Road Network Rating Based on Land Use of Pokhara

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KEYWORDS

Road Network Rating Analysis, Land Use, Volume Capacity Ratio, GIS

ABSTRACT

Road Network Analysis considering land use has high potential uses in our country, where the coordination between land use and transportation planning is lacking in many aspects. This research proposes road network analysis based on land use for the current road network of old Pokhara city, one of the urbanizing cities that have led to the rapid urbanization recently. The road network in this city needs to be evaluated to develop efficient and better transportation facility. This study uses Geographic Information System(GIS) to create network database and analyze the current road network based on land use pattern and road attribute, identifying the worst area for transportation supply. This study further evaluates the road network with network volume capacity ratio of the same road section. Rating analysis along with network volume capacity evaluation has provided clear understanding of the links of road network on ward no 8 of Pokhara city having problem with traffic coordination. Among the major roads of the ward 8, Nayabazar road section is found in an unacceptable Level of Service (LOS) but other roads along with the highway passing are within the acceptable limit of LOS.

1. INTRODUCTION

Road Network evaluation considering land use has high potential uses in our country, where the coordination between land use and transportation planning is lacking in many aspects. Road planning deals with the definition of circulation infrastructure pavements, roads and terminals. It also covers the physical and operational characteristics of public transport (Vasconcellos, 2001). Road Network Analysis has been quite interesting topic in recent times. Many researches have been conducted in the field of road network optimization and overcoming the traffic problems such as congestion. Road Network Analysis with land use system includes all activities that are performed so as to determine the saturation capacity of network and predict the links that have issues, which creates traffic related problems such as congestion.

Sun, *et. al*., (2015) analyzes the interactive relationship between land use and traffic system. Feasibility judgment of planning scheme is implemented based on land attribute, represented by urban floor area ratio and road area ratio. Whereas Sai, *et. al*., (2015) presents brief practical review on the road network in the urban areas that constitutes of the essential infrastructures for the development of the city and also to meet the demands of the people and uses GIS based road network configuration and

performs the behavioral model to improve the existing road infrastructure and also suggest the improvements over the existing infrastructure. Research conducted on Jeddah city (Al-Enazi, 2016) uses several GIS functions, also used in this paper including network analysis and overlay analysis using ArcGIS 10.2. The priority results are utilized in evaluating congestion points according to roads direction, which helps a planner in re-assigning roads directions to mitigate congestion points at all parts of Jeddah city.

This study considers the current road characteristics with the parameters road area ratio, road density and urban volume rate from the land use pattern as basic parameters to analyze current road network considering a case study of the ward boundary of the old Pokhara city. This study further analyses the current network, whether the current road is critical or not in the matter of volume capacity and also shows the link between land use pattern and road network for the effectiveness of the system.

2. RESEARCH METHODOLOGY

2.1 Study Area

Pokhara, a beautiful and historical town of Nepal which was made town municipality in 1962. Designation of Pokhara as the headquarter of Western Development Region of Nepal in 1972, contributed to upgrade Pokhara Municipality in the present status of Metropolitan City in 2017 with 33 wards. Being the regional headquarter of western region and the second tourist center after Kathmandu, it has attracted a large population from the surrounding areas. It accounts for the highest growth rate of population among the designated towns in the country. Pokhara city is selected as the study area rather than the whole Pokhara Metropolitan city because of its rapid process of urbanization and fast change in land use. According to the national population census information, total population of Pokhara sub metropolitan city is projected for the year 2017AD, for detail ward wise population projection.

2.2 Methodology for Data Analysis

This research will follow four step procedures analysis, giving full consideration to the advantages and disadvantages of each step evaluation method, and the result will conclude towards a single evaluation method.

2.2.1 Analysis based on Land use

This analysis method includes creating the land use map and land cover map along with determining road characteristics, buildup types and identification of the important areas that contribute trip generation.

Land use of Pokhara City

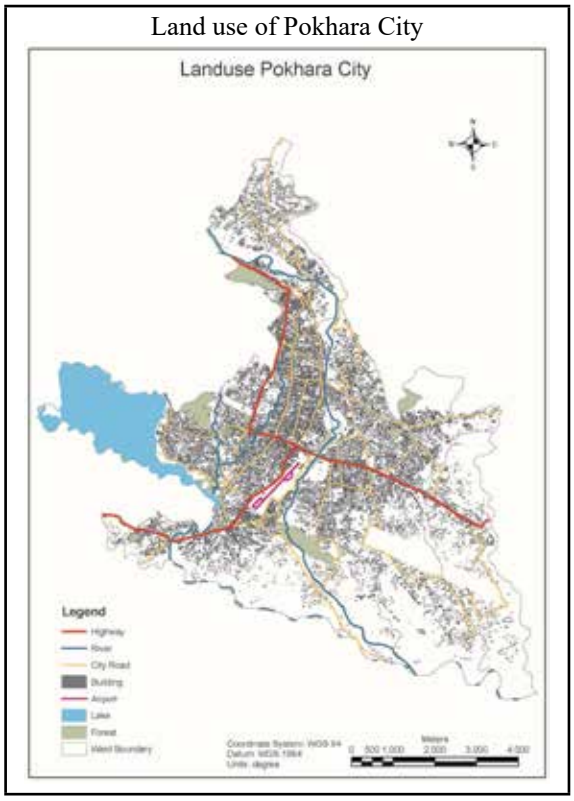


Figure 1: Land Use Map of Study Area

a) Urban Volume Rate

$R_1 = C_{building} / C_{land}$; where R_1 = Urban Volume Rate; $C_{building}$ = Urban Building Area (m^2); C_{land} = Urban Land Area(m^2)

b) Road Area Ratio

$R_2 = C_{road} / C_{building}$; where R_2 = Road Area Ratio; C_{road} = Urban Road Area (m^2); $C_{building}$ = Urban Building Area (m^2)

c) Road Density

$R_3 = 1000 \times A_{road} / P_{Population}$; where R_3 = Road Density / 1000; A_{road} = Area of Road (Km^2); $P_{population}$ = Population in Area (m^2)

2.2.2 Analysis based on Road Attribute

Road characteristics are defined by lots of characteristics. The predominant characteristics that influence the traffic flow such as lane condition, parking condition, road pavement, traffic signal, no of intersection, etc. are found to be in less variation than the number of intersection per length which is used as a rating parameter to obtain the road network map using GIS.

2.2.3 Analysis based on Service Area of different facilities

GIS map indicating important areas that contribute trip generation will consider different facility such as:

- School
- Hospitals
- Parks
- Museum
- Government Offices
- Oil Store
- Shopping Complex
- Bus Park
- Auditorium Hall
- Etc.

Service area map created by using the network analysis tool by using ArcGIS is analyzed on the basis of ward area which has most influence on the service area from different facilities. As such we can give more meaningful conclusion to the rating done on the basis of land use and the road attribute.

2.2.4 Analysis of the road on the critical ward with the network volume capacity ratio

The major road in the critical ward selected is further evaluated on the basis of network volume capacity ratio. Traffic volume count is done in order to find out the traffic volume at the peak hour.

IRC (1994), road network capacity is further calculated for different links based on the road width (carriageway).

S = 525 × W where, S = Saturation flow (Vph); W = Width of approach road (m)

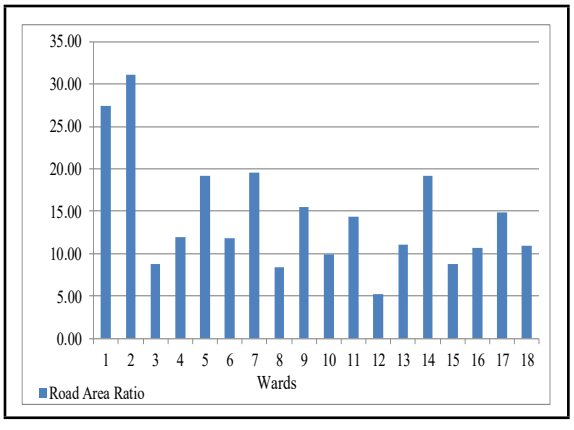
3. RESULT AND DISCUSSION

3.1Analysis based on Land Use

Two parameters were used for the analysis of the land use and the road network, i.e. road area ratio and road density per population data which were extracted using GIS. While the next parameter urban volume rate is used to provide more meaning to the rating obtained from the combine ranking of the two parameters, i.e. road area ratio and road density per population.

3.1.1 *Road Area Ratio*

For the calculation of the road area ratio the parameters which are needed are calculated separately for each ward and the road area ratio for each ward is calculated individually.

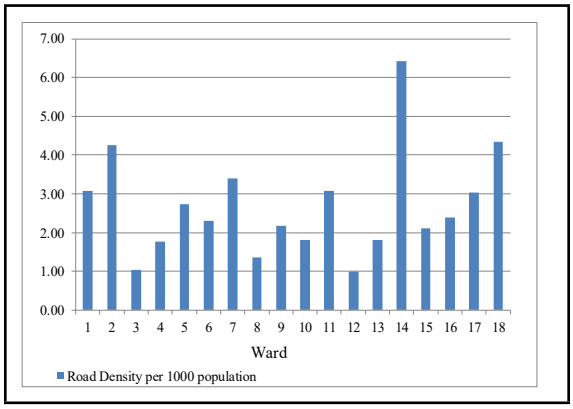


Bar 1: Road Area Ratio

From the analysis of Bar 1; ward 1 and 2 have the highest road area ratio which means that these wards have sufficient roads to serve the area than other wards. Whereas ward no 3, 8 and 12 have low road area ratio which concludes insufficient or serious shortage of transport supply as the ratio means lower road network to serve the large built up area.

3.1.2 Road Density per population

For the calculation of the road density per population the parameters which are needed are calculated separately for each ward and the road area ratio for each ward is calculated individually.



Bar 2: Road Density per Population

Also from analysis of Bar 2; ward 2, 14 and 18 have the highest road density per population which means that these wards have sufficient roads to serve the population living in these areas than other wards. Whereas ward 3, 8 and 12 have low road density per population, which concludes insufficient or serious shortage of transport supply to meet the demand of population living in these area.

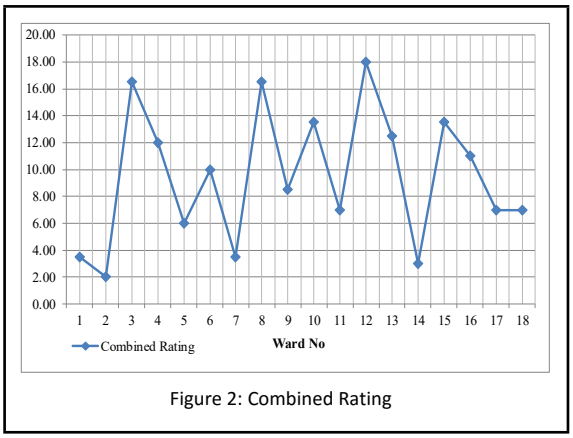
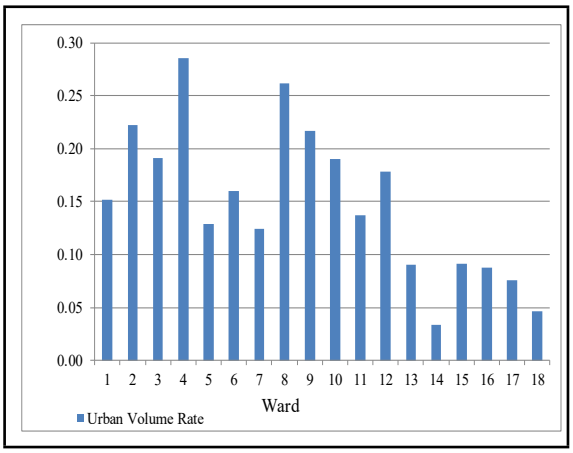


Figure 2: Combined Rating

From combined rating obtained as per the methodology by using road area ratio and road area per population we can see that ward no 3, 8 and 12 are facing serious shortage of the transport supply. So the results show that the road network in these areas should be analyzed further.

3.1.3 *Urban Volume Rate*

Though Urban Volume Rate is not used for the rating of the ward on the basis of roads considered of the wards, it is used further to interpret the ranking done by using road area ratio and road density per population such that it provides a meaningful conclusion.



From the result of the combined rating ward no 3, 8 and 12 area are the areas having the shortage of the road supply. Combined rating alone doesn't provide much more information about the shortage of transportation on these areas. Here the urban volume rate comes to aid on the

above conclusion whether the demand of the transportation is high or not in these areas. From Bar 3; ward no 4 and 8 are having relatively high urban volume rate which concludes that the demand of transportation is high. If we compare both results from combined road area rating and urban volume rate, we can see that ward no 8 is having both serious shortage of transportation.

3.2 Analysis based on Road Attribute

The road network that lies in Pokhara city is mapped with the bounding boundary which is the ward boundary of the Pokhara sub metropolitan city. The minor links have been ignored for mapping as the flow pattern on these links is uncertain. Every such link is connected to the major link such that the effect of these links has been considered.

The road network considered is identified along with its attributes which will lead to the analysis of road network and will represent the supply factor of the road network. From the analysis based on road intersection ratio per length it can be concluded that the roads having higher road intersection ratio per length will certainly have unbalanced demand and supply than the road having lower intersection ratio per length.

3.3 Analysis based on Service area

Service area includes the major areas/ infrastructures that contribute the trip generation and affect the traffic flow on the road network. Therefore study of service area provides meaningful and effective analysis for the above results. For this analysis, the major service centers are identified and are plotted and by the network analysis, the service area is determined for 5 mins and 10 mins drive areas taking the ward boundary.

Based on service area analysis done by using network analysis tool from GIS for different facilities, it can be summarized that the service area is concentrated on the center area of the study area which are ward no 4, 7, 8 and 9 which shows the road network that lies in these wards will interact more to traffic supply and demand.

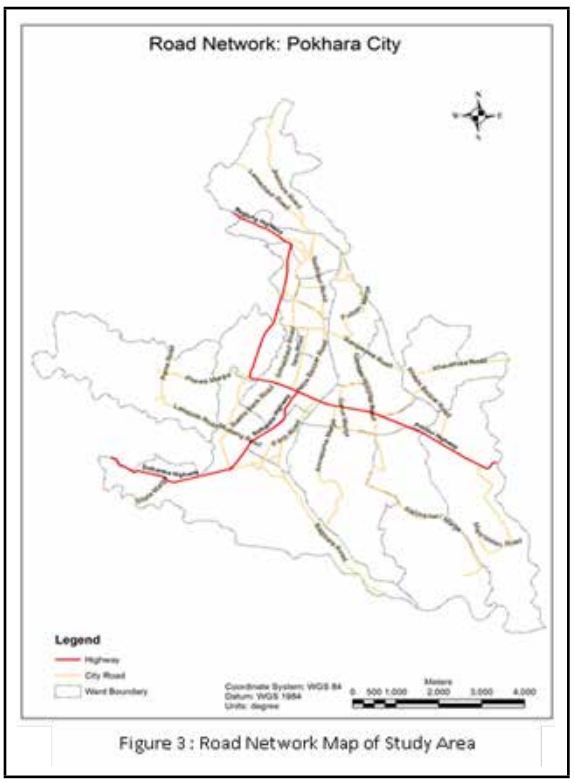


Figure 3 : Road Network Map of Study Area

3.4 Network Volume Capacity ratio

The proportion of vehicles in a traffic stream is very important parameter to determine the network volume capacity and gives general idea of traffic condition. Analysis of traffic composition gives the idea of supply and demand condition. So, it is crucial to know the traffic composition of various sections. Vehicle class percentages on different segments of the study area are shown below. It is found that motor cycle has the highest percentage in the traffic stream.

1.1.1.1 *Flow Volume of Traffic*

Due to the non-lane based traffic condition, traffic does not move in lane. Such traffic is analyzed on the basis of total width of approach and hence, the option of vehicle counting is adopted. Flow volume is calculated independently for each observed hour. All counted vehicles are added in terms of PCU to get peak hour PCU per hour.

The highest value among each observed data is taken to analyze the critical condition. Table below gives PCU per hour at considered road section along with peak hour factor with peak flow volume.

Also the major highways are taken into consideration as the highways also pass through ward no 8. For the secondary data used to determine the traffic flow volume, refer Table 2.

1.1.1.2 *Estimation of Volume Capacity Ratio*

Volume Capacity Ratio (V/C) is estimated by the ratio of the volume of the traffic in PCU/hr during peak hour and the capacity of the road. As explained in the methodology the capacities of the roads that have been considered are calculated as per the width of the effective carriageway. For relative index summary of the V/C ratio, refer Table 3.

Table 1: Peak Hour Traffic volume

	NayaBazar Road			***New Road***			***Simalchaur Road***		
	Day 1	**Day 2**	**Day 3**	**Day 1**	**Day 2**	**Day 3**	**Day 1**	**Day 2**	**Day 3**
Peak hour PCU/ hr	1,945	1,947.5	1,976.5	2,328	2,349.5	2,408.5	670	649	673
Peak Factor (K)	0.905	0.95	0.967	0.85	0.89	0.958	0.9	0.95	0.92
Critical PCU / hr	2,148	2,052	2,044	2,732	2,646	2,512	742	682	732
Adopted Critical PCU / hr	2,148			2,732			742		

Table 2: Peak Hour Traffic Volume of Highway

S.N	**Road Section**	**Peak hour PCU/ hr**			**Adopted Critical PCU / hr**
		Day 1	**Day 2**	**Day 3**	
1	Baglung Highway (II)	958	451	468	958
2	Prithivi Highway (I)	641	677	667	667
3	Siddhartha Highway (III)	446	451	468	468

Table 3: Volume Capacity Ratio of Roads

S.N	**Name of Road**	**Length (m)**	**Carriageway (m)**	**Traffic Capacity (PCU/hr)**	**Traffic Volume (PCU/hr)**	**V/C**
1	NayaBazar Road	1,650.77	7	3,675	2,148	0.58
2	New Road	1,550.94	14	7,350	2,732	0.37
3	Simalchaur Road	1,500.26	5	2,625	742	0.28
4	Baglung Highway (II)	1,450.64	7	3,675	958	0.26
5	Prithivi Highway (I)	4,789.41	7	3,675	667	0.18
6	Siddhartha Highway (III)	2,769.13	7	3,675	468	0.12

From this research most of roads taken into consideration lie in LOS 'A' as V/C < 0.35, except New Road which lies in LOS 'B' as 0.35<V/C < 0.55 and Nayabazar road which lies in LOS 'C' as 0.55<V/C < 0.77 as recommended by HCM. But the NRS suggests that LOS 'B' can be used for the design capacity of roads. So we can conclude that the road infrastructure of Nayabazar road which has LOS 'C' needs to be upgraded.

4. CONCLUSIONS

Land use pattern shows the rising urbanization as the land use pattern is mostly concentrated by the buildup in the core areas, which certainly does have adverse effect on traffic coordination leading to the unbalanced supply and demand of road network. This research carried out the analysis based on land use pattern along with the effect of service area and road attribute taking the ward boundary of the old Pokhara city. After determining the worse ward area, the study further narrow down the analysis to the road within the critical ward area by determining the road volume capacity ratio.

Analysis of land use map and service area map shows ward no 8 as a worse ward which on further analysis of roads within the ward on the basis of network volume capacity concludes that the ward is having supply and demand shortage of transportation. As the road area ratio is 8.38 and road area per population is 1.37 which is minimum relative to other wards and also this ward has urban volume rate 0.26 which is relatively high with respect to other wards, this ward seems to have shortage of transportation supply and lots of interaction of traffic on the road network. Also roads that lie in this ward when further analyzed with roads attributes show that the major roads such as New Road, Nayabazar road, Simalchaur road and Prithivi Highway are having poor intersection per length rating. The analysis based on network volume capacity for the major roads of ward no 8 shows that among the major roads, Nayabazar road section is not in the acceptable LOS i.e. V/C ratio 0.55<V/C < 0.77 but other roads along with the highway passing are within the acceptable limit of LOS i.e. V/C < 0.55 and are running in free flow condition. Therefore the research can conclude that the current road capacity is not the only reason to create imbalance between supply and demand of transportation but the current available road network is insufficient to meet the demand and supply of transportation in the current ward.

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