INFORMATION AND COMMUNICATION TECHNOLOGY FOR IMPROVED INTRA-CITY TRAFFIC FLOW IN IBADAN CITY, NIGERIA

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Abstract

That there is a strong degree of affinity between efficient transport service delivery and Information and Communication Technology (ICT) is not an understatement in this century. However, the persistent traffic dilemma in Nigerian cities including Ibadan city undermines the importance of transportation to the socio-economic affluence of the country. Despite the continuous efforts of the government in road expansion and construction, the menace of traffic bottlenecks in Ibadan city is alarming and the traffic situations still recorded a high level of dismal performance. It is based on the foregoing that this study examined the traffic situations in Ibadan city and demonstrated strategies towards improved intra-city traffic flow in the city through the use of ICT-based traffic management system. 400 road users were sampled randomly along seven stratified traffic corridors in Ibadan. Data were analysed descriptively and inferentially. Major findings revealed that the majority of the road users are commuters (50%), between 31-40 years (57.5%) and actively engaged in productive activities (over 70%). The study also revealed major ranked traffic challenges and factors contributing to traffic challenges in the city. Again, epileptic electricity supply, poor funding, absence of reliable traffic facilities and data, poor internet facilities and cost-effectiveness of ICT facilities are 1st, 2nd, 3rd, 4th and 5th respectively as major constraints of ICT-based traffic management in Ibadan. Meanwhile, improved traffic management system, reduced congestion, improved traffic safety, sustainable urban transport operation and reduced traffic incidence are the major ranked prospect of ICT-based traffic management. Based on the findings, adequate integration of ITS/ICT mechanisms to the urban transport system in Ibadan city and cities with similar issues was strongly recommended towards enhancing the efficient and effective performance of transport infrastructural facilities and services delivery.

Keywords: Intelligent Transport System (ITS), Urban Transport, Traffic flow, Congestion, Ibadan City

JEL Classification: L91, R41

1. INTRODUCTION

Information and Communication Technology (ICT) as a veritable tool for efficient service delivery is not an understatement, while the fact that 'Transportation' as the only way to Nigeria's socio-economic development was well acknowledged by the colonial administration. Transportation is, all in all, that is the demand of all demand, it is life (Badejo, 2011), nurtures lives and equally play a significant role in the efficient running of modern societies including mobility service delivery as well as socio-economic and political affluence. Despite, its pivotal roles in achieving human survival and sustainable development, it is still characterised with obvious challenges including traffic crashes or mishaps, persistent delay, congestion, crime, among others. These transportation externalities particularly the persistent traffic congestion in many Nigerian urban centres are however undermining the benefits of transportation to the individuals, socio-economic activities and various communities at large. It is worthy to note that traffic congestion as an increasingly problematic issue in cities has become popular and a call for concern since the 1950s when the interacting vehicles on urban road networks battle for moving space, queue and rage with each other for active speed and flow relationships. By definition, traffic congestion is a condition of a transportation system that is characterised by slower speeds, longer trip times and increased vehicular queueing. Geenhuizen (2009) observed traffic congestion as a function of interacting vehicles due to inactive speed and flow relationship when volumes approach capacity at which both the vehicles going slow and vehicles travelling at high speeds queue, contribute and accounted for accumulated traffic delay and other socio-economic consequences.

The socio-economic consequences of traffic congestion necessitate persuasive reasons in taking actions before related or associated problems become more difficult to manage since solutions to traffic congestion in cities across the globe as identified in the literature require a multi-faceted approach. As Nigeria's economy, urbanization and population continue to grow, especially with the nations quest to be among the twenty leading global economy in 2020, traffic congestion which is expected to be reduced and better, is on the increasing rate that is getting worse day by day, particularly in large urban centres, state capitals and other urbanized areas in the country where demand for service delivery is extremely high. The national attention to ever-increasing traffic congestion in Nigeria reached the peak in 1977, when 'Transportation in Nigeria National Development' formed the theme of the National Conference held at University of Ibadan, Nigeria re-vibrated the challenges of transportation in Nigeria cities and therefore calls for immediate stakeholders intervention particularly the government and professionals

Despite government's significant interventions, particularly through improvement on the urban road network and capacity expansion in recent times, accessibility and mobility are being increasingly degraded by growing intra-city traffic delay and congestion especially in major urban centres including Ibadan, Lagos, Benin, Osogbo, Akure and even Abuja among others. Therefore, the acute limitation and dismal performance of other traffic control measures such as human and traffic behavioural control, incessant road maintenance, road pricing and capacity expansion coupled with intelligent transport system and traffic information system in arresting the ever-growing traffic congestion in our urban centres is no doubt obvious.

According to Nwakaire, Ohagwu and Ani (2009), reformation and advancement in Information and Communication Technologies have resulted in wider applications all over the world in the last two centuries. Hence, the embracement and integration of Intelligent Transport Systems (ITS) through ICT solutions become necessary towards achieving a smooth flow of traffic in Ibadan and other metropolitan areas in the country. ITS incorporate the use of ICT in enhancing and optimally managing the operations and efficiency of transportation in general, as Oyesiku (2002) observed that it has helped manage road networks, coordinate traffic (to reduce congestion), improve safety and reduce travel times. ICT is a value enhancement strategy for ensuring free traffic flow towards achieving effective traffic management in contemporary settlements across the world. Thus, ICT traffic management systems are critical in managing traffic flow in contemporary societies. Hence, the rationale for this study in unveiling the traffic issues in the Ibadan city, examine the determinants of traffic challenges in the study area, identify the constraint of the use of ITS-ICT based traffic management and establish the prospects of the use of ICT-based traffic management towards achieving improved intra-city traffic flow and route connectivity in Ibadan city and other cities with similar issues in Nigeria.

2. CONCEPTUAL UNDERPINNING AND LITERATURE REVIEW

2.1. CONCEPT OF SMART TRANSPORT

This paper is anchored on the concept of Smart Transport. According to Mitchell (2006), smart transport encompasses a range of systems and applications to tackle transportation challenges. It is otherwise known as Intelligent Transport Systems (ITS) which can include different modes of transport and traffic management, real-time traveller information, centralised fleet management, road usage charging, smart charging for electric vehicles and vehicle-to-vehicle systems among others. The global investment in smart transport systems (intelligent traffic management systems) is estimated to be US$13.1 billion between 2011 and 2017.

ICT enables the elements within the transport system (vehicles, road, traffic controlling equipment (signs and traffic lights)) to become intelligent by embedding sensors and microchips in these elements. Using wireless technologies to enable communication between these elements, the performance of the system

can be greatly enhanced, reducing congestion and increasing road safety (Mitchell, 2006). Better traffic management to ease congestion means that vehicles do not sit in roads and highways, emitting harmful carbon gases. ITS vary in applications and ranges from basic management systems such as car navigation and traffic signal control systems to more advanced applications that integrate live data and feedback.

Several scholarly authors have examined ICT and ITS in different perspectives over the years. Geenhuizen (2009) sees Information and Communication Technology as a set of heterogeneous technologies (hardware and software) that allow for electronic communication, data collection and processing in distributed networks as well as electronic guidance and management through sensor technologies. However, ICT applications through Intelligent Transport System in the transport system development and sustainability differ in complexity, ranging from simple electronic communication (signals) to interactive and highly intelligent applications in traffic management and control. Thus, ITS is a system of layers comprising infrastructures, services on these infrastructures, vehicles moving through the system of infrastructures, and persons and freight moving in these vehicles.

From another perspective, Shimizu, Shomura, Masukawa and Takeda (2014) are of the view that ICT covers both information technology (IT) and telecommunications that are useful as traffic management solutions for social innovation. Hence, ICT satisfies requirements such as optimization of investment (expanding data communications traffic and data storage capacity at low cost) and innovation (promoting business innovation and helping establish and expand new businesses) by which it has profound effects on society and its production capacity.

Similarly, the European Commission (2013) is of the view that ITS is a key enabler to achieve public policy objectives, support the design of urban mobility and offer tailor-made measures, adapted to the wide variety of urban mobility situations. Therefore, as the core of urban mobility package, ICT/ITS can provide very concrete solutions for traffic and travel operations and management, thereby reducing congestion and its resulting negative externalities.

2.2. LITERATURE REVIEW

2.2.1. Ibadan City Traffic in Perspectives

Ibadan city is recognized as a nodal settlement because of its transportation network advantage facilitated by its aged long political, administrative and commercial functions as well as her suitably geographical location enjoyed till date (Ogunsesan and Akanmu, 2010). For instance, before the development of various categories of modern roads, a rail line was constructed to link Ibadan with Lagos in 1901, and later extended to Offa, Ilorin and the far North on a single narrow-gauge track system. Also, the first modern road in Nigeria was constructed between Ibadan and Oyo in the early 20th century.

The principal routes in Ibadan are Lagos/Ibadan highway to the South, Ibadan/Oyo/Ilorin highway to the North; Ibadan/Ife/Ilesha/Akure highway to the

East and Ibadan/Ijebu/Abeokuta to the West. Furthermore, several other intracity routes and corridors transverse Ibadan to provide both mobility and accessibility for all land uses, residents and visitors in a less-congested manner. Accordingly, as observed the most congested intracity routes in Ibadan metropolis include University of Ibadan-Dugbe Route, Dugbe-Apata Route, Olomi/Odinjo/Beere road, Challenge-Podo road, Challenge-Molete-Mapo-Bere road, Inalende-Oritamerin route, Lagos-Ibadan Tollgate - Ojoo route, Dugbe-OkeAdo-Molete route and Challenge-Molete-Beere route. Others include Mokola-UCH/Total Garden-Gate route, Beere-Oje-Iwo road, Beere-Total garden secretariat-U. I road, Sango-Eleyele road, Eleyele-Dugbe road, Eleyele-Ologuneru road, Apete-Ijokodo-Sango road, Ojo/U.I.-Mokola-Dugbe road and Apata-Dugbe road among many others.

These observed routes were congested with long hours delay particularly during the morning, afternoon and evening peaks of the week coupled with longer hours delay which sometimes led to terrific traffic delay situations during weekend rush with uncontrollable and carefree attitudes of road users as a major factor causing the unwanted traffic situation within the observed city. The observed traffic characteristics of these routes were noted in studies of Orioke (1977) as well as Ogunsesan, Akanmu and Ogunsesan (2012).

Among the factors identified by Ogunsesan and Akanmu (2010) as responsible for chaotic traffic situation in Ibadan are faulty intersections, narrow road/street, neglect of pedestrian facilities, poor road network, absence of road discipline, vehicular, cyclists/pedestrians conflicts and indiscriminate location of traffic generating land uses along the major roads/intersections. Meanwhile, Salisu (2019) noted that lack of intelligence transport control devices, excesses and attitude of the traffic officers and policemen, haphazard on-street parking, poorly operated traffic management devices, lack of pedestrian and cycling facilities, poor connectivity of road networks, absence of road discipline etc. are causes of traffic congestion along major corridors within intra-city in Lagos, Ogun and Oyo States. However, with some of the hindrances to free-flow of traffic being taking care of by state government, especially in Ibadan city and other parts of Oyo State, there is still need for the enhancement of the intra-city movement in Ibadan for efficient service delivery.

2.2.2. Historical Attempts at Improving Ibadan City Traffic Situation since 1975

The fact that the traffic congestions in Nigerian urban centres have been attracting several attentions from government, researchers, institutions, professional bodies and scholars since the mid-70s is not an understatement. Studies such as Orioke (1977), Ogunsanya (2002), Oyesiku (2002), Ogunsesan (2011), and Ogunsesan, Akanmu and Ogunsesan (2012) among others have critically assessed urban traffic congestions in Nigeria (and especially in Ibadan) over the years, and suggested measures for its curtailment in several national academic discourse and publications.

The importation of traffic congestions to Ibadan might have dated to 1974 as Orioke (1977) observed that free flow of vehicular movement was enjoyed in

Ibadan up till 1973, while Ibadan traffic congestion reached peaked in May 31, 1977, when the then serving governor (Brig. Jemibewon of Federal Road Safety Commission) had to personally controlled traffic along Cultural Centre/Secretariat road. The continued worsening traffic congestion in Ibadan led to the commissioning of Ibadan Traffic Committee on December 31, 1975, by Oyo State Government (Orioke, 1977), and the submission of the report in March 1977 which produced a far-reaching decision. The implementation of the Committee recommendations produced the dualization and expansion of vital intra-city roads in Ibadan, installation of traffic control lights and the establishment of Oyo State Road Safety Corps (Ogunsesan, Akanmu and Ogunsesan, 2012).

However, the Oyo State Government through her Ministry of Works and Transport (2001) rejuvenated attempt to enhance traffic flow in Ibadan with the involvement of transport consultants, and subsequently established 'volunteered Oyo State Traffic Control Corps in 2002'. 2004 witnessed the composition of another Committee for Oyo State Traffic Management, the report of which led to the enactment of Oyo State Road Traffic Management Act of 2004. However, the Act was not implemented until 2007 when the Oyo State Road Traffic Management Agency was established. The Agency was dissolved in 2011 and later reconstituted in 2012 by the present administration through the 'Yes-O' Scheme. Ironically, despite noticeable improvement measures by the stakeholders, particularly the government, it's imperative to note that the traffic situation on major roadways within Ibadan city is getting worse most especially during week and weekend peaks.

2.2.3 Understanding ICT-Based Traffic Management Issues

Among the underlying issues in ICT-based traffic management are:

i. Intersection: Traffic congestion that normally impedes efficient service delivery and hinders the free flow of both vehicular and human movements usually commenced at intersections, junctions and interchanges where vehicles merge, diverge and cross paths. It is in this process and spots that delay and other associated challenges are ushered in especially in large urban centres across the globe. However, the complex traffic situation and flow characteristics particularly at intersections requires a well-designed, flexible and easily monitored ICT based traffic management system to control and manage all categories of traffic.

ii. Fixity and mobile (inbuilt): The ICT innovations in transport can be fixed (or semi-fixed) and mobile. The fixed include video surveillance and response, informational signing and signalization that are commonly used for road traffic management at specific road sections and nodes. The mobile application is in-built into the vehicle and is more advanced applications, mostly integrated with the fixed applications to arrive at a better fine-tuning of traffic systems to enhance the efficient and effective flow of traffic.

iii. Traffic Data Traffic Management Solutions: These are based on the accumulation, analysis and control of traffic data. The variety of traffic status data are collected consistently from which analysis and control are performed, most especially for prediction, and forecasting future traffic characteristics. Traffic

management in smart transport is scientific and as such, be guided by scientific doctrines of objectivity and data operations and management.

iv. Investment in equipment: ICT solutions based around TMSs deliver investment optimization and innovation (Geenhuizen, 2009), and the investments in telecommunication and communication equipment are crucial ingredient. This is optimized through a real-time collection using flow data, high-speed analysis, platform, real-time bandwidth and compression control based on policy control techniques.

v. Smart Transport component: The smart transport components in ICT/ITS, according to Geenhuizen (2009) involves the following among many others:

a. Video Surveillance and Response (VSR): This involves continuous monitoring of key network locations to determine if traffic is moving or encountering congestion. Such monitoring is done with strategically located sensors or television cameras, including different radar sensors, infrared and visible spectrum imaging and laser technology to observe flow interruptions and threats continuously.
b. Informational Signing (variable messages): This includes electronic changeable message signs along the highway that assistant in communicating with drivers regarding major congestion points on the road ahead. Often these signs give directions as to ways to avoid upcoming congestion points related to accidents, delay, congestion and the likes.
c. Traffic Information Center (TIC): The Traffic Information Center manned by personnel on 24 hours basis is usually connected with other outside fixed and semi-fixed as well as mobile technologies from where traffic flows are being monitored and information disseminated to field units. TIC is connected with VSR, CCTV, GPS, trackers, webcams, a navigation system (through the use of GPS, GIS and mobile communication) and many other technologies.
d. Spatial planning: The nature of traffic flow in an area is usually a reflection of its pattern and structure of land uses. Smart transport is most efficient when the principles of land use planning are fully embraced and practised in urbanized areas.

3. MATERIALS AND METHODS

Geography of the Study Area (Ibadan City)

Ibadan is located approximately on longitude 30 5' East of the Greenwich Meridian and Latitude 70 23' North of the Equator (Fourchard, 2000). The approximate land area of Ibadan Region (i.e. 11 Local Government Areas-LGAs) is 55km by 70km totalling 3850 square kilometres or 385,000 Hectares, which is about 14.13 % of the total landmass of Oyo State (27,249 square km). The present site of Ibadan was formerly known as 'IGBO-IPARA', without any settlement around nor people living there and was a neutral ground (i.e. forest) between the Ijebus in the forestland, and Oyos in the grassland. According to Falola (2009),

Ibadan emerged around 1830 at a time of political turmoil in Yoruba land and first served as a war camp to these refugees before it grew to a full-fledged town, and later to attain the status of a city-state with the largest population size in Yoruba land.

The Land-mass of Ibadan city extends for about 55km from Asejire in the east to Agemo in the West, and for about 70km from Iroko in the North to Mamu in the South. The growth of Ibadan became more rapid when it was made the Headquarters of the defunct Western Region of Nigeria. According to Ogunsesan (2011), by 1970, it was estimated that Ibadan had developed over a large area approximated to 103.8 square km, while in 1982 it was estimated that the city had then covered an area of about 130.5 square Km. The landscape of Ibadan is dotted with Hills, River valleys and plains. The drainage network of Ibadan Region consists of Rivers and streams. The Rivers are Ona, the Ogunpa and Kudeti River. Others include Ogbere, Gege, Alalubosa, Labo, Olojuoro etc. (see figures 1, 2 and 3). A good proportion of the area lies at heights less than 60 meters above the sea, level while the mean height is 230m. The major rivers that drain these landforms are River Ona, River Ogbere and River Ogunpa. River Kudeti is the major tributary of River Ogunpa and drains the eastern part of the city, while River Ona drained its western part. Other important river tributaries in Ibadan are Alapata, Omi, Oshun, Yemoja, Alalubosa and Orogun among others. The combination of hills and river valleys provide good drainage for Ibadan.

Ibadan city is inhabited by 3,464,000 in 2019 based on the projected population of 2006 National Population Census. Many surrounding villages are not connected by good roads with Ibadan. Public transport services are provided mainly by the private sector, these services are however supplemented by the state government-owned Pacesetter Transport service whose vehicles operates more intercity transportation than intra-city. The city public transport operation is mainly dominated by unconventional public transport modes including taxis, motorcycles, mini-buses, tricycles.

Methods

The resources employed for this study comprises of both primary and secondary sources of data. The primary data was majorly through questionnaire administration and complemented by field observation of traffic situations and traffic control devices identified along principal routes in Ibadan city. This approach, being among the viable primary means of data collection provided the first-hand perspective on the nature and pattern of traffic flow, the challenges of traffic congestion, issues of ITS devices and prospect of ITS-ICT mechanisms to enhancing better traffic flow in the study area. It also gives an insight into the design, operation and condition of existing roads and intersection (at-grade) in the area under review, coupled with the operational characteristics of traffic control lights and other devices installed at vantage spots along observed road corridors. Furthermore, the consultation of relevant and related literature on traffic

congestion, ITS and ICT provided veritable inputs and platform for the study. However, deductions and inferences were objectively and subjectively made based on the two data sources.

Stratified and random sampling was used to administer 400 copies of questionnaire to road users (motorists, cyclists, pedestrians or commuters) along seven route corridors in Ibadan. The routes/corridors are Iwo road/Challenge, Bere/Oje/Iwo road, Bere/Yemetu/UI, UI/Sango/Dugbe, Challenge/Ring Road/Dugbe, Dugbe/Apata and Dugbe/Eleyele. The sample size (400) was extracted from the 2019 population of residents of Ibadan (3,464,000) using Taro Yamane size formula: $n=N/1+N*(e)^2$

Where n= the sample size, N= the population size and e= the acceptable sampling error

However, data collected was analysed descriptively and inferentially (Sum of Mean Weight Value). The administered questionnaire was analysed on a Likert scale with a relative index estimated for statistical tables.

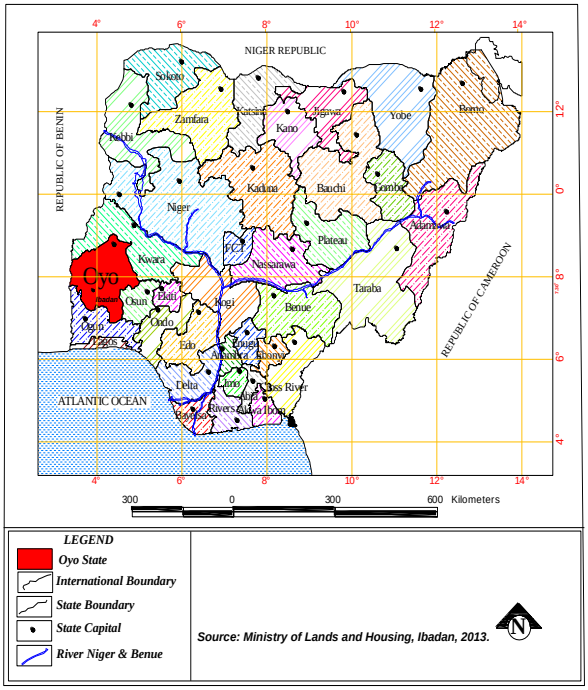

Figure 1. *Oyo State in National Context*

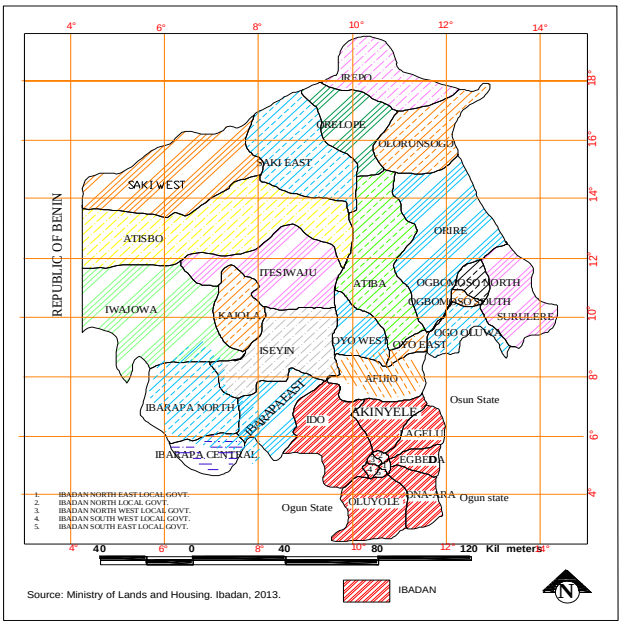

Figure 2. *Ibadan Metropolitan Area in Oyo State*

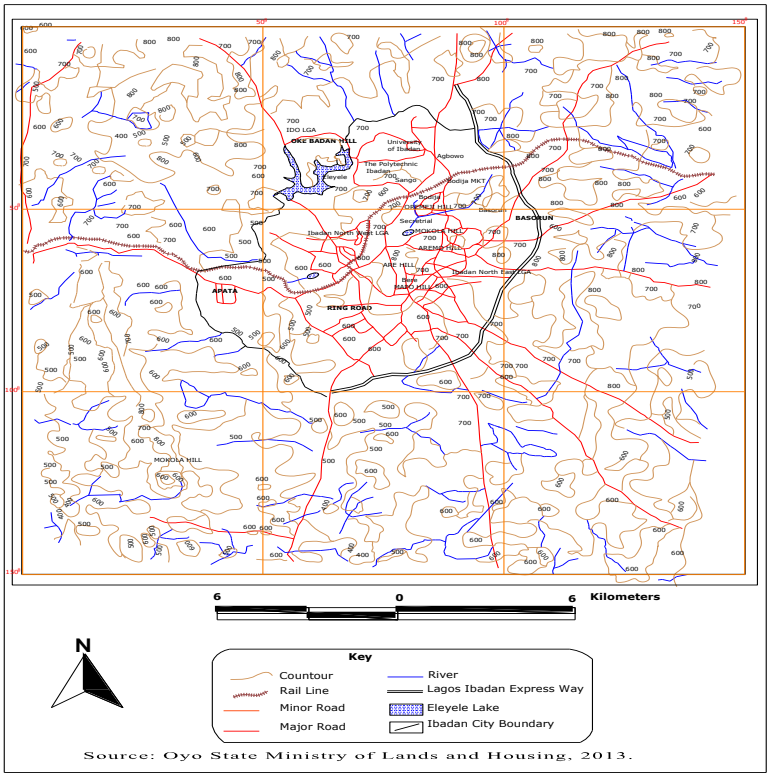

Figure 3. *Relief and Drainage of Ibada*

4. RESULTS AND DISCUSSION

This section presents the results of analysed data on the administered questionnaire to selected motorists/commuters in Ibadan, Nigeria. It gives the outcomes and interpretation of responses on the socio-economic attributes of road users, urban traffic issues in the study area, determinants of traffic challenges and constraints to ICT-based traffic management as well as impact of the proposed ICT-based traffic management in the study area.

4.1. SOCIO-ECONOMIC PROFILE OF ROAD USERS

The significant proportion of respondents in any transport operations related studies is the pedestrians/commuters, as they usually constitute the most vulnerable unit in transport operations particularly in urban areas. Precisely, Table 1 shows that road users are categorized into three in this study in which 50% are pedestrians/commuters, while more than one quarter (27.5%) are motorists, and the remaining 22.5% are cyclists. Accordingly, concerning the socio-economic attributes of road users, their age categorizations consist of 18-30 years (15.0%), 31-40 years (57.0%), 41-50 years (23.75%), 51-60 years (3.25%) and above 60 years (0.5%). This shows that the working-age population constitute a large proportion of the people selected for this study. Also, more than three-quarter of respondents is married (76.25%), 8.75% are single, while divorced constitutes 13.75% and the remaining 1.25% is widow/widower. In the same vein, the educational level of respondents revealed that 105 has no formal education, 6.25% has a primary education, while 21.25% has secondary education and more than half (62.5%) has tertiary education. This denotes a high level of literacy and education among the respondents in this study. There is a low level of car ownership among the respondents. More than three-quarter of respondents has no car of their own, while those with personal car accounts for the remaining 20%. Concerning occupational engagement, it is observed that 7.5% are students, 12.5% engaged in self-employment or personal business, 17.5% is unemployed, while 37.5% are in public service and the remaining 37.5% are in private employment. Correspondingly, data analysed on the average monthly income of respondents revealed that a quarter earns less than #30,000; 37.5% earns #30,000-#70,000 monthly, while 23.75% earns #70,001-#100,000 monthly and the remaining 13.75% earns more than #100,000 monthly. Further, it is observed from Table 1 that the modal choice of respondents are shared by public transport (89%) and private transport (11%) denoting high preference for public transportation by trip makers in the study area. In this regard, respondents make use of paratransit mode of transport in the study areas their preferred means of transport consist of car (10%), minibus (15%), motorcycle (37.5%), tricycle (11.25%), bicycle (1.25%) and taxi (25%).

Table 1. *Socioeconomic Attributes of Road Users*

Category of respondents	Freq.	%	Occupational engagement	Freq.	%
Pedestrians/commuters	200	50	Student	30	7.5

Motorist	110	27.5	Business/ self-employed	50	12.5
Cyclists	90	22.5	Unemployed	70	17.5
	400	100	Public servant	100	25
Age	**Freq.**	**%**	Company / private employee	150	37.5
18 – 30 years	60	15.0		400	100
31 – 40 years	230	57.5	**Average income**	**Freq.**	**%**
41 – 50 years	95	23.75	Less than 30,000	100	25
51 – 60 years	13	3.25	30,000 – 70,000	150	37.5
Above 60 years	2	0.5	70,001 – 100,000	95	23.75
	400	100	Above 100,000	55	13.75
Marital status	**Freq.**	**%**		400	100
Single	35	8.75	**Modal choice**	**Freq.**	**%**
Married	305	76.25	Public	356	89
Divorced	55	13.75	Private	44	11
Widow/ widower	5	1.25		400	100
	400	100	**Preferred means**	**Freq.**	**%**
Educational level	**Freq.**	**%**	Car	40	10
No formal education	40	10	Minibus	60	15
Primary	25	6.25	Motorcycle	150	37.5
Secondary	85	21.25	Tricycle	45	11.25
Tertiary	250	62.5	Bicycle	5	1.25
	400	100	Taxi	100	25
Car ownership	**Freq.**	**%**		400	100
Yes	80	20			
No	320	80			
	400	100			

Source: Authors' survey, November 2019

4.2. URBAN TRAFFIC CHALLENGES IN IBADAN CITY, NIGERIA

The result of fourteen (14) elements of urban traffic issues identified in the study area which were measured on a four-point Likert scale is presented in Table 2 with the use of a relative index. The index is measured on 4 points Liker's scale with gradation values consisting of Very High (VH=4), High (H=3), Low (L=2) and Very Low (VL=1). The index for each of the variables is arrived at by dividing the Summation of Weight Value (SWV) by the total number of responses. According to Olaniyi (2015), the SWV for each of the variables is obtained through the addition of the product of the number of responses to each aspect and the respective weight value attached to each rating. This is expressed mathematically as thus: SWV = $\sum_{i=1}^{5} X_i Y_i$

Where:

SWV = Summation of Weight Value,

X_i = number of respondents to rating i

Yi = the weight assigned a value (i = 1, 2, 3, 4)

Thus, the higher the RMI, the higher the level of effectiveness for the variable under consideration is and this is expressed quantitatively as (and in a subsequent part of this analysis): RMI = $\frac{SWV}{\sum_{i=1}^{4} i = x_i}$

With the estimation having mean index value (MIV) of 3.256, it is observed from the Table 2 that incessant traffic congestion (3.525) is the foremost and leading issue of concern to trip makers in the study area and is closely followed by violation for traffic control devices (3.500) while increasing crime incident and safety threats ranked third with index value of 3.475. Also, peculiar parking difficulties (4.370), environmental pollution (3.418), automobile dependency (3.363), commuting difficulty for non-motorized traffic provision (3.310), unpredictable urban trip pattern (3.275) and unpredictable trip duration (3.265) are among the concern urban traffic issues in the study are adversely affecting the trip makers. However, violation of rod traffic signs (3.033), high fare stutterer (3.015), frequent road traffic crashes/incidences (3.013), high infrastructural maintenance cost (3.000) and poor urban routes connectivity are relatively of less concerned issues to the trip makers considering their index values which are below the relative index value of the analysis.

Table 2. *Urban Traffic Issues in Ibadan City, Nigeria*

S/N	Issues	VH-4	H-3	L-2	VL-1	TWV	RIM	MWV	RK
1	Frequent road traffic crashes/incidences	460	600	120	25	1205	3.013		12
2	Incessant traffic congestion	980	360	70	0	1410	3.525		1
3	Violation of traffic control devices	1000	330	60	10	1400	3.500		2
4	Violation of road design/speed limit	396	714	80	23	1213	3.033		10
5	Unpredictable urban trip pattern	800	420	60	30	1310	3.275		8
6	Increasing crime incident and safety threats	1000	300	80	10	1390	3.475		3
7	Unpredictable trip duration / longer commuting period	848	345	80	33	1306	3.265	3.256	9
8	Peculiar parking difficulties	1000	294	84	10	1388	3.470		4
9	Commuting difficulty for non-motorized traffic provision	848	360	96	20	1324	3.310		7
10	High infrastructural maintenance cost	440	600	140	20	1200	3.000		13
11	High environmental pollution	928	336	100	3	1367	3.418		5
12	High fare stutterer	480	636	60	30	1206	3.015		11
13	Automobile dependency and competition	880	360	90	15	1345	3.363		6
14	Poor urban routes connectivity	368	630	150	23	1171	2.928		14

4.3. DETERMINANTS OF TRAFFIC CHALLENGES IN THE STUDY AREA

In the same vein, fifteen (15) factors identified by respondents to be contributing to traffic challenges in the study area were also analysed on four-point Likert scale and produce mean weight value of 3.098 as presented in Table 3. Precisely, road conditions and unguided street parking are ranked first and second

among the factors with mean index value of 3.488 and 3.465 respectively, while excesses of transport unions (3.432), automobile competition (3.285), excesses of traffic management officers (3.275) inadequate road capacity and connectivity (3.265), excesses of commercial vehicle operators (3.163) and poor vehicle condition (3.110) have values slightly higher than the mean weight value to denote their significant contributions to traffic challenges in the study area. However, other factors which include road discipline, high demand for service, poor timing of traffic control devices, poor road design, spatial impedance and non-spatial impedance are less impactful because their index values are below mean weight value of the analysis.

Table 3. *Determinants of Traffic Challenges in the Study Area*

S/N	Factors	VH-4	H-3	L-2	VL-1	TWV	RIM	MWV	RK
1	Road condition	980	330	80	5	1395	3.488	3.098	1
2	Road discipline	460	630	140	5	1235	3.088		9
3	Vehicle condition	480	636	120	8	1244	3.110		8
4	Excesses of motorist	460	720	80	5	1265	3.163		7
5	Poor road design (entry and exit barriers)	368	630	150	23	1171	2.928		12
6	Inadequate road capacity and connectivity	848	345	80	33	1306	3.265		6
7	Excesses of traffic management officers/police	880	345	40	45	1310	3.275		5
8	Unguided vehicle stops and poor street parking	1000	294	80	12	1386	3.465		2
9	Spatial impedance (weather frequency of stops distance etc.)	460	600	50	60	1170	2.925		13
10	Non-spatial impedance (cultural, legal, political barriers etc.)	320	300	360	40	1020	2.550		14.5
11	High demand for service	440	600	120	30	1190	2.975		10.5
12	Absence of road furniture	320	300	360	40	1020	2.550		14.5
13	Violation / poor timing of electronic traffic control devices	400	630	140	20	1190	2.975		10.5
14	Automobile competition	848	360	76	30	1314	3.285		4
15	Attitude and excesses of the transport union	928	336	104	1	1369	3.423		3

4.4. CONSTRAINTS OF ICT-BASED TRAFFIC MANAGEMENT IN IBADAN CITY, NIGERIA

To improve traffic flow through ICT- based technologies, there is a need to take into consideration the ten constraints identified by trip makers which are analysed through four point's Likert's scale in the study area. The analysis as shown in Table 4 produces mean weight value of 3.085 in which epileptic electricity supply is ranked first with index value of 3.500 and closely followed by poor funding (3.448), absence of reliable traffic data (3.388), poor internet facilities

(3.265) and cost-effectiveness/affordability issue (3.130) in descending order respectively among the significant constraints. However, poor maintenance culture, inadequately trained traffic personnel, policy/regulatory constraints, insufficient infrastructural endowment and indecent road behaviours are less significant because of their index values of relatively below the mean index value of the analysis.

Table 4. *Constraints of ICT-Based Traffic Management in Ibadan City, Nigeria*

S/N	Constraints	VH-4	H-3	L-2	VL-1	TWV	RIM	MWV	RK
1	Epileptic electricity supply	980	330	90	0	1400	3.500		1
2	Absence of reliable traffic data	920	345	70	20	1355	3.388		3
3	Indecent road behaviour / carefree attitude of motorist	148	285	410	69	912	2.280		10
4	Poor maintenance culture of available facilities	460	630	130	10	1230	3.075		6
5	Poor internet facilities	848	345	80	33	1306	3.265	3.085	4
6	Poor funding	940	336	100	3	1379	3.448		2
7	Insufficient infrastructural endowment	300	630	184	3	1117	2.793		9
8	Cost-effectiveness/affordability issue	480	636	136	0	1252	3.130		5
9	Policy and regulatory constraints	340	606	210	18	1174	2.935		8
10	Inadequate trained personnel/shortage of operators skills	484	600	106	26	1216	3.040		7

These constraints to the adoption of ICT applications in Nigerian urban transport system hinders not only the efficiency and effectiveness of traffic flow but also affects the sustainability of urban transport operations which are the sine qua non to the development and sustainability of cities.

Epileptic electricity supply: Smart transport functions effectively in the environment endowed with constant public power supply. The success recorded in the improved Ghana traffic control practices is attributed to the integration of her intra-city traffic control to electronic road signal that is anchored on consistent and uninterrupted electricity supply (Akanmu, 2012).

Absence of reliable traffic data collecting devices: Traffic counts devices to collect data for all critical periods such as morning peak, midday peak, evening peak, Saturday midday peak, Sunday evening peak and late evening among others as well for formulation traffic management measures are grossly lacking on most intra-and-inter-city roads within the country (Salisu, 2019). The manually used method of traffic count which is perhaps the most commonly used is unreliable and poorly conducted and documented for further use. More so, various levels of government and the local government, in particular, are yet to realize the importance of collecting and analysing traffic data before making decisions relating to the transport system. Hence, ICT based traffic management is mostly a product of data collection, analysis and prediction for optimal performance.

Indecent road behaviour: Road indiscipline, vandalisation and high rate of misuse of transport infrastructure are constraints to effective applications of ICT based transport management in most Nigerian urban centres and Ibadan in

particular. This is compounded by weak regulatory and enforcement structures for violators of traffic regulations in the country.

Maintenance: The persistent deterioration of road surfaces and other associated facilities in Nigerian urban centres is attributed to their poor, irregular and inconsistent maintenance in addition to their substandard construction.

Poor/weak internet facility: Efficient ICT-based transport management relies seriously on uninterrupted internet facility and other satellite-based technologies. Realizing this fact, Government of Singapore, strategized to have an all-fibre network and the next generation Nationwide Broadband Network (NBN) that will deliver ultra-higher broadband access speeds of 1 Gbps and more throughout the nation by 2015 (Shimizu et al, 2014). However, poor, weak internet facility and fluctuating internet facility that characterized most internet service providers in the country shall also be a constraint to full embracement of this concept for efficient service delivery in the country.

Political will: Strong political will of city administrators to invest financially, legislatively humanly and technologically in transport development and management generally is a major pre-requisite for ICT enabling traffic management that will usher inefficient service delivery in any nation. Supporting this notion, Shimizu et al (2014) believed that Singapore government proactively promotes the use of ICT to improve efficiency service delivery by invested heavily in building ICT infrastructure worth $83 billion in 2011.

4.5. PROSPECT OF ICT-BASED TRAFFIC MANAGEMENT IN THE STUDY AREA

The result of the evaluation of the impacts of the prospect of ICT-based traffic management in the study area through the four-point Likert's scale with gradation values consisting of Strongly Agree (SA=4), Agree (A=3), Disagree (D=2) and Strongly disagree (SD=1) is presented in Table 5. Likewise, the index for each of the variables is arrived at by dividing the Summation of Weight Value (SWV) by the total number of responses, while the SWV for each of the variables is obtained through the addition of the product of the number of responses to each aspect and the respective weight value attached to each rating expressed mathematically as SWV = $\sum_{i=1}^{5} X_i Y_i$

Where:

SWV = Summation of Weight Value,

X_i = number of respondents to rating i

Yi = the weight assigned a value (i = 1, 2, 3, 4)

Thus, the higher the RMI, the higher the level of effectiveness for the variable under consideration is and this is expressed quantitatively as (and in a subsequent part of this analysis): RMI = $\frac{SWV}{\sum_{i=1}^{4} i = X_i}$

The analysis produces mean index value (MIV) of 3.114 in which improved traffic management system received the outstanding rank of first (3.513),

while congestion reduction is ranked second with an index value of 3.500. Also, respondents strongly agree with improved traffic safety (3.455), sustainable transport (3.265), reduced traffic crash (3.160) and improved route accessibility. However, others such as improved city sustainability, maximization of capacity utilization, efficient service delivery, improved urban mobility, improved spatial arrangement and enhance traffic flow has to be thoroughly examined to ease the commuting challenges of residents in the study area.

Table 5. *Prospect of ICT-Based Traffic Management in the Study Area*

S/N	Impact	SA-4	A-3	D-2	SD-1	TWV	RIM	MWV	RK
1	Improved route accessibility and connectivity	460	630	130	10	1230	3.075	3.114	6
2	Improved traffic safety	940	336	106	0	1382	3.455		3
3	Improved urban mobility	360	600	184	18	1162	2.905		10
4	Efficient service delivery and parking management	340	606	210	8	1164	2.910		9
5	Sustainable transport / traffic operation	848	345	80	33	1306	3.265		4
6	Improved traffic management system	980	345	80	0	1405	3.513		1
7	Maximized capacity utilization of infrastructural facilities	360	636	150	23	1169	2.923		8
8	Improved city sustainability	380	630	184	3	1197	2.993		7
9	Reduced traffic crashes/incidents	368	780	116	0	1264	3.160		5
10	Improved spatial arrangement/organization	320	600	220	10	1150	2.875		11
11	Improved traffic information	1000	60	60	0	1120	2.800		12
12	Reduced congestion index	1000	360	20	20	1400	3.500		2

Improved safety: The ICT innovations in the transport system no doubt improve safety and security and significantly, most effective in fatality reduction. The literature gives an estimated reduction rate of ICT contributions in fatalities reduction up to 30% and 40% and even 60% by particular types of Advanced Drivers' Assistance System along some particular sections of road networks in some developed economy including United States of America, United Kingdom (Gueeinzen, 2009).

Improved Urban Mobility Index: The urban mobility index determines how good or bad mass transportation is in a particular city (Little, 2014). The index assessed the mobility maturity and performance of 84 cities worldwide with the global average score of 43.9 points of which Africa and the Middle East are the lowest-performing regions with average point totals of 37.1 and 34.1 respectively. However, Lagos is only Nigerian city selected and ranked 72nd with 37.1 points, while Ibadan and other major cities and state capitals in the country are lacking in the selection and ranking. Thus, using ICT-based traffic management will enhance the mobility status of Ibadan and other urban centres in the country.

Efficient Service Delivery: The efficient delivery of goods and services with the achievement of just-in-time and just-in-place for all movements which facilitate socio-economic activities is another benefit of using ICT for transportation. With this, growth and development in all spheres of social, industrial and the economy will be achieved.

Maximize the capacity of the infrastructure: The use of ICT in transport management shall maximize the capacity of the infrastructure, and make various improvements in the urban transport infrastructure (such as new roads, highways and bridges among others) perform effectively,

Sustainable Transport System Operations and Management: ICT innovations in the transport system are possible ways of accomplishing the outcome of sustainability, reducing excessive driving (through signalization, navigation system (through the use of GPS, GIS and mobile communication) as well as providing better strategies for improving and keeping up to date information, measures and strategies for efficient traffic and transport management in cities.

5. CONCLUSION AND RECOMMENDATIONS

Considering the various issues guiding smart transport, it is not an overstatement that Nigeria partially or wholly practices traffic control based on discretion, political goal and mostly for revenue drives but with less concern on effectiveness and efficiency of traffic control and management mechanisms in cities including the study area. This is because of the current practices in most Nigeria urban centres (except for Lagos) devoid of the scientific doctrines and principles that could facilitate efficient service delivery. The high rate of delays, traffic congestions, frustrations, traffic rules violations and road accidents on Nigerian urban roads attested to this.

Therefore, realizing the efficacy of transport as a connector and basis for all activities, disciplines and practices is of utmost importance to efficient service delivery in the country. Importantly, embracing the underlying issues and removing constraints to ICT-based traffic management in the country is the panacea for benefiting the numerous prospects ICT-based traffic management as achieved in the developed world if well introduced, implemented and monitored. Based on the study findings, the stakeholders of the transport sector most especially the government who are in charge of the provision and management of transport infrastructural facilities, services and operational arrangement should adequately integration of ITS/ICT mechanisms to the urban transport system in Ibadan city and cities with similar issues towards enhancing efficient and effective performance of transport infrastructural facilities and services delivery as well as improving the socio-economic affluence of the city and reaping the all associated benefits it brings including the growth, development, and sustainability of man.

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