Integrated Analysis

Potential accessibility values for attribute population yield the same result as that from demographic hierarchy, with Kathmandu being the most attractive and Janakpur the least attractive. The effect of desnity illucidated in the figure, where birgunj takes the place of Pokhara and stands second whilst Bhimdatta is by far the least attractive.

For both employment and manufacture output, the potential accessibility of Kathmandu is peerless with other locations. Birjung, Pokhara and Biratnagar have comparable attractions. Bharatpur and Dhangadhi are the least attractive for both attributes.

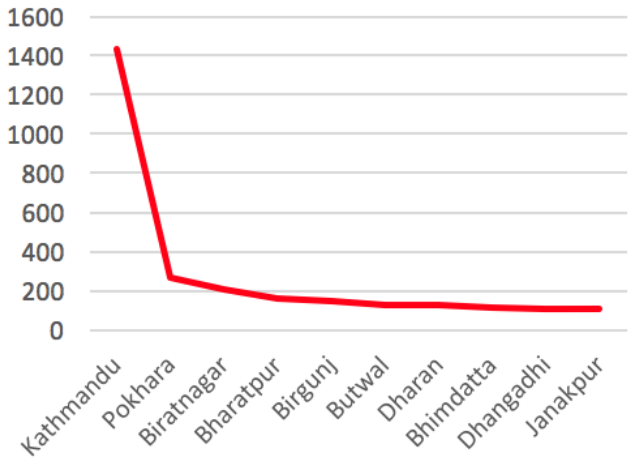

Figure 6: AP for Population

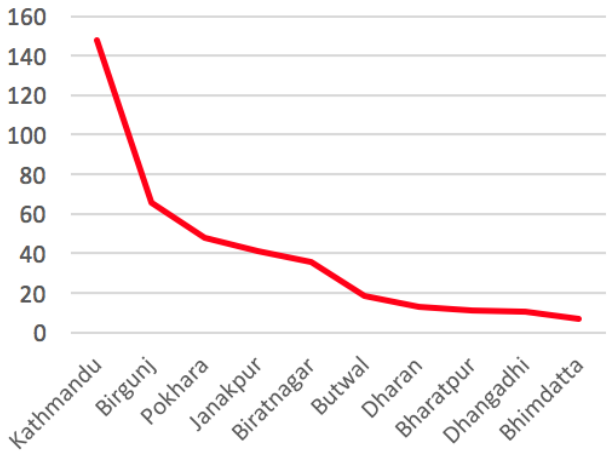

Figure 7: AP for Population Density

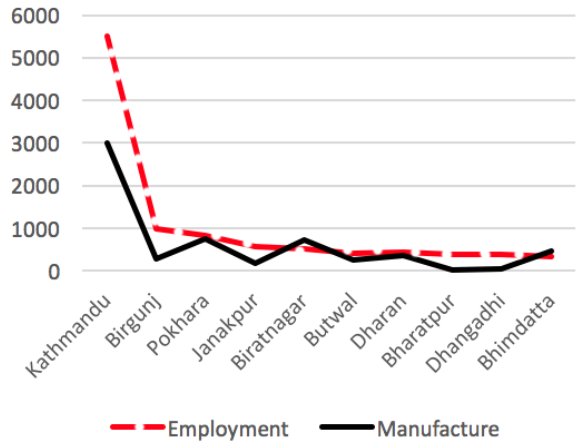

Figure 8: AP for Employment & Manufacture

From the computed AP values, Kathmandu is most attractive with Biratnagar in second position, and Bharatpur in eighth position. Similarly emissive values also cohere with attractiveness, implying approximately equal attraction and distraction. The reason behind this influecne reclines in the fact that Biratnagar possess high manufacturing output.

Results from Intrusion Effect

To visualize the influence of network improvements over the existing network the intrusion of KKHT for the same urban centres have resulted in different values of AP matrix, the summary of which for population and population density presented reveal the positive effect as is clear from the attractiveness values of locations.

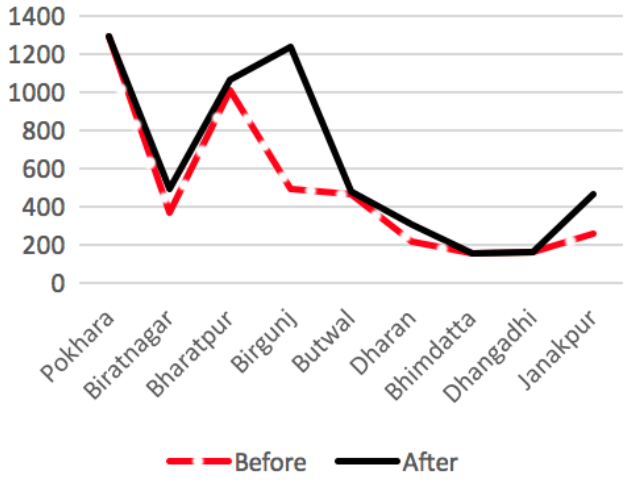

Figure 9: Effect of KKHT for AP

Table 1: Effect of KKHT-AP

SN	Urban	Before	After
1	Kathmandu	14280	14292
2	Birgunj	1427	1509
3	Janakpur	1040	1068
4	Biratnagar	2072	2083
5	Dharan	1242	1253

In order that the influence of improvements over the network is deeply realized, only five locations are considered on the right side of the SRN diagram, as the effect are less noticed as the distance reduction takes on the right side. Before and after analysis as depicted by

table are impressive. From the table, stern effect are appealing for individual values of attraction for Kathmandu, similar is the case with other centres.

Table 2: Effect of NSFT-AP

SN	Urban	Before	After
1	Kathmandu	14280	14304
2	Birgunj	1427	1516
3	Janakpur	1040	1123
4	Biratnagar	2072	2116
5	Dharan	1242	1286

For the same five locations, the effect of NSFT has been established as divulged by the table above. A snapshot into detail results on the impact of NSFT for various stated locations support the view relinquished from the same table.

4. Conclusions, Recommendations & Further Research

Conclusions

Network improvement projects are bound to enhance economic activities, insofar as the change is increased by connectedness and increased or diminished corresponds to the distance among the centres previously connected.

Different locations specialize in different attribute, and hence are not equal. The most accessible locations do not supersede those with lower accessibility in economic trait, imply the presence and upshot of other forces associated for growth, hinting, networks strength is not sufficient condition for economic vitality.

The intrusion of NSFT yields the same increase pattern of attractiveness of the locations, as did KKHT, and both impart changes on eastern part the country. This buttresses the opinions in favour of either of them, de facto, other exact economic analysis are to be inevitably decomposed.

Albeit economic potentiality differ profoundly within the selected centres, connectivity results group these locations into single cluster with nuance variation. Thus hierarchical setting singly from the topology is incompatible for complex networks.

Recommendations

The applicability for both the cases of prioritizing of nodes for development, planning, maintenance, upgrading and addition of new links to best suit the burgeoning urban density and economic attribute, the Government body actively held responsible for planning pay due attention to study the effect of network and plan as to maximize economic attributes.

Dispersion of spatial economy and a balance among the regional/ urban centres achieved by increased or diminished attraction correspond the reverse, the planners ought to envision such changes to alleviate unhealthy population concentration in one or few urban centres.

Stringent commendation pertains to the use not, the notion of simple accessibility alone for prioritizing the nodes and links, but based upon the integrated indices.

Further Research

The study does set aside other transport networks as such airport, encompassing the whole road network and other important transport modes to study the effect on development potential sounds rational for planning of other small towns and cities, which exist or may evolve.

Historical and archaeological importance of locations, role of tourism are other economic indicators, not touched by the study, can be included for more refined and ground reality.

Having bounced up ample of times by the scenario incorporation of traffic flow between the locations, this parameter, an indication of economic activity has been unwillingly mulled over, this might present a different scenario if be included is left in the hand of future anxiety.

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