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Level of Service (Los) of Road Capacity along Lasu/Isheri Road

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ABSTRACT

Cities in developing countries are categorized by the continuous growth in the level of vehicle ownership and limited transport infrastructure and service development. This research identified the needed indices that hinder different Levels of Service in LASU/Isheri Road, Ojo, Lagos, Nigeria, and convey factors that enhance positive Levels of Service and their modes of sustainability. This was accomplished by the collection of traffic parameters such as traffic composition and volume-capacity ratio; these were appraised to examine the levels of services on the LASU/Isheri road which are critical in Lagos metropolis. The traffic composition analysis revealed a passenger bus as the predominant model for the entire route. Furthermore, the result also revealed a poor parking system, increase volume of traffic, street trading, and bad roads, too many petrol filling stations, and poor geometric design are factors affecting the level of service. In due course, the result of this study will help the government and transport agencies to proffer adequate measures for the reduction of traffic congestion

Keywords: *level of service; traffic flow; LASU/Isheri road; Lagos*

INTRODUCTION

Cities in developing countries are categorized by the continuous growth in the level of vehicle ownership and limited transport infrastructure and service development to meet the present and future surge of demand. These cities are mostly faced with congestion, poor mobility, and poor accessibility, economic waste, environmental issue, and safety challenges. Examining the level of congestion is supposed to be a major undertaking for transport professionals in developing countries. Congestion usually emanates with the increasing traffic demand which results in total utilization of road capacity. To typify congestion and other traffic dynamics, there is a need to examine the level of service.

According to Popoola, Abiola, and Adeniji (2013), road traffic congestion is one of the major indices of a city's socio-economic effervescence. It has recurrently challenged the pains and hard work of transport planners and city planners on the highways, the issue is frequent delays and longer travel time over time and space. Also, it has equally created barriers to the effective flow of goods and persons on the highways effectively, thereby connecting major towns. The traffic situations on Nigeria roads are in a grim situation that is caused by daily frequent congestion and accidents.

It is pertinent to note that capacity and level of service are two related terms. As capacity tries to give a better understanding of how much traffic a given transport infrastructure can accommodate, so also does the level of service tries to justify how good the present traffic situation on a given infrastructure is. Thus it gives a qualitative and quantitative approach of examining traffic. Road capacity and level of service on road infrastructure vary based on the category of road infrastructure, the purpose being served, the current situation of road condition, usual traffic dynamics, etc Tom *et al*, (2014).

Capacity is defined as the maximum number of vehicles, customers, or the like, per unit time, which can be accommodated under given conditions with a reasonable expectation of occurrence. Capacity is independent of demand and deals with the physical amount of vehicles and passengers a road infrastructure can accommodate. It does not depend on the total number of vehicles demanding service. On the other hand, it depends on traffic conditions, geometric design of the road, etc. For example, a curved road has lesser capacity compared to a straight road. Capacity is expressed in terms of units of some specific thing (car, people, etc.), so it also does depend on the traffic composition (Tom *et al*., 2005).

According to the Transport Research Board (2010), Level of Service (LOS) is a designated term used to qualitatively describe the operating conditions of a roadway based on parameters such as volume/ capacity ratio, speed, travel time, maneuverability, delay, and safety. It divides the quality of traffic into six levels ranging from level A to level F. Level A represents the best quality of traffic where the driver has the freedom to drive with free-flow speed and level F represents the worst quality of traffic. Kadiyali (1995), defined the operating conditions for these six levels of service as indicated in the HCM:

Level of Service "A"

This typifies free flow, with low volume and high speed. Traffic density is low, with speed controlled by drivers' desired speed limits and physical roadway conditions. Individual users are virtually unaffected by others in the traffic stream; v/c =0.00 to 0.60.

Level of Service "B"

This represents the range of stable flow but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected but there is a slight decline in the freedom to maneuver within the traffic stream from LOS A; v/c = 0.61 to 0.70.

Level of Service "C"

This represents the range of stable flow but the selection of speed is affected by the presence of others. Maneuvering within the traffic stream requires substantial vigilance on the part of the user, v/c =0.71 to 0.80. This is the target LOS for some urban and most rural highways.

Level of Service "D"

This typifies the unstable flow that is evidenced with tolerable operation speed being maintained though considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operation speeds. Drivers have little freedom to maneuver; comfort and convenience are low, but conditions can be tolerated for short periods. Minor incidents are expected to create delays, v/c=0.81 to 0.90.

Level of Service "E"

This represents unstable flow, operating at capacity, Cannot be described by speed alone but represent operations at even lower operating speeds than in level D with volumes are or near the capacity of the highway. At capacity, speed is typical but not always in the neighborhood of 50 km/h. Flow is unstable, and there may be a stoppage of momentary duration. The drivers' level of comfort becomes poor. Freedom to maneuver within the traffic stream is extremely difficult, v/c=0.91 to 1.00.

Level of Service "F"

This typifies a forced flow operation at low speeds, where volumes are below capacity. Conditions resulting from queues of vehicles backing up from a restriction downstream. Speeds are reduced substantially and stoppage may occur for a long or short period, because of downstream congestion. Travel time cannot be predicted, with generally more demand than capacity. A road in a constant traffic jam is at this LOS. In extreme, both speed and volume can drop to zero, v/c greater than 1.00.

The LOS concept was adopted for this study in other to evaluate the level of service of the road under study using the volume to capacity ratio parameter. According to Anand, Shekar, and Karim (1999), the need for passenger car equivalence (PCE) to the traffic engineer both in the design of traffic facilities and also in the management of vehicle operations is essential. Each vehicular types such as tricycle, motorcycles, car, buses, trucks/lorry in the traffic stream cannot be considered as equivalent to each other as there is a significant difference in the vehicular and flow characteristics of each vehicle class. Therefore a Passenger Car Equivalent is majorly the impact that a mode of transport has on traffic variables (such as headway, speed, density) compared to a single car. Table 1 is the passenger car equivalents used to convert the traffic volume to passenger car units per hour (pcu/hr) as pointed by Kadiyali (1995).

Table1. *Passenger Car Units (PCU)*

Vehicle Type	Equivalent Passenger Car Unit
Pedal Cycle, Tricycles, and Motor Cycles	0.5
Motor-car, Station Wagon, Taxi, Kit-Car or Pick-up, Jeep, Land Rover, Light Delivery Van, Minibus Trailer attached to above	1 1 2 2
2-Axle Truck Class, Lorry including Timber Lorry, Truck, Mammy Wagon,	2 3

Petrol Tanker Trailer attached to above	
3 to 5 Axle Combination, Tractor Trailer including Low Loader, Petrol Tanker, Bus (Excluding Municipal)	3
Municipal Bus, More than 5 Axle Combination	4

TRAFFIC FLOW THEORY

Traffic flow theory is a tool that helps transportation engineers understand and express the properties of traffic flow. At any given time, there are millions of vehicles on our roadways. These vehicles interact with each other and impact the overall movement of traffic or traffic flow. Whether the task is evaluating the capacity of existing roadways or designing new roadways, most transportation engineering projects begin with an evaluation of the traffic flow. Therefore, the transportation engineer needs to have a firm understanding of the theories behind Traffic Flow Analysis.

Traffic Flow Parameters

Traffic flow is a difficult phenomenon to describe without the use of a common set of terms. The following paragraphs will introduce most of the common terms that are used in discussions about traffic flow.

Speed (v)

The speed of a vehicle is defined as the distance it travels per unit of time. Most of the time, each vehicle on the roadway will have a speed that is somewhat different from those around it. In quantifying the traffic flow, the average speed of the traffic is a significant variable. The average speed, called space mean speed, can be found by averaging the individual speeds of all of the vehicles in the study area.

Volume

Volume is simply the number of vehicles that pass a given point on the roadway in a specified period. By counting the number of vehicles that pass a point on the roadway for 15 minutes, you can arrive at the 15-minute volume. Volume is commonly converted directly to flow (q), which is a more useful parameter.

Flow (q)

Flow is one of the most common traffic parameters. Flow is the rate at which vehicles pass a given point on the roadway, and is normally given in terms of vehicles per hour. The 15-minute volume can be converted to flow by multiplying the volume by four. If our 15-minute volume were 100 cars, we would report the flow as 400 vehicles per hour. For that 15-minute interval of time, the vehicles were crossing our designated point at a rate of 400 vehicles/hour.

Peak Hour Factor (PHF)

The ratio of the hourly flow rate (q_{60}) divided by the peak 15-minute rate of flow expressed as an hourly flow (q_{15}). PHF= q_{60}/ q_{15}

Density (k)

Density refers to the number of vehicles present on a given length of roadway. Normally, density is reported in terms of vehicles per mile or vehicles per kilometer. High densities indicate that individual vehicles are very close together, while low densities imply greater distances between vehicles. Headway, spacing, gap, and clearance are all various measures for describing the space between vehicles. These parameters are discussed in the paragraphs below

Headway (h)

Headway is a measure of the temporal space between two vehicles. Specifically, the headway is the time that elapses between the arrival of the leading vehicle and the following vehicle at the designated test point. You can measure the headway between two vehicles by starting a chronograph when the front bumper of the first vehicle crosses the selected point, and subsequently recording the time that the second vehicle's front bumper crosses over the designated point. Headway is usually reported in units of seconds.

Spacing (s)

Spacing is the physical distance, usually reported in feet or meters, between the front bumper of the leading vehicle and the front bumper of the following vehicle. Spacing complements the headway, as it describes the same space in another way. Spacing is the product of speed and headway.

Gap (g)

The gap is very similar to headway, except that it is a measure of the time that elapses between the departure of the first vehicle and the arrival of the second at the designated test point. The gap is a measure of the time between the rear bumper of the first vehicle and the front bumper of the second vehicle, where the headway focuses on front-to-front times. The gap is usually reported in units of seconds.

Clearance (c)

Clearance is similar to spacing, except that the clearance is the distance between the rear bumper of the leading vehicle and the front bumper of the following vehicle. The clearance is equivalent to the spacing minus the length of the leading vehicle. Clearance, like spacing, is usually reported in units of feet or meters.

Traffic flow can be divided into two primary types. Understanding what type of flow is occurring in a given situation will help you decide which analysis methods and descriptions are the most relevant.

The first type is called *uninterrupted flow* and is flow regulated by vehicle-vehicle interactions and interactions between vehicles and the roadway. For example, vehicles traveling on an interstate highway are participating in an uninterrupted flow.

The second type of traffic flow is called *interrupted flow*. Interrupted flow is flow regulated by an external means, such as a traffic signal. Under interrupted flow conditions, vehicle-vehicle interactions and vehicle-roadway interactions play a secondary role in defining the traffic flow.

Lagos as an emerging megalopolis and acclaimed economic and business capital of Nigeria is being hindered by unprecedented environmental problems arising from Transport infrastructure and land-use problems arising from lack of a comprehensive and coherent national urban planning and effective city governance policy. Lagos is noted for its traffic congestion, shortage of shelter, unemployment, inadequate social facilities such as electricity, water supply, medical, education and sewage facilities, Lagos environment in certain quarters is noted for squatter settlement, blighted slums and environmental degradation. It is important to note that land use and transportation are two sides of the same coin, transportation affects land use and land use affects transportation and decision in one affects the other. This implies that effective coordination of transportation and land use planning decision is of paramount importance to creating a complementary role between the two rather than contradictory roles as currently observed (Gbadamosi *et al*., 2013).

Traffic generation with its attendant problems, arising from intense traffic congestion from the surroundings zones in terms of composite use i.e. residential, institutional buildings recreation with overwhelming impact of commercial activities arising from newly imposed land use from land-use conversion that is mostly commercial in nature. Traffic problems experienced in Nigerian cities today can be traced down to the discovery of petroleum that resulted into increase in disposable income and thus increase in vehicle ownership, and for this vehicles to be operational, there needs fuel, so this led to the building of petrol service stations at strategic locations to meet the demand of vehicle owners (Abdul *et al.*, 2009).

The Influence of Land Use on Traffic Volume and Travel Behavior

According to perception, suggestions have been made that traffic volumes on a busy arterial roadway are associated with the type and density of activity built along that roadway. For example, the entrance to a shopping mall is frequently teeming with cars, and suburban commercial strips also give visual evidence of customers maneuvering in and out of parking lots or disrupting flow by trying to cross several lanes of traffic to make a turn at a busy intersection. These are inescapable facts of urban life. The fact is that travel patterns are complex, with travel being a “derived demand” necessitated by the needs of households and customers to reach daily activities (Kuzmyak, 2012)

In the transportation planner’s view, the nature of the subsequent travel demand is best seen as a regional “trip table” of productions and attractions, or demands for travel matched against multiple locations where those demands can be fulfilled. Many factors are considered when deciding where to go to satisfy a particular trip purpose, although travel time and cost are frequently prominent in these decisions. The transportation network is the mechanism by which this diverse pattern of origin demand and destination supply is connected. Trips of many purposes and geographic orientation are superimposed upon the network at any given time such that at any given location, the travel stream may be composed of trips with many different purposes from many different locations throughout the region. Typically, trips being made on the highest functional class of highways (freeways and interstates) are the longer trips on the system, while those on arterial and connector roadways have proportionately higher shares of local travel (Kuzmyak, 2012).

However, these relationships quickly dissolve if congestion clogs one group of facilities more than another or the road system lacks sufficient connectivity between particular points. As a result, travelers in suburban areas frequently use the freeways to make local trips, traveling only between one or two exits, or long-distance travelers use local roads to avoid congestion on higher class highways or as a shortcut. Hence, traffic volumes and congestion on a given roadway segment are seldom well explained by immediately adjacent development but have multiple contributing causes. Preferences about housing type location and affordability, employment, schools, and other factors cause households to make varied decisions about where to live, where to work, where to shop or recreate, and how to travel.

Growth and new development have a way of changing the conditions that were once prized and expected, such as when a trouble-free, 30-minute commute gradually becomes a frustrating 60 to 90-minute ordeal, or a favored shopping district is suddenly impossible to access at particular times. If a long commute becomes too unbearable to drive, the commuter with options lives within easy access to efficient transit service or can take advantage of a priority high occupancy vehicle (HOV) lane. For residents fearing difficult access to traffic-choked shopping centers, location in a community that offers a variety of services and amenities locally—either within walking distance or a short car trip on local streets—can be a periodic or regular substitute to longer trips in heavy traffic. (Kuzmyak, 2012)

Landuse/transport interactions are also masked by many other mega trends and socio-economic developments (e.g. demographic, economic, social, policy-making) with potential (stronger or weaker) linkages to the land-use/transport systems. Wegener (1996) summarises these mutual interactions in “the land-use transport feedback cycle”. A way of illustrating the linkages between land-use and transport is shown in Figure 1. It should be clear that the time scales of various impacts in Figure 1 are widely different: from more or less daily route and mode choices, to intermediate time horizon changes of location (moves), car ownership, travel patterns, traffic management, and transit supply to very long term changes of transport network design, urban form, and settlement structure. (Lundqvist, 2004)

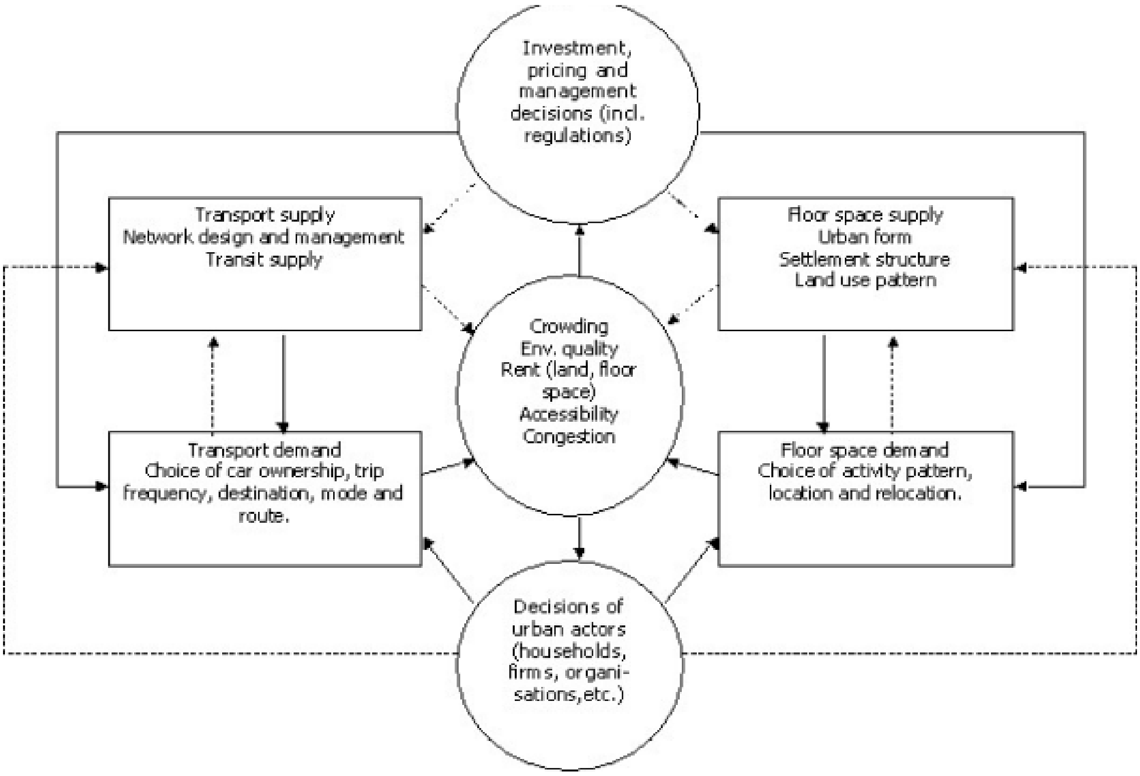


Figure1. *Linkages between the transportation market and the land-use market (dotted arrow: medium to long-term impacts; solid arrow: short to medium-term impacts).*

Another way of illustrating some fundamental relationships between land-use and transport behavior is the “Brotchie triangle”. A simplified version is shown in Figure 2. Any urban structure is characterized in two dimensions: one indicator of spatial interaction (e.g. average trip length or travel time) and the other indicator of dispersal of non-residential land-use (e.g. degree of decentralization of working places). After defining proper indicators for these two dimensions, any urban region can be represented as a point in the diagram at any point in time (e.g. D). Different urban regions can be compared with each other at any point in time and the development over time of any urban region can be represented as a trajectory in the diagram (e.g. D → E). It is instructive to think of a circular and symmetric city with residents distributed around the geographical center. Spatial interaction is measured in terms of the average trip length for commuting. Point A in Figure 2 represents the case where all employment activities are located in the city center. All commuters have to travel to the center (many-to-one interaction) and the average trip length can be uniquely defined. Radial transport systems and mass transit constitute relevant options in such a context. At the other extreme, along the axis, B-C employment has the same spatial distribution as a residential location (i.e. complete decentralization). In this case, the trip length depends heavily on travel behavior: if residents choose the nearest employment opportunity, point C would be the result with very short local trip length, while if residents choose employment opportunities at random, point B would be the result with very long average trip length. Point C would reflect one-to-one interaction on local networks while point B corresponds to many-to-many interactions with dispersed traffic flows on complete networks. Different kinds of socio-economic scenario assumptions and technological developments can be related to various parts of the diagram. A few examples are indicated in Figure 2. The prevailing development trend can be represented as a trajectory in the "eastern" or "north-eastern" directions (like D → E) towards more decentralization of employment, more car traffic, and tendencies towards longer trip lengths in more dispersed travel patterns. (Lundqvist, 2004)

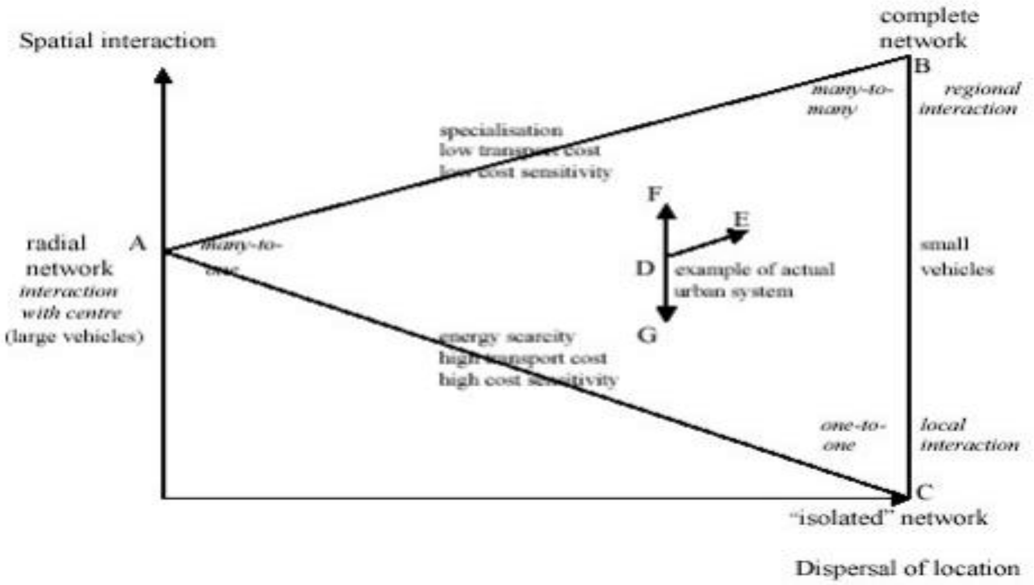


Figure2. *Main features of the "Brotchie triangle" on land-use and travel behavior.*

METHODOLOGY

Level of Service (LOS) Parameter

The parameter adopted by this study to measure the LOS of the road under study id the volume to capacity ratio, adopted from the Highway Capacity Manual (HCM), 2000.

$V{:}C = \frac{V_m}{C}$……………….....................equation 3.1

Where:

V:C = Volume to capacity ratio

C = 4 lanes dual carriage way capacity- normally 2600pcu/hr for a directional segment

V_m = Maximum hourly volume (pcu/hr)

$V_m = \frac{V_P}{PHF}$……………….....................equation 3.2

Where:

V_p = Passenger equivalent volume for peak period

PHF = Peak hour factor for a typical urban multilane carriageway. (PHF=0.92)

RESULTS AND DISCUSSION

Vehicle Composition and Volume of Traffic along the Road Corridor

The volume of traffic along the corridor was converted to Passenger Car Unit which is a vehicle unit used for expressing highway capacity. One car is considered as a single unit, cycle, the motorcycle is considered as half car unit. Bus, truck causes a lot of inconvenience because of its large size and is considered equivalent to 3.0 cars or 3.0 PCU.

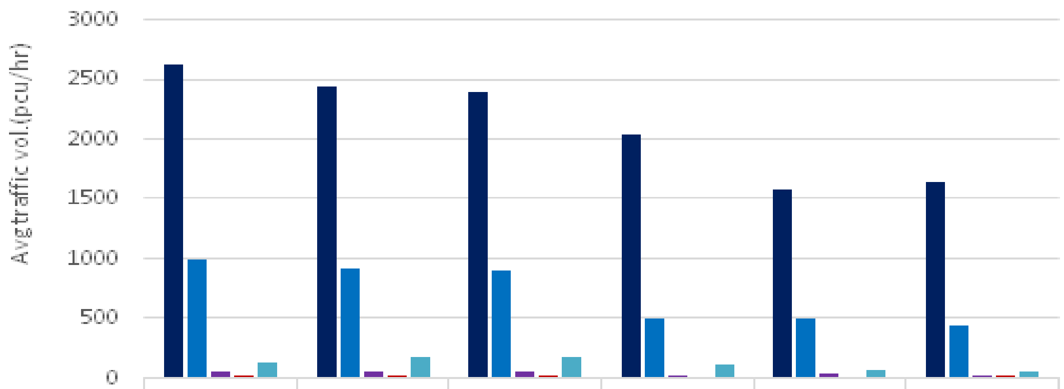
Vehicle Composition

Figures 4.4a&bshows the vehicle composition of the traffic stream on the road understudy during the 6days survey period. The charts revealed that the most predominant mode of transportation along the road corridor is the yellow minibusses popularly known as "Danfo", which constituted approximately 69.2% of the traffic stream, followed by private car constituting 24.3% and motorcycles, tricycles, and high-density vehicles (HDV) constituting 1.7%, 0.9%, and 4.0% respectively.

This implies that most people within the region depend mostly on commercial vehicles as a means of commuting. This is because people residents within the region are mostly low and medium-income earners and could not afford a personal means of conveyance. However, the over-concentration of minibusses along the corridor have negative implications on the traffic flow along the corridor because a high number of small occupancy vehicles increases the traffic density along the corridor. Also, the inordinate picking and dropping off passengers by minibusses at any point along the road often results in traffic bottlenecks.

Moreover, for these buses to remain operational, they need fuel, this necessitated the establishment of filling stations along the corridor. With the percentage of commercial buses along the corridor, the filling station enjoys high patronage. Most times, especially during periods of high demands, the queue in the filling stations spills over to the roadway, and some commercial buses due to their impatience form two-lanes of queues to be serviced by filling stations on the roadway, thereby causing impedance to the free flow of traffic on the roadway.

Conclusively, the major means of conveyance within the region are mostly small occupancy vehicles, (Minibusses, Cars, Tricycle, etc). This results in high vehicular density along the road, which in turn affects the free flow of traffic, especially during peak periods. This high vehicular density also contributes to the length of queues at the filling stations, in that more vehicles are queuing for fuel unlike in areas dominated my High Occupancy Vehicles (HOVs).



	MONDAY	TUESDAY	WEDNESDA Y	THURSDAY	FRIDAY	SATURDAY
BUS	2631.2	2444.3	2401	2050.25	1577.25	1650.75
CAR	993	929	912	510.5	513	446.25
MOTORCYCLE	69.125	62.875	64	36.125	41.625	32.125
TRICYCLE	36.375	31.375	27.1	21.75	15.25	26.956
HDV	133	182.25	184.75	120.5	74.25	54

Days of the week

Figure3. *Average Daily vehicle composition of traffic along LASU/Isheri road.*

Traffic Volume in PCU

Figure 3 and Table 2 reveals the volume per hour variation among the days of the week. The maximum / highest hourly volume was estimated to be 3862.7 pcu/hr which was recorded on Monday. The lowest or minimum volume for the week was observed on Saturday (2210.1pcu/hr). This shows that the traffic volume along the road is usually high during weekdays and low on the weekend. The results of the traffic volume on the road depict a high level of land use activities going on in the area.

The volume of traffic along the road which is considerably high with a peak hour volume of (4198.6pcu/hr), reveals the reason why there is always traffic congestion on the road during peak periods, knowing high traffic volume have negative implications on traffic flow. It also explains the reason why there is a high demand on the petrol filling stations along the corridor necessitating in-flow and out-flow of traffic at filling stations which at times due to the haphazard siting of the filling station impedes traffic flow along the corridor especially during the period of fuel scarcity when there is usually spillover of queues to the roadway thereby reducing the carriage capacity of the road and consequently causing traffic congestion.

Table2. *Traffic Volume in PCU*

Days of the week	Traffic vol. (pcu/hr)
MONDAY	3862.7
TUESDAY	3649.8
WEDNESDAY	3588.9
THURSDAY	2739.1
FRIDAY	2221.4
SATURDAY	2210.1
Maximum peak hour traffic volume(pcu/hr)	4198.6

Note: *The maximum peak hour traffic volume was gotten by dividing the maximum peak hour traffic volume (3862.7) which was observed on Monday by the Peak Hour Factor (PHF): 0.92*

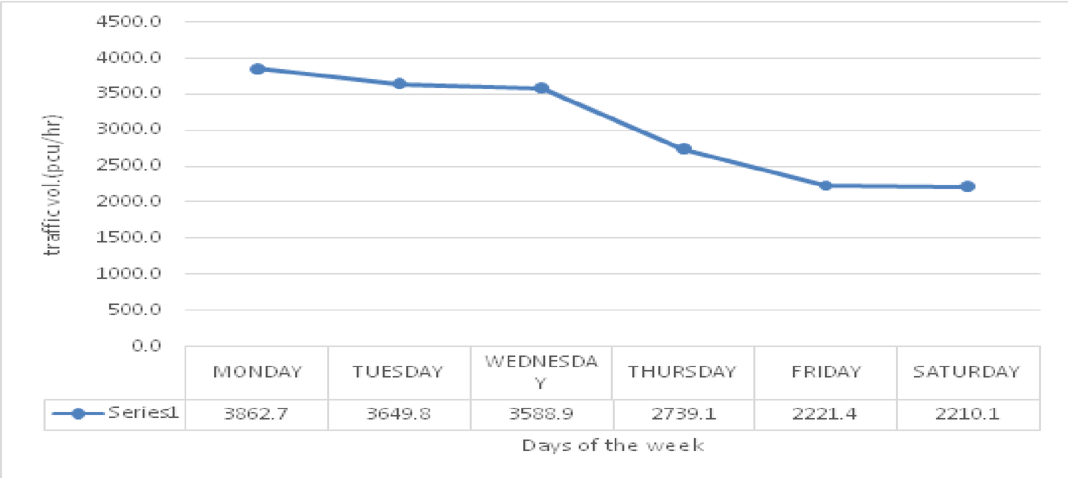


Figure4. *Average Volume per hour variation for the week*

Level of Service (LOS) Of LASU/Isheri Road Concerning the Carrying Capacity of the Road

Table 3 is the summary of the result for the LOS determination for the road. See the interpretation and implication in Table 4. LOS is dependent on the volume of traffic along the road which is generated or attracted by the land use activities in the region. Filling stations along the road contributes significantly to the volume of traffic attracted to the road thereby to some extent reducing the LOS of the road.

Table3. *LOS of LASU /Isheri road.*

Traffic stream	Maximum peak hour volume(V) (pcu/hr)	The capacity of a two-lane directional flow (C)	V/C ratio	LOS
A	1859.1	2600	0.715	D
B	2339.5	2600	0.899	

Note: *Traffic Stream A is LASU – Isheridirectional flow; Traffic Stream B is Isheri – LASU directional flow*

Table4. *Interpretation of LOS result and implications*

LOS	HCM standard	Implications	Causes
D	Heavy congestion	Approaches unstable flow, high density, reduced speed, significant operational difficulties on the highway, delay. There are severe restrictions on a driver's ability to maneuver, with poor levels of comfort and convenience.	• The high volume of traffic which is dominated by passengers' minibusses (Danfo) and other small occupancy vehicles (SOV), • High level of land use activities along the road. • Unregulated location of petrol filling stations.

Sources: *HCM: (Highway capacity manual, 2010) and Author's Field survey, (2017)*

Conclusion

Cities in developing countries are categorized by the continuous growth in the level of vehicle ownership and limited transport infrastructure and service development. This research identified the needed indices that hinder different Levels of Service in LASU/Isheri Road, Ojo, Lagos, Nigeria, and convey factors that enhance positive Levels of Service and their modes of sustainability. This was accomplished by the collection of traffic parameters such as traffic composition and volume-capacity ratio; these were appraised to examine the levels of services on the LASU/Isheri road which are critical in Lagos metropolis.

LOS is dependent on the volume of traffic along the road which is generated or attracted by the land use activities in the region. Filling stations along the road contributes significantly to the volume of traffic attracted to the road thereby to some extent reducing the LOS of the road. The traffic composition analysis revealed a passenger bus as the predominant model for the entire route. Furthermore, the result also revealed a poor parking system, increase volume of traffic, street trading, and bad roads, too many petrol filling stations, and poor geometric design are factors affecting the level of service. In due course, the result of this study will help the government and transport agencies to proffer adequate measures for the reduction of traffic congestion.

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