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Comparative Study: Level of Service in Indonesia and India

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Abstract*: The road level of service (LOS) is the most common measure of effectiveness to evaluate the measure of effectiveness (MOE) on the performance of existing traffic facilities. From a qualitative point of view, LOS is proven and widely accepted to measure road effectiveness. However, the assessment of road infrastructure performance based on LOS depends on the qualitative parameters of density and volume. Adding probabilities of continuous traffic or detailing them proves to be more efficient for traffic monitoring. Monitoring of road capacity and service level (LOS) is the key to achieving sustainable performance. In Indonesia the degree of saturation (DS) is defined as the ratio of road flow to capacity, which is used as the main factor in determining the level of road service. While in India there are many methods such as Cluster Analysis, Percentage Speed Reduction, Fuzzy Set Theory to define the level of road service, but the V/C ratio and average speed methods are the best methods in urban and rural areas. This study will identify differences in the calculation of the level of service carried out in Indonesia and in India through a comparative study of the calculation of the level of service in previous studies. The road level of service in the two countries has the same calculation formula, namely volume per capacity ratio, but differs in each sub-variable on the variable road capacity and traffic volume. Indonesia has a methodology to calculate road service levels by conducting road capacity analysis, traffic flow and composition analysis, degree of saturation analysis and land use modeling analysis. India has a methodology to calculate road service levels by performing Passenger Car Unit (PCU) analysis, Stream Equivalency Factor (Se) analysis, road capacity analysis, adjustment factor analysis, and road service level analysis.*

Keywords: Level of Service, Road Capacity, Traffic Volume

1. Introduction

Transportation is important for the development and growth of a country by facilitating trade, commerce and social interaction. The movement of people and goods is the basis of transportation carried out to achieve basic goals or tasks that require moving from one location to another [1]. Most cities in Asian countries are also experiencing rapid urbanization and causing problems such as congestion. The rapid socio-economic changes of the community have resulted in a sharp increase in vehicle ownership, accompanied by the slow development of transportation infrastructure. The increasing imbalance between the volume of traffic on urban roads in developing countries and their limited capacity results in severe congestion [10].

In urban areas, traffic congestion is a major problem. Heavy traffic flows on national highways at high speed when meeting local traffic at intersections then traffic jams are likely to occur. This causes many negative problems such as pollution, delays, accidents and widespread road congestion, the movement of goods and people slows to a halt and transportation costs increase [10]. In urban areas there is a rapidly increasing development of new construction and new developments generating and attracting traffic around the road network, this traffic having a negative impact on urban transport. Both developed and developing countries one of the main causes of traffic congestion is more due to lack of planning and provision of traffic. Traffic impact analysis studies mean analyzing current traffic conditions around the road network and possible mitigation actions for integrated land use and transportation planning for new development areas [5].

Road level of service is the most common measure of effectiveness for evaluating the measure of effectiveness (MOE) on the performance of existing traffic facilities, but the method of evaluating LOS is still a challenging task [2]. Previous studies have tried to apply various parameters such as speed, delay, and volume to evaluate LOS [7,8,14]. Traffic flow density is the most commonly used parameter to identify the threshold value for LOS [2]. From a qualitative point of view, LOS is proven and widely accepted to measure road effectiveness [9]. However, the assessment of road infrastructure performance based on LOS depends on the qualitative parameters of density and volume. Adding probabilities of continuous traffic or detailing it has proven to be more efficient for traffic monitoring [9]. Monitoring of road capacity and service level (LOS) is the key to achieving sustainable performance [2].

In Indonesia, the degree of saturation (DS) is defined as the ratio of road flow to capacity, which is used as the main factor in determining the performance level of intersections and road segments [4] While in India there are many methods such as Cluster Analysis, Percentage Speed Reduction, Fuzzy Set Theory to define the level of road service, but the V/C ratio and average speed methods are the best methods in urban and rural areas [6]. Based on several studies, traffic volume plays an important role in indicating existing conditions and makes it possible to predict future traffic volume conditions [6].

Improved road infrastructure failed to cope with the growth rate of traffic. The constant incremental approach does not accommodate the exponential growth in traffic, especially given the already saturated cities. The main road traffic load also spreads to other sections and the road network, causing traffic disruptions. The focus for optimization of congestion problems is to increase efficiency in quality traffic movement rather than expansion [2].

Based on the background, it can be seen that the calculation of the level of road service is important and there are differences in the calculation of the level of road service. This study will identify differences in the calculation of the level of road service carried out in Indonesia and in India through a comparative study of the calculation of the level of road service in previous studies.

2. Research Study

This study is a review of the methods used to measure the level of road service in Indonesia and India, so the guide to measuring the level of road service will identify the object of this research. Measurement methods for road service levels were collected through a literature study.

3. Method

In this study, comparative analysis was conducted on the variables of road capacity and traffic volume as well as the stages of the calculation process at the two case study locations. This comparison is done in order to know the strengths and weaknesses of each other so that an alternative or recommendation is obtained from the best process for calculating the level of road service.

4. Result

4.1 Level of Service's Variable in Indonesia

Based on Indonesian Highway Capacity Manual [4]there is two variable for level of service. The variables are traffic volume and road capacity. However, in the literature study there is the development of a calculation to calculate the volume of traffic, namely the total volume is the internal volume added to the external volume. The external volume is the volume of continuous flow calculated according to the standard in Indonesia's Highway Capacity Manual, while the internal volume is the volume of traffic originating from land use. Based on Waloejo [13] internal volume is obtained through land use interaction modeling using multiple linear regression.

Interaction Model of Road Network-Land Use

$$VCR = (\sum V_{internal} + \sum V_{external}) / C$$

in which:
VCR = Level of Service
V = Traffic Volume (PCU/hour)
$V_{internal}$ = Total Volume of Vehicles from Trip Generation/Attraction of Land Use
$V_{external}$ = Total Volume of Continuous Vehicle Flow on the Main Road Section
C = Road Capacity (PCU/hour)

This analysis is used to find the relationship between land use and road network usage, which employs the following formula:

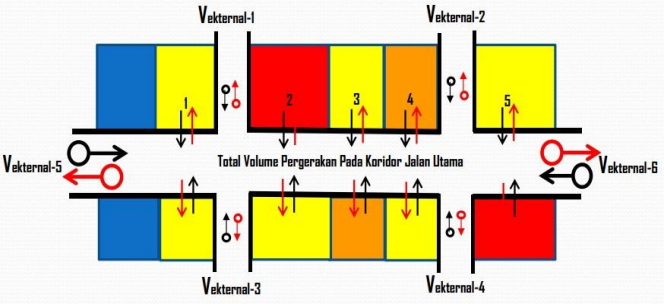

Figure 1: The Land Use and Road Network Model [13]

$$V_{total} = V_{internal} + V_{external}$$

in which:
V_{total} = Total volume of vehicle movement/hour on the main road corridor
$V_{internal}$ = Total volume of vehicle movement/hour from trip generation/attraction of land use
$V_{external}$ = Total volume of external vehicle movement/hour on the main road corridor from the volume of vehicle movement/hour from alleys added by the volume of continuous vehicle movement/hour on the main road

$V_i = e_1 Y_1 + e_2 Y_2 + e_3 Y_3 + \cdots e_n Y_n$ Vi = $e_1Y_1 + e_2Y_2 + e_3Y_3 + \cdots e_nY_n$

Total volume of vehicle movement/hour from land use on the main road corridor

in which:
$e1=V_1/Y_1$ = Ratio of the total volume of vehicle movement entering/leaving the land use during certain hours compared to the total volume of vehicle movement/day
Y_1 = Volume of vehicle movement/day affected by trip generation/attraction of residential land use
Y_2 = Volume of vehicle movement/day affected by trip generation/attraction of educational land use
Y_3 = Volume of vehicle movement/day affected by trip generation/attraction of health land use
Y_4 = Volume of vehicle movement/day affected by trip generation/attraction of office land use
Y_n = Volume of vehicle movement/day affected by trip generation/attraction of land use-n

while:
$V_{External}$ = Total volume of external vehicle movement/hour on the main road corridor

in which:
$V_{External} = V_{Ex-1} + V_{Ex-2} + \cdots + V_n \ldots + V_{Ex-5} + V_{Ex-6}$ V_{Ex-1} = Volume of vehicle movement/hour from alleys - 1
V_{Ex-2} = Volume of vehicle movement/hour from alleys - 2
V_{Ex-5} = Volume of continuous vehicle movement/hour on the main road - 5
V_{Ex-6} = Volume of continuous vehicle movement/hour on the main road - 6

So that the level of service's variable in Indonesia is as follows.

Table 1: Level of Service's Variable in Indonesia

Variable	Sub Variable	Indicator	Reference
Road Capacity	Road geometry	• Road Width • Shoulder Width • Effective Line Width • Road Length • Road Type • Road Hierarchy • Road Pavement	[4,11,12,13]
	Flow composition and direction separator	Total traffic volume	[4,11,12,13]
	Side hindrance	Side hindrance type data	[4,11,12,13]
	Traffic control	• parking restrictions and stops along the side of the road • restricted access to certain types of vehicles • restricted access from roadside land	[4,11,12,13]
Traffic Volume	Internal Volume	Volume of vehicle movement/hour from attraction/generation of land use	[11,12,13]
	External Volume	The volume of external vehicle movement/hour in the main road corridor from the volume of vehicle movement/hour from neighborhood roads/alleys plus the volume of continuous vehicle movement/hour on the main road	[11,12,13]

4.2 Level of Service's Variable in India

Based on Indian Highway Capacity Manual (2017) there is two variable for level of service. The variables are traffic volume and road capacity. However, the sub-variables and indicators used are different from Indonesia. Traffic flow is described and measured using three interrelated variables namely space mean speed (V), volume or rate of flow (Q), and density (K). Green shield relation is considered for the development of the relationship between speed, flow and density. Speed – density relation is a straight line, having maximum speed (free speed) when traffic is low and zero speed when vehicles are jammed. The speed - volume relationship is a parabola having maximum volume at a value of density equal to half the jamming density. The relationship between speed-flow-density is given in equation.

$Q = K + V$

in which:

Q = Traffic flow in PCU/hour
K = Density in PCU/km
V = Space Mean Speed in km/hour

Speed and density are inversely proportional to each other and their relationship is linear in nature having the generalized linear form as given in equation.

$$V = a – b * K$$

in which:

V = Speed in km/hour
K = Density in PCU/km
'a' and 'b' are constants representing free flow speed and ratio of free flow speed to jam density respectively.

Capacity of a two-lane road is influenced by the road conditions and drivers' behavior. A linear relation between operating speed of standard cars and capacity of any given two road two-way section is found to exist as given in Equation and illustrated in Figure below. The operating speed on a road is taken as the 85th percentile of free flow speeds of standard cars. A vehicle travelling with headway 8 seconds or more is considered as free flowing. The base capacity of two-lane road at the operating speed of 80 km/h is around 3100 PCUs/hour.

Base Capacity of Two Lane = $394 + 34 * V_{os}$

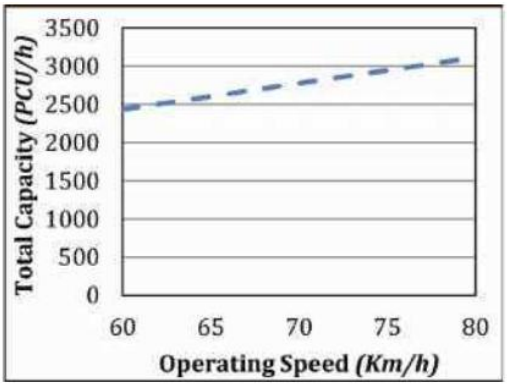

Figure 2: Relationship between Operating Speed and Capacity of Two Lane Roads [3]

So the level of service's variable in India is as follows.

Table 2: Level of Service's Variable in India

Variable	Sub Variable	Indicator	Reference
Road Capacity	Road geometry	• Road type • Lane Width • Paved shoulders • Road field • International Roughness Index (IRI) • Road slope	[3]
	Vehicle speed	• 85th percentile speed • Passenger cars	[3]
Volume lalulintas	Passenger Car Unit (PCU)	• Number of existing vehicles • Projected number of vehicles	[3]
	Stream Equivalency Factor (Se)	Number of vehicles	[3]

4.3 Level of Service's Methodology in Indonesia

Indonesia has a methodology to calculate road service levels by conducting road capacity analysis, traffic flow and composition analysis, saturation degree analysis and land use modeling analysis. The stages of analysis used in Indonesia to calculate the level of road service are shown in Figure 3.

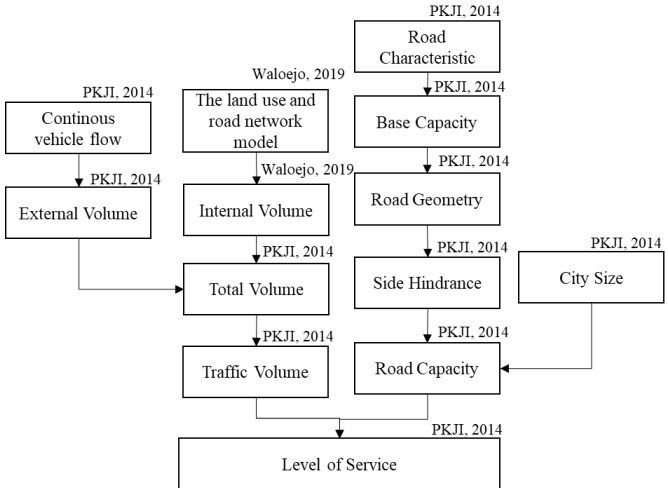

Figure 3: Methodology for Estimation of Capacity and LOS in Indonesia

4.4 Level of Service's Methodology in India

India has a methodology to calculate the level of road service by conducting Passenger Car Unit (PCU) analysis, Stream Equivalency Factor (Se) analysis, road capacity analysis, adjustment factors analysis, and level of service analysis. The stages of analysis used in India to calculate the level of road service are shown in Figure 4.

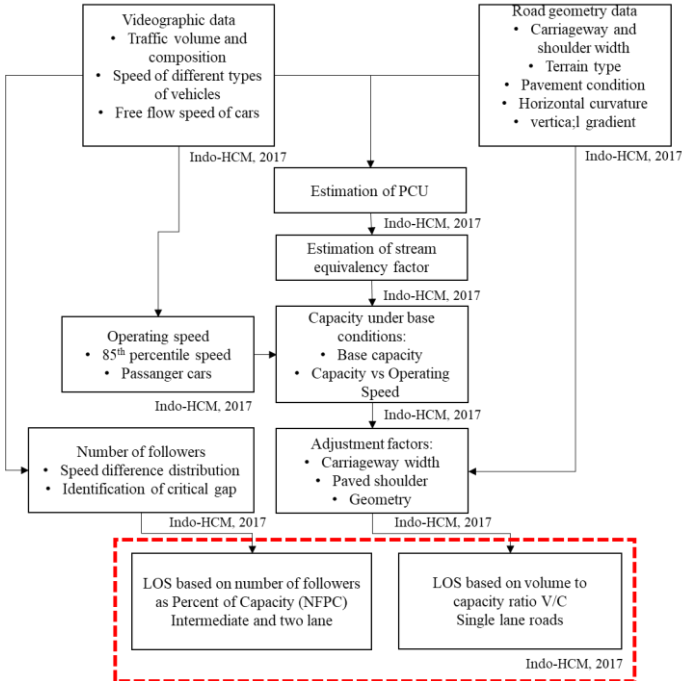

Figure 4: Methodology for Estimation of Capacity and LOS in India [3]

5. Conclusion

Indonesia and India have different methodologies in analyzing the level of road service. The following are the differences that have been identified.

Variable capacity in Indonesia has sub-variables of road geometry, composition of flow and direction separator, side barriers, and traffic regulation. Meanwhile, the capacity variable in India has sub-variables of road geometry and vehicle speed.

The variable volume of traffic in Indonesia has sub-variables of internal volume and external volume. While the traffic volume variable in India has sub-variables Passenger Car Unit (PCU) and Stream Equivalency Factor (Se).

The level of road service in the two countries has the same calculation formula, namely volume per capacity, but differs in each sub-variable on the variable road capacity and traffic volume, so the analysis used to calculate the level of road service is also different. Indonesia has a methodology to calculate road service levels by conducting road capacity analysis, traffic flow and composition analysis, saturation degree analysis and land use modeling analysis. India has a methodology to calculate road service levels by performing Passenger Car Unit (PCU) analysis, Stream Equivalency Factor (Se) analysis, road capacity analysis, additional factor analysis, and road service level analysis.

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