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Impact of information and communication technology on traffic management in Kaduna metropolis, Kaduna State

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Abstract
This study used control analysis for research design to focus on the impact of Information Communication Technology on Traffic Management in Kaduna metropolis. Primary data was collected from respondents in the study area through well-structured questionnaires and personal interviews. 100 questionnaires were distributed, and the collected data were analysed using descriptive statistics. The result of the study revealed that most of the road crashes recorded are traceable to drivers' errors. The findings also found that records of traffic offenders, easy monitoring and surveillance, managing the road network, and improved traffic safety are all impacted by CCTV and traffic lights on the traffic management system in the study area. The study therefore concluded that Kaduna State Traffic and Environmental Law Enforcement Agency (KASTELEA) and the Police in charge of road traffic management hardly make use of technology in traffic management, and this reduces operational efficiency and poses a challenge. The study recommended that the Kaduna State government should sponsor special training in abroad for traffic management worker like KASTELEA, Police and some FRSC on the use of technologies like Video Detection System, CCTV and traffic light and inductive loop detector, and also partner with Corporate body to establish committee of Engineers for Repairs of existing CCTV and traffic light along major junctions in Kaduna Metropolis.
Keywords: Inductive Loop, information technology, Kaduna metropolis, traffic management, video detector

1. Introduction

Globally, Information Communication Technology (ICT) has brought changes as it is applicable to any facet of the society as it played vital roles in traffic management. Such technology like Traffic Light, CCTV camera, Intelligent Transport Systems (ITS) are necessary tools in ensuring smart metropolitan in many developed countries (Tran et al., 2023; Ouallane et al., 2022; Telang et al., 2021). This aid is to reduce traffic congestion, which has hampered business activities for population of road users across the globe. The traffic gridlock coupled with the environmental hazard accrued (Saches, 2023; Senecal; & Leach, 2021; Wen et al., 2019).

Most developed countries like the US, France, Britain, and China use a technologically integrated traffic management solution to control traffic. Sensors and mobile applications were developed to monitor traffic. This provides road users with real-time traffic information through their mobile phone and also suggests alternative routes. Also, the use of video surveillance devices has successfully reduced the road traffic gridlock and offenders (Al-Turjman, & Lemayian, 2020; Salisu et al., 2020; Shepelev et al., 2020).

However, while the developed countries embrace ICT that assisted in minimizing the traffic gridlock on major roads, ICT has also assist the work of traffic controller to get acquainted with technology measures, most developing countries of Africa are not well acquainted with ICT in traffic management system which will be a useful tool in control of traffic (Onu, & Mbohwa, 2021; Quaye, et al., 2022).

For example, in Addis Ababa, Ethiopia, traffic issues persist as ICT has not been sustained by traffic management institutions to ensure safe access to stations, safe vehicle movements under viaducts, and safe pedestrian track crossings (Barma et al., 2024).

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This is applicable to Nigeria as ICT has not yet been sustained in the management of traffic across many cities and states. This has created a problem as the economy and population continue to grow, the number of vehicles plying the roads and highways continues to increase in volume and intensity. Also, traffic congestion and complementary adverse consequences continue to escalate with far-reaching implications and resultant effects in society (Gbadamosi & Akanmu, 2019).

Kaduna State traffic management has adopted approaches in order to minimise traffic issues in Kaduna metropolis by building facilities like roads, bridges and viaducts. Using traffic lights as a measure to control traffic flow has resulted in causing delays for road users, which increases the transportation cost, including carbon (II) oxide emissions (Al-Turaki, et al., 2020).

Over time, road traffic has caused fatal road crashes, traffic gridlocks, and unfriendly environmental challenges, which could be mitigated by the adoption of ICT in traffic management in Kaduna metropolis. Non-application of ICT increases poor traffic management, leading to traffic congestion. Coupled with interacting vehicles, low traffic throughput occurs when volumes approach capacity, at which both the vehicles go slow (Geenhuizen, 2019). Insufficient traffic management systems have posed a great challenge to national development in the state. It affects both motorists and road users, as well as reducing economic efficiency (Onokala & Olajide, 2020).

In Kaduna metropolis, despite the laudable efforts by traffic management agency like Federal Road Safety Corporation (FRSC) and other State institution in charge of traffic management, traffic has been worsening and the measures put in place are not enough, like the traditional traffic control measures including road capacity expansion, overpass and underpass construction, ring road and traffic signals in addition to the human manual control through the statutory agencies, have not achieved desired results of ensuring a free flow of traffic (Salisu et al., 2020). Therefore, this study focuses on the assessment of Information Communication Technology on Traffic Management in Kaduna Metropolis.

2. Literature review

2.1 Conceptual Framework

The study brings to fore the conceptual definitions of the variables in line with the research purpose. These concepts are discussed below;

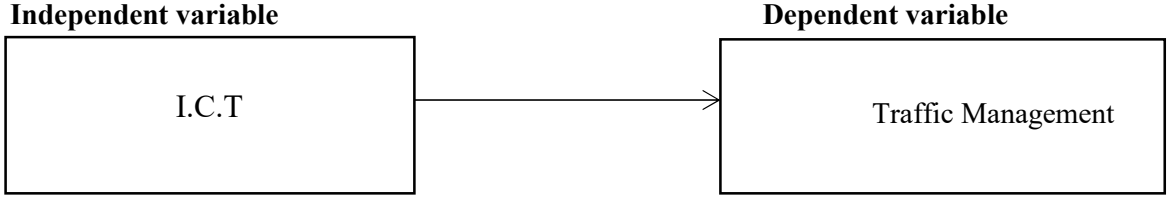

Figure 1. Variables of the Study

2.2 Information Communication Technology

ICT is an acronyms that epitomize information, communication and technology. To understand the meaning of ICT, it would be important to discuss each of its elements (Lloyd, 2020). Information is a processed data capable of changing human perspectives and opinions about a particular state of matter. Whereas, Information Technology has made significant contributions in creating, keeping, recapturing, confiding, and disseminating information (Poster, 2020).

Again, Information can also be seen as the obtaining, advancement, holding, and spreading of messages or ideas by means of computers and telecommunication gadgets. An Information technology system is made up of hardware, software technologies, semiconductors, web browsers and servers, multimedia systems, open microprocessor systems, High Performance Computing and Networking (HPCN) technologies, photonic technologies and digital multimedia services (Englander & Wong, 2021).

2.3 Traffic Management System

Lee, et al. (2020) assert that a traffic management system can be controlled manually or by the use of automated machine. Manual Traffic Management (MTM) is a system where a Traffic Police officer performs scheduling using intuition based on the current situation of the road to control traffic (Nama et al., 2021; Nigam et al., 2023). In automated traffic management, a traffic light control system performs the scheduling in static or dynamic mode. The effectiveness of traffic of traffic flow management is measured in terms waiting times, travel times, level of service and number of accidents.

2.4 Video Detection System and Traffic Management

Yue, et al. (2021) developed for Shanghai, a traffic monitoring and estimation system using Virtual Sensor Networks (VSNs). They proposed two methods: circuit patrol and greedy patrol control algorithms to improve the performance of Matrix Completion (MC) based traffic monitoring. Simulation results have shown that the proposed algorithms reduced the traffic estimation error from 35% to 10% compared with the random patrol method. Vehicle-to-vehicle communication also helps in reducing traffic congestion (Pavithra et al., 2023).

2.5 CCTV and Traffic Light on Traffic Management

Gomides et al. (2022) presented a congestion avoidance model for traffic control over a vehicular ad-hoc network created between the sensors and cars in traffic. The road side wireless equipment (also called Wireless Traffic Lights, WTLs) collects the data from cars in different road segments and accumulates it to form a road map and its costs. They evaluated the proposed model using a VN-Sims simulator. Their evaluation results showed that the average time desired for the vehicle to reach its endpoint recorded a significant decrease of up to 40%.

3. Methodology

3.1 Population and Sample Size of the Study

The Kaduna Metropolis population in 2023 is 1,187,000, a 2.5% increase from 2022. Also, other institutions in charge of traffic management are assessed. Population staff of FRSC and KASTELEA deployed in Kaduna metropolis is approximately 620. The Yamane's Formula is adopted to determine the sample size of the study as stated below. Population staff of FRSC and KASTELEA in Kaduna Metropolis: 620

$$n = \frac{\mathrm{N}}{1+N(e)^2}$$

Where n = Sample Size

N = Size of the Population

e = Significance level (at 10%)

$$\mathrm{N} = \frac{\mathrm{N}}{1+\mathrm{N}\,(\mathrm{e})^2}$$

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$$n = \frac{620}{1+620\,(0.10)^2} \qquad \mathbf{n = 100}$$

Thus, the sample size used for this study is 100 people selected from Road Safety and KASTELEA workers in Kaduna metropolis. Primary data obtained through administration of well-structured questionnaires. Descriptive statistics model including frequency distribution and cumulative percentage was adopted to analyse the primary data collected.

4. Results and Discussion

Questionnaire was administered in order to sample the opinion of the respondents. 100 questionnaires were administered, only 97 responses was retrieved. This represents 97.5 percent response which is considered acceptable for this study.

4.1 Professional Classification of Traffic Management Worker

Table 1. Professional Classification of Traffic Management Worker in Kaduna Metropolis

Serial	Responses	Frequency	Percentage
1.	Police Yellow Fever	9	9.2
2.	KASTELEA	37	38.1
3.	FRSC	29	29.9
4	Others	22	22.7
4.	Total	97	99.9

Source: Research Survey (2025).

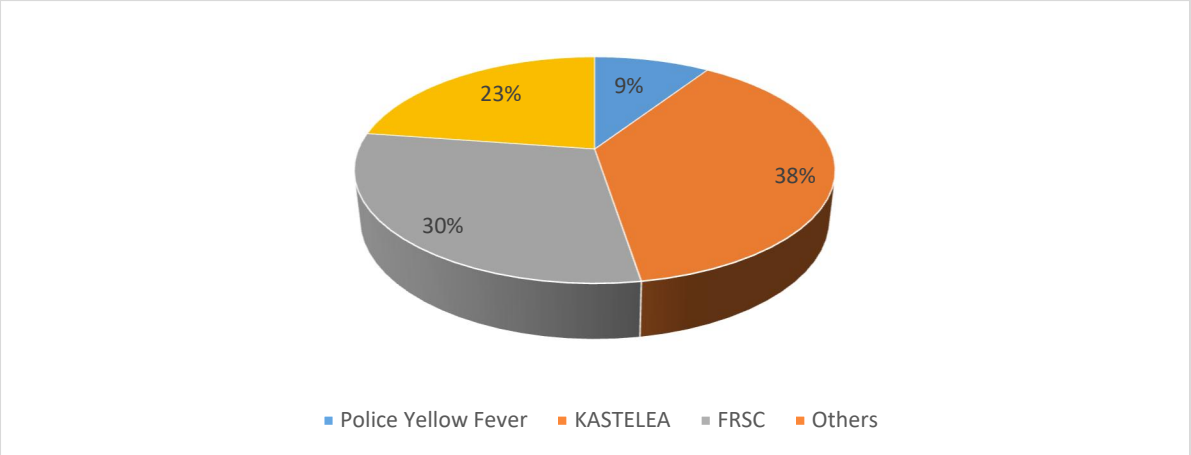

Figure 2. Professional Classification of Traffic Management Worker in Kaduna Metropolis

Table 1 above indicate that 9.2 percent of the respondents are Police Yellow Fever, while 38.1 percent of the respondents are KASTELEA workers. Furthermore, 29.9 percent of the respondents are FRSC staff. Moreover, 22.7 percent of the respondents are other traffic management workers. Therefore, most of the respondents are KASTELEA workers.

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4.2 Effect of Video Detection System and Traffic Management System in Kaduna Metropolis

Table 2. Response to Effect of Video Detection System on Traffic Management System in Kaduna Metropolis

Serial	Response	Frequency	Percentage %
1	Reduce traffic congestion	24	24.7
2	Reduce rate of accident	18	18.5
3	Efficient service delivery	13	13.4
4	Improve human capacity	11	11.3
5	All of the above	31	31.9
	Total	97	99.9

Source: Research Survey (2025).

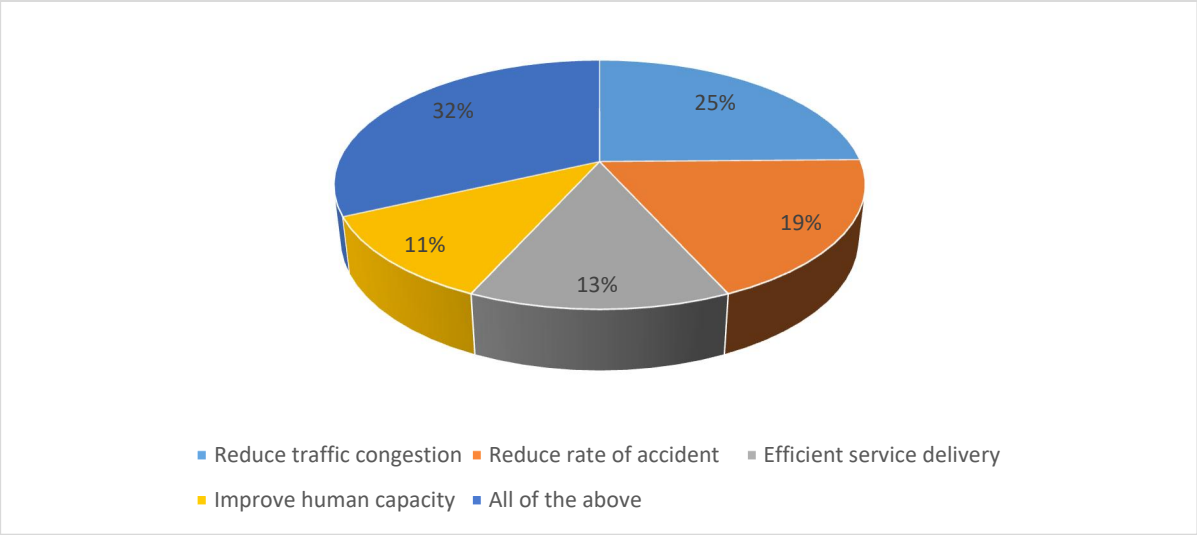

Figure 3. Effect of Video Detection System on Traffic Management System in Kaduna Metropolis

Table 2 above showcase that 24.7 percent of the respondents agreed that reduce traffic congestion are effect of video detection system on traffic management system in Kaduna metropolis. While, 18.5 percent of the respondents posit that reduce rate of accident are effect of video detection system on traffic management system in Kaduna metropolis. Also, 13.4 percent of the respondent said that efficient service delivery are effect of video detection system on traffic management system in Kaduna metropolis. However, 11.1 percent of the respondent opined improve human capacity are effect of video detection system on traffic management system in Kaduna metropolis. Furthermore, 31.9 percent of the respondent agreed that all the above mentioned are effect of video detection system on traffic management system in Kaduna metropolis. Therefore, majority agreed that reduce traffic congestion, reduce rate of accident, efficient service delivery and improve human capacity are effects of video detection system on traffic management system in Kaduna metropolis.

4.3 Impact of CCTV and Traffic Light on Traffic Management System in Kaduna Metropolis

Table 3. Impact of CCTV and Traffic Light on Traffic Management System in Kaduna Metropolis

Serial	Response	Frequency	Percentage %
1	Records of traffic offenders	31	31.9
2	Easy monitoring and surveillance	28	28.9
3	Manage road network	14	14.4
4	Improved traffic safety	24	24.7

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	Total	97	99.9

Source: Research Survey (2025).

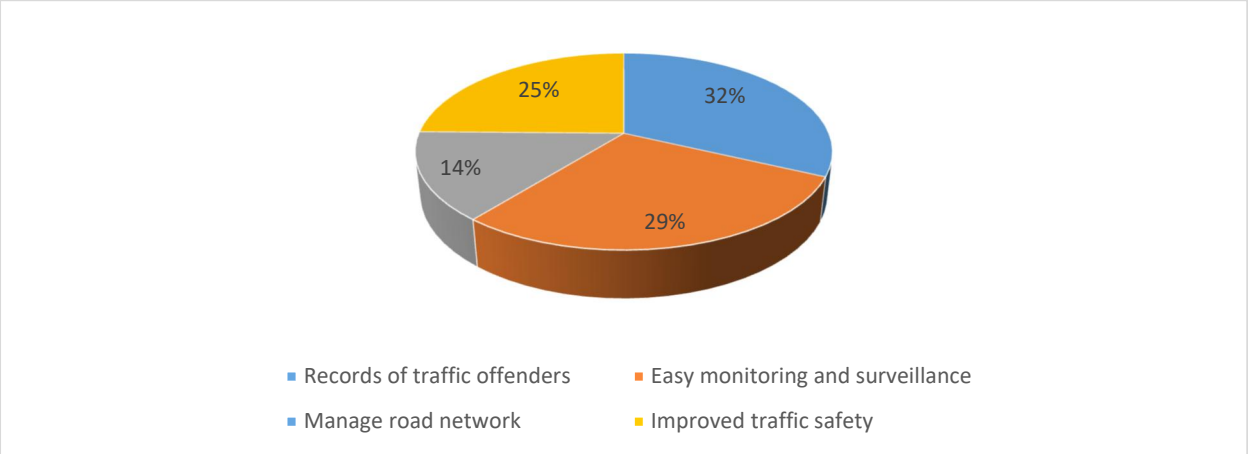

Figure 4. Showing Impact of CCTV and Traffic Light on Traffic Management System in Kaduna Metropolis

Table 3 above observed that 31 percent of the respondents agreed that records of traffic offenders is an impact of CCTV and traffic light on traffic management system in Kaduna Metropolis. While 28.9 percent of the respondent are of the opinion that easy monitoring and surveillance is an impact of CCTV and traffic light on traffic management system in Kaduna Metropolis. However, 14.4 percent of the respondents obliged that manage road safety is an impact of CCTV and traffic light on traffic management system in Kaduna Metropolis. Moreover, 24.7 percent of the respondents averred that improved traffic safety is an impact of CCTV and traffic light on traffic management system in Kaduna Metropolis. Therefore, records of traffic offenders, easy monitoring and surveillance, manage road network and improved traffic safety are all impact of CCTV and traffic light on traffic management system in Kaduna Metropolis but much emphasis is centred on records of traffic offenders.

Table 4. Response to determine effect of Inductive Loop Detector on Traffic Management System in Kaduna Metropolis

Serial	Response	Frequency	Percentage %
1	Insensitive to weather condition	19	19.6
2	Provides best accuracy	15	15.5
3	High frequency in classifying traffic data	12	12.4
4	Flexible design for applications	9	9.2
5	All of the above	42	43.2
	Total	97	99.9

Source: Research Survey (2025).

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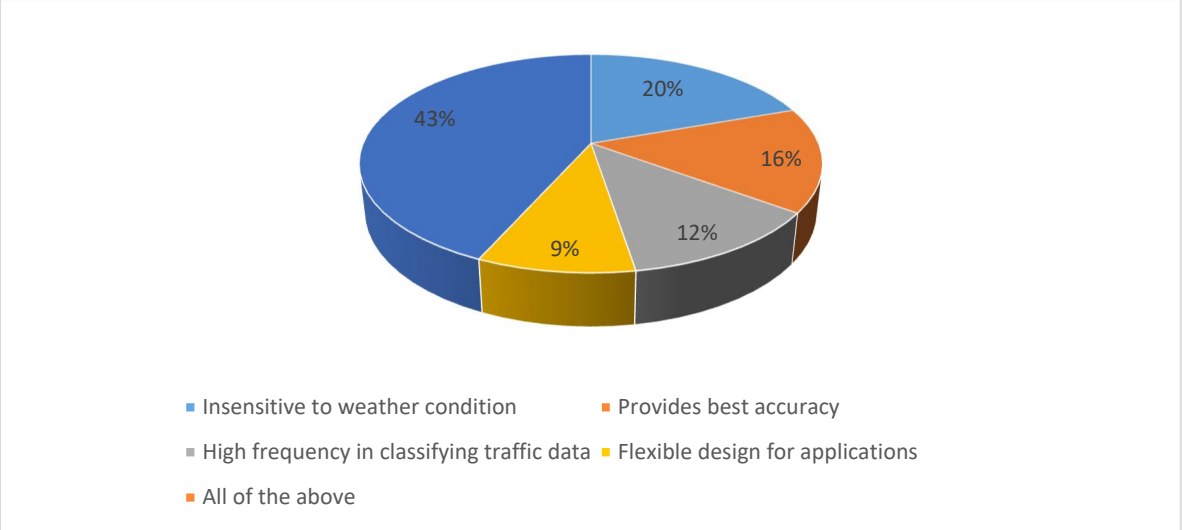

Figure 5. Showing Effect of Inductive Loop Detector on Traffic Management System in Kaduna Metropolis.

Table 4 above showcase that 19.6 percent of the respondents agreed that insensitive to weather condition is an effect of inductive loop detector on traffic management system in Kaduna metropolis. While, 15.5 percent of the respondents posit that provides best accuracy is an effect of inductive loop detector on traffic management system in Kaduna metropolis. Also, 12.4 percent of the respondent said that high frequency in classifying traffic data is an effect of inductive loop detector on traffic management system in Kaduna metropolis. However, 9.2 percent of the respondent opined that flexible design for application is an effect of inductive loop detector on traffic management system in Kaduna metropolis. Furthermore, 43.2 percent of the respondent agreed that all the above mentioned are effect of inductive loop detector on traffic management system in Kaduna metropolis. Thus, it is observed that insensitive to weather condition, provides best accuracy, high frequency in classifying traffic data and flexible design for application are effect of inductive loop detector on traffic management system in Kaduna metropolis

4.2.3 Major Constraint Faced by Traffic Management System in use of Information Communication Technology in Kaduna Metropolis

Table 5. Major constraint faced by Traffic Management System in Use of Information Communication Technology in Kaduna Metropolis

Serial	Response	Frequency	Percentage %
1	Insufficient Funds	14	14.4
2	Unstable power supply	22	22.6
3	Weak internet facility	19	19.6
4	Non-availability of reliable traffic data	11	11.3
5	All of the Above	31	31.9
	Total	**97**	**99.9**

Source: Research Survey (2025).

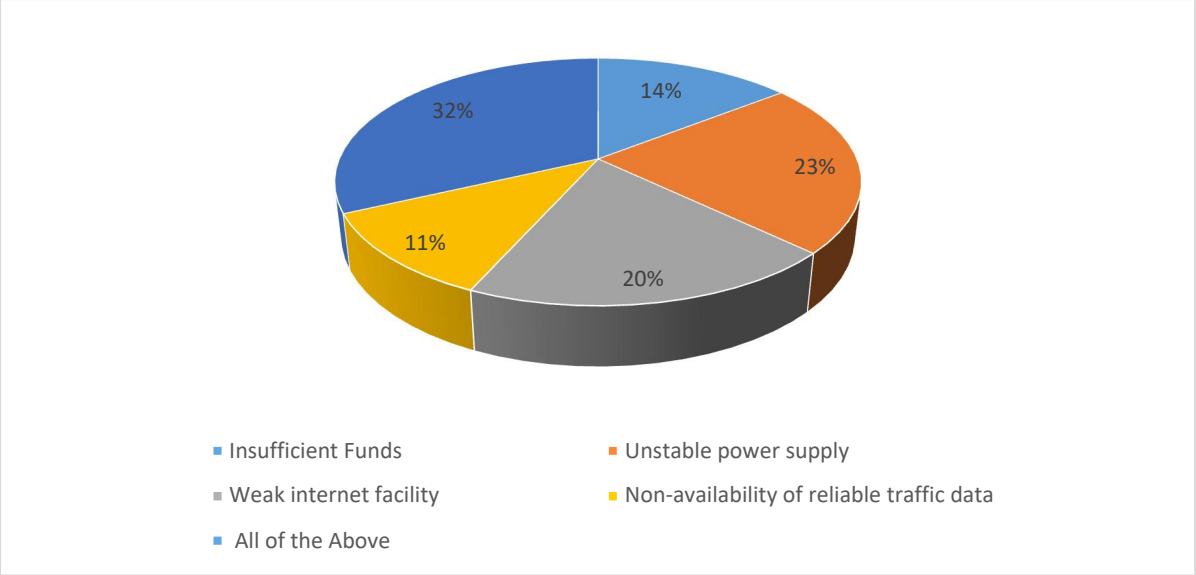

Figure 6. Showing major constraint faced by Traffic Management System in Use of Information Communication Technology in Kaduna Metropolis.

Table 5 above indicated that 14.4 percent of the respondent agreed that insufficient funds are major constraint faced by traffic management system in use of information communication technology in Kaduna Metropolis. While 22.6 percent agreed that unstable power supply are major constraint faced by traffic management system in use of information communication technology in Kaduna Metropolis. However, 19.6 percent agreed that weak internet facility are major constraint faced by traffic management system in use of information communication technology in Kaduna Metropolis. Moreover, 11.3 percent of the respondent agreed that non-availability of reliable traffic data are major constraint faced by traffic management system in use of information communication technology in Kaduna Metropolis Above all, 31.9 percent of the respondent agreed that all of the above mentioned are major constraint faced by traffic management system in use of information communication technology in Kaduna Metropolis. Therefore, from the respondent opinion, insufficient funds, unstable power supply, weak internet facility and non-availability of reliable traffic data are major constraint faced by traffic management system in use of information communication technology in Kaduna Metropolis.

4.2.4 Alternatives to Improve Information Communication Technology and Enhance Traffic Management System in Kaduna Metropolis

Table 6. Alternatives to Improve Information Communication Technology and Enhance Traffic Management System in Kaduna Metropolis

Serial	Response	Frequenc	Percentage %
1	Adequate Funding	13	13.4
2	Stable power supply	22	22.6
3	Establish traffic information centres	16	16.5
4	Transparency and accountability in Management	18	18.5
5	All of the Above	28	28.9
	Total	97	99.9

Source: Research Survey (2025).

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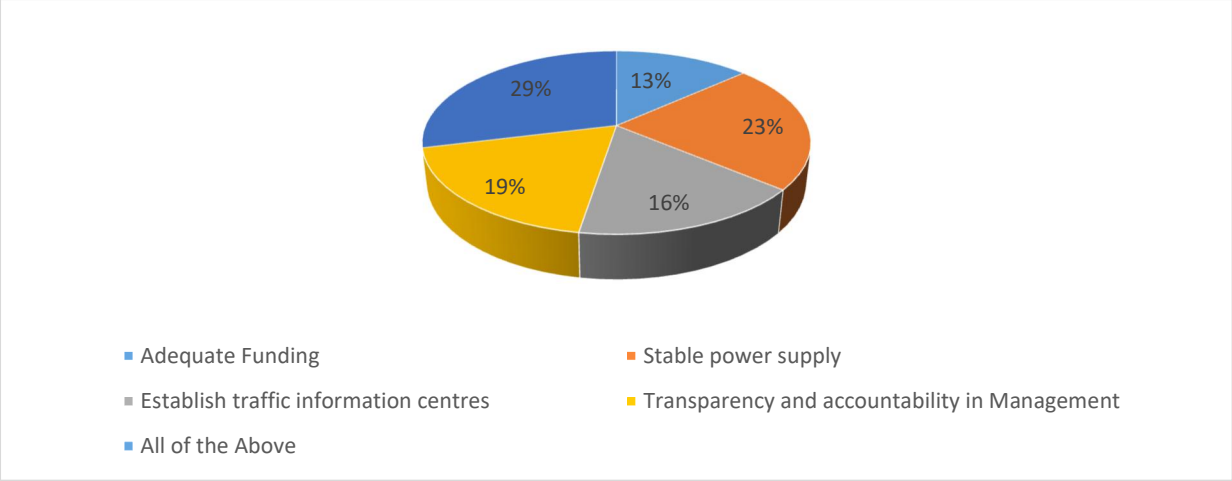

Figure 7. Showing alternatives to Improve Information Communication Technology and Enhance Traffic Management System in Kaduna Metropolis

Table 6 indicated that 13.4 percent of the respondent said that adequate funding is alternative to improve information communication technology for enhance traffic management system in Kaduna metropolis. However, 22.6 percent of the respondents agreed that stable power supply is an alternative to make information communication technology efficient for enhance traffic management system in Kaduna metropolis. While, 16.5 percent of the respondents agree that establish traffic information centres is alternative to improve information communication technology for enhance traffic management system in Kaduna metropolis. Moreover, 18.5 percent of the respondents said that transparency and accountability in management is alternative to improve information communication technology for enhance traffic management system in Kaduna metropolis. Above all, 28.9 percent of the respondents agree that all the aforementioned are alternative to improve information communication technology for enhance traffic management system in Kaduna metropolis. Therefore, majority of the respondents agreed that adequate funding, stable power supply, establishing traffic information centres, transparency, and accountability in management are alternatives to improve information communication technology to enhance the traffic management system in Kaduna metropolis.

5. Conclusion

The adoption of technology in traffic management techniques and measures is necessary to control traffic in the Kaduna metropolis. Such technologies include video detection systems, CCTV, traffic lights, inductive loop detectors, and Intelligent Transport Systems (ITS). The study, however, opined that to reduce traffic congestion, the rate of accident occurrence, and improve service delivery and human capacity, the effects of the video detection system on the traffic management system in Kaduna metropolis should be considered. The video detection system enables vehicles to establish interconnected networks that facilitate communication to enhance driver safety, support improved monitoring by Traffic Control Centres (TCCs), and ease traffic congestion through the delivery of real-time traffic updates to drivers. The Kaduna State Traffic and Environmental Law Enforcement Agency (KASTELEA) and the traffic Police officers, which are in charge of road traffic management, hardly make use of technology in traffic management, and this reduces operational efficiency and poses a challenge. The persistent traffic congestion in Kaduna metropolis undermines the importance of traffic institutions and national growth in numerous dimensions. The study recommended that the Kaduna State government should sponsor special training abroad for traffic management workers, such as KASTELEA, the traffic Police officers, and some FRSC personnel, on the use of technologies like

video detection systems, CCTV, traffic lights, and inductive loop detectors. It also suggested partnering with corporate bodies to establish a committee of engineers for the repair of existing CCTV and traffic lights along major junctions in Kaduna metropolis.

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