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Assessment of Road users' Perception of the Challenges of Intelligent transport system adoption in Minna metropolis, Nigeria

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Abstract

The integration of Intelligent Transport Systems (ITS) into public transportation across African cities particularly in Minna, Nigeria has remained limited, despite global advancements in autonomous vehicle technologies. This study investigates the barriers to ITS adoption in Minna, employing a survey research design. The target population consisted of vehicle owners and operators traversing major road intersections within Minna metropolis. Utilizing Taro Yamane's sample size determination formula, 383 structured questionnaires were administered. Descriptive statistics were used to analyze the collected data, while Principal Component Analysis (PCA) via SPSS Version 21 was employed to identify the predominant challenges impeding ITS implementation. Findings revealed that the absence or inadequacy of government policies supporting ITS adoption (53.25%), low public awareness of ITS benefits (20.62%), and financial constraints (12.09%) constitute the primary impediments to ITS integration in Minna. The study concludes that addressing these barriers through targeted policy development, increased stakeholder engagement, and robust public awareness campaigns is critical to fostering ITS adoption. It recommends that policymakers prioritize the formulation of ITS-specific policies, and that governmental agencies actively promote the benefits of ITS to the general public.

Keywords: Intelligent Transport Systems, financial constraints, vehicle owners/operators, personnel competence, Minna metropolis.

1 INTRODUCTION

Road transport externalities have been increasing in recent years due to the rise in vehicle ownership and operations in urban areas. Traffic congestion, road traffic accidents, and environmental pollution are some of the transport externalities that have been affecting urban mobility. In order to reduce these excesses, Intelligent Transport Systems (ITS) were introduced. According to Papadimitratos *et al*. (2009), an Intelligent Transport System (ITS) is an emerging concept in transportation that integrates real-time information and enables communication between vehicles and transport infrastructure. The goal of ITS is to improve road safety, enhance mobility, and reduce the environmental impacts of transportation (Yanginlar, 2024). Other applications of ITS include electronic toll collection, highway data collection, traffic signal control, and emergency vehicle notification (Jun *et al*., 2011; Lee *et al*., 2008).

Over time, the acceptance of Intelligent Transport Systems (ITS) has been growing among high-income countries such as the USA, Japan, China, and nations in Europe (Camacho *et al*., 2018). In contrast, low-income countries particularly Nigeria are yet to widely embrace these technologies in their public transport systems due to poor economic development (World Bank, 2018). Although megacities in Nigeria like Lagos, Abuja, and Port Harcourt have adopted this technology, it is primarily used within estates to provide security and regulate vehicle entry and exit. Minna is one of the cities in Nigeria yet to fully integrate ITS into its public transport system. The former governor of Niger State, Abubakar Sani Bello, was an advocate of ITS usage in Minna; in 2022, he introduced CCTV cameras at major road intersections across the city.

However, since his tenure ended and His Excellency Umar Mohammed Bago succeeded him, the city has not witnessed further development in ITS adoption.

Several factors may be responsible for the slow adoption and acceptance of ITS in Minna. Recent studies have identified issues such as compatibility, rapidly changing technology, financial constraints, privacy concerns, and national culture as global challenges to ITS adoption (Diderot *et al*., 2023; Ravish & Swamy, 2021). Additionally, the lack of policies on ITS deployment, low awareness of its benefits, technical problems, and a shortage of competent personnel remain common barriers both globally and in Minna. It is against this backdrop that the present study utilizes a survey research design to examine vehicle owners' and operators' perception of the challenges hindering ITS adoption in Minna metropolis. The study relies on

Principal Component Analysis (PCA) to identify the key factors preventing the effective implementation of ITS.

2. LITERATURE REVIEW

2.1 Theoretical review

T he theory of Diffusion of Innovation (DOI) underpins the present study. The theory was introduced by Everett M. Rogers in 1962 in his book titled Diffusion of Innovation. According to the theory, the adoption of new ideas, concepts, and technologies is typically slow within any social system. The theory explains how, why, and how quickly new ideas and technologies diffuse across cultural barriers. It posits that, in order to adopt new technology or innovation within any social group, there must be adequate knowledge of the technology, followed by persuasion, decision-making, implementation, and confirmation.

Additionally, the theory categorizes adopters of new ideas into five groups: innovators, early adopters, early majority, late majority, and laggards (Fichman, 2018).

In the context of this study, ITS adoption is influenced by road users' knowledge of the technology, ease of use, and the flexibility of the technology. However, the theory has been criticized for oversimplification, as it rigidly categorizes people into specific adopter groups, making it difficult to account for individuals who fall outside these neat classifications (Kaminski, 2011).

Another theory that may provide a theoretical foundation for this study is the Technology Acceptance Model (TAM). This is an information systems theory that describes how users accept and utilize new technologies. The theory was developed by Davis (1989). It posits that perceived usefulness and ease of use are key factors influencing societal acceptance and use of technology. Empirical studies by Cheng *et al*. (2019) have shown that ITS applications help road users plan their routes, schedule travel, and optimize the use of transport vehicles. Furthermore, the Unified Theory of Acceptance and Use of Technology (UTAUT) may also serve as a theoretical framework for the present study. The theory was proposed by Venkatesh *et al*. (2003) and aims to explain users' intentions to use information systems and their subsequent usage behavior. The theory identifies performance expectancy, effort expectancy, social influence, and facilitating conditions as major determinants of technology acceptance and use. Other factors that may influence the acceptance and usage of new technology, according to the theory, include sex, age, and voluntariness of use. A study by Waqar *et al*. (2023) shows that competency issues, funding problems, and poor economic growth are factors limiting the deployment of ITS.

Concept of ITS

The term Intelligent Transport System (ITS) has been conceptualized by many researchers, and the ideas put forward by these researchers generally convey the same meaning. According to Lin *et al*. (2017), ITS refers to the application of information and communication technology to transportation systems in order to enhance transport safety and efficiency. The applications of ITS include traffic management, congestion control, pollution reduction, and increased benefits for both commercial and private vehicle operators. In another view, Tom (2014) describes ITS as the use of computers, electronics, communication technologies, and management approaches to oversee transportation systems. ITS ensures road user safety and optimizes transportation systems by providing travel information.

In 2015, Mandzuka described ITS as a holistic control and ICT-based approach to transport and traffic management, which significantly enhances mobility, traffic flow, and the efficient movement of goods and services. Diderot *et al*. (2023) believe that ITS provides real-time information regarding traffic conditions and, therefore, allows transport managers to forecast traffic patterns. The Intelligent Transport System enhances mobility and optimizes transportation systems by reducing traffic congestion and improving traveler information and comfort.

Application of ITS to transport management

The traditional methods of managing traffic over the years such as traffic wardens, highway police, traffic signals, and control systems have proved inefficient, as traffic congestion continues to increase in most urban areas. Ogochukwu et al. (2018) in their study revealed that the adoption of Intelligent Transportation Systems (ITS) may reduce traffic congestion in Enugu, Nigeria. In a study on the role of ITS in mitigating traffic congestion in the USA, Cheng *et al*. (2019) used longitudinal data on traffic congestion and ITS usage. The results revealed that ITS deployment assists commuters in travel scheduling, route planning, and optimization of work-trip transport vehicles.

In a systematic review, El Mokaddem & Jawab (2019) studied the use of ITS in urban areas. The findings indicate that ITS deployment is mainly for advanced transportation management systems, providing information to travelers, and enhancing public transportation systems. Taie & Elazb (2016)

studied the application, benefits, and challenges of ITS in regions such as North America, Europe, and Asia. The results indicate that ITS applications enhance traffic flow, improve road safety, reduce insecurity, and improve overall public transportation. The study identifies funding issues as a major bottleneck preventing the effective use of ITS. Another application of ITS in transportation systems is toll collection. Electronic toll collection allows road users to pay for access without interacting with personnel. According to Qureshi & Abdullah (2013), electronic toll collection systems improve toll station performance, save road users time, reduce environmental impact, and lower fuel consumption.

2.4 Challenges of ITS

Many factors are responsible for the non-acceptance and lack of implementation of Intelligent Transport Systems (ITS) in cities around the world, particularly in Minna. Financial constraints are key challenges preventing the global adoption of ITS. These technologies are very expensive to acquire, and the cost of maintaining them is also high. In most cases, developing countries find it difficult to invest in ITS technologies due to their weak economies. Study by Diderot *et al*. (2023) indicate that the lack of capital to invest in ITS technologies is one of the major bottlenecks hindering their adoption in Sub-Saharan African countries, including South Africa.

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Most countries classified by the World Bank (2018) as developing nations—such as Nigeria, Ghana, Niger, and Mali are low-income countries and among the poorest in the world. Consequently, adopting ITS in these regions may be challenging..

Waqar *et al*. (2023) examined the bottlenecks preventing the deployment of ITS in urban mobility using a survey research design. Their results indicate that technical problems, resource-related issues, interoperability challenges, poor management, lack of competent staff, and economic constraints are major factors hindering ITS adoption. In another study, Shaaban *et al*. (2021) investigated the benefits and challenges of adopting ITS in Qatar. Their findings show that coordination among stakeholders, keeping up with evolving technologies, integration with existing transport infrastructure, and financial constraints are the key challenges to ITS adoption.

`Similarly, Muchaendepi *et al*. (2018) revealed that stiff competition from foreign transport operators is a major challenge to the deployment of ITS in Zimbabwe. The study suggests that road freight transport companies should train their staff in ITS usage, employ competent personnel, and reform their management structures to enhance ITS utilization in Zimbabwe. In Tehran, Behruz *et al*. (2013) examined the challenges associated with ITS implementation in Iran. The study found that drivers deactivating GPS devices, covering their vehicle plate numbers to avoid detection, and the deliberate destruction of road cameras are some of the challenges facing ITS deployment in the country.

3. RESEARCH METHODOLOGY

The study utilized a descriptive research design to describe the characteristics of the study population. The study population comprised vehicle users and vehicle operators across Bosso and

Chanchaga Local Government Areas of Minna, Niger State.

The study utilized a questionnaire survey, while volumetric counting was employed to determine the sampling frame. Based on volumetric counting, the sampling frame consists of 8,764 vehicles across six (6) major road intersections in Minna: Dutsen Kura Junction, Government House Junction, Kpakungu Roundabout, City Gate Roundabout, Obasanjo Complex Roundabout, and Mobil Roundabout. The sample size of 383 was determined using Taro Yamane's (1967) formula, as shown in equation (1).

$$n = \frac{N}{1+N(e)^2} \quad \text{.....eq.1}$$

Where, n= sample size, N= sample frame (8,764) and e = confident level (0.05).

The study used a systematic sampling technique to administer questionnaires among road users. Data were collected with the aid of two field assistants who distributed the questionnaires to road users, while vehicle inspection officers assisted the researchers by stopping vehicles at regular intervals of four vehicles.

Table 1: Number of questionnaires distributed at each road intersection

S/n	Intersections	Number of vehicle counts	Number of questionnaires
1.	Dutsen Kura junction	1,046	46
2	Government house junction	1,017	44
3	Kpakungu roundabout	1,380	60
4	City gate roundabout	1,720	75
5	Obasanjo complex roundabout	1,461	64
6	Mobil roundabout	2,140	94
	Total	8,764	383

Sources: Field Survey (2025)

The study used a proportionate method, applying the formula in Equation (2) to determine the number of questionnaires administered to vehicle operators or owners across the six (6) major road intersections studied in Minna metropolis.

$$n = \frac{Ni}{SF} \times SS \quad \text{.....eq.....2}$$

Where n is the number of questionnaires administered at each intersection, Ni is the number of vehicles at the road intersections, SF is the sample frame, and SS is the sample size. However, these distributions are shown in table 1.

Also, the study employed content validity, using scholarly articles to determine the validity of the research instrument. The collated data were analyzed using frequencies, percentages, and mean scores, while ANOVA statistics were used to determine the statistical significance of the respondents' responses regarding the challenges of adopting ITS in Minna...

4. RESULTS AND DISCUSSION

4.1 Socioeconomic features of the vehicle owners/operators

The analysis of the gender of the respondents in figure 1 reveals that 77% of vehicle owners or operators in Minna were male, while only 23% were female. This outcome suggests that there are more male vehicle owners compared to females in Minna. These findings indicates that gender dynamics may influence the perception and adoption of the Intelligent Transport System (ITS) in Minna. Since males constitute the majority of vehicle operators, their preferences, concerns, and willingness to adopt ITS will significantly shape its overall implementation in the metropolis.

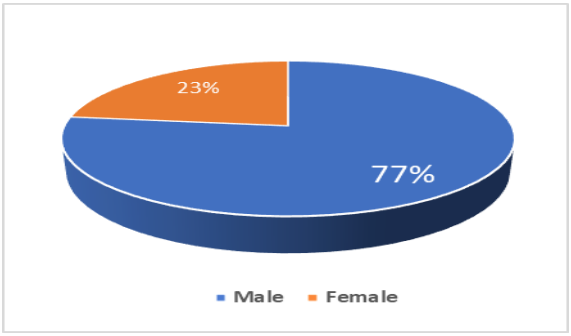


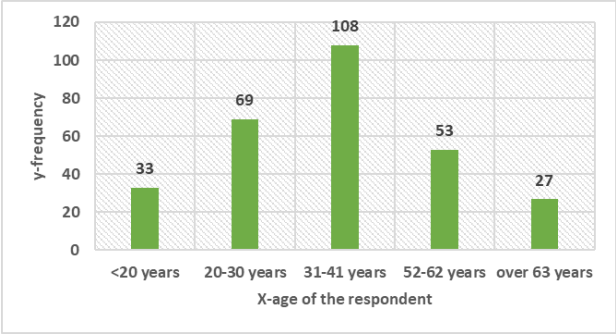
Figure 1: Gender of the respondents

Sources: Field Survey (2025)

The analysis of the respondents' ages in figure 2 reveals that the majority were in their mid-age range of 31 to 41 years.. About 69 respondents were in their youthful age range of 20 to 30 years, 53 were between 52 and 62 years, 33 respondents were younger than 20 years, and only 27 respondents were above 63 years of age. These findings reveals that majority of the vehicle owners may accept the adoption of ITS as a transport solution because a significant proportion of them are youths, although some individuals above 52 years may find it challenging .Therefore, the findings suggests that policymakers and ITS promoters should tailor their campaigns and training pro-

grams to engage both younger and older vehicle users in Minna. In fact, user-friendly designs and support systems should accommodate different levels of technology awareness.

Figure 2: Age of the respondents



Sources: Field Survey (2025)

Figure 3 shows the marital status of vehicle owners in Minna. From the analysis, a larger proportion (i.e., 47%) of the vehicle owners/operators were married, 39% were single, 8% were divorced, and 6% were widowed. Since the majority of the respondents were married, they may have responsibilities that impact their perception of ITS, such as concerns about the cost of acquiring the technology, safety, or convenience for family mobility.

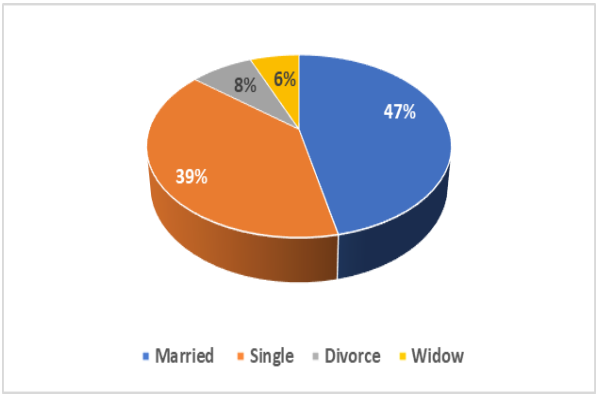


Figure 3: Marital status

Table 2: Educational Background of Respondents

S/n	Criterion	Frequency	Percentages
	Civil servant	93	32.0
	Company employee	38	13.1
	Self-employed	77	26.6
	Business owner	54	18.6
	Artisans	28	9.7
	Total	290	100.0

Sources: Field Survey (2025)

The analysis of the educational background of the respondents in table 2 reveals that 36.2% of the vehicle owners/operators had a higher diploma certificate or degree, about 28.3% had a National Diploma (ND) or National Certificate of Education (NCE), and 16.6% had a secondary school certificate. Additionally, about 10.7% of the vehicle owners in Minna had primary school education, and only 8.1% had a postgraduate certificate. The relatively high proportion of vehicle owners with ND/NCE and HND/Degree qualifications suggests that vehicle owners/operators in Minna possess the educational capacity to understand and engage with intelligent transport system technologies, which could facilitate their adoption.

Table 3: Occupation of the vehicle owners

Criterion	Frequency	Percentages
Primary sch. Cert	31	10.7
Secondary Sch. Cert	48	16.6
ND/NCE	82	28.3
HND/Degree	105	36.2
Postgraduate studies	24	8.1
Total	290	100.0

Sources: Field Survey (2025)

Table 3 shows the result of analysis of the occupations of vehicle owners/operators in Minna. 32% of the vehicle owners were civil servants, 26.6% were self-employed, and 18.6% were business owners. This outcome reveals that civil servants, business owners, and self-employed vehicle owners may have varied perceptions, but they may still be willing to accept the development. Due to the nature of their occupations, they tend to prioritize reliability, affordability, and efficiency in ITS solutions for commuting compared to other groups of vehicle owners/operators.

Similarly, table 3 indicates that 13.1% of the respondents were company employees and 9.7% were artisans. However, company employees and artisans may have differing views, exposure to ITS technology, and financial capacities, which could influence their ability to adopt ITS. In fact, artisans may find it challenging to afford ITS and may have limited awareness of its benefits.

4.2 Challenges of possible adoption of ITS in Minna

Table 4 shows the mean scores of the level of agreement among vehicle owners/operators regarding the challenges preventing ITS adoption in Minna. A higher mean index score (closer to 5) implies a stronger agreement that the component is a significant challenge, while a lower mean suggests less concern. From the result summarised in Table 4, the greatest challenge that may affect the adoption of ITS in Minna is the absence or inadequacy of government policy regarding ITS adoption, with a mean score of 3.8759. Vehicle owners/ operators in Minna strongly believed that the absence of clear policies on ITS may pose a hindrance to its adoption.

Table 4 also indicates that vehicle owners/operators in Minna believed that financial issues (M = 3.8345) could impact the adoption of ITS in Minna. This finding aligns with the work of Diderot *et al.* (2023), who claimed that a lack of capital base is a key bottleneck to ITS adoption in Sub-Saharan Africa. In addition, table 4 recorded lack of awareness (M = 3.7517) as another obstacle to ITS adoption in Minna. This outcome reveals that the majority of vehicle owners/operators do not understand the benefits of ITS. Therefore, stakeholders should initiate public awareness campaigns on the benefits of ITS, which are essential to increasing public acceptance.

Furthermore, table 4 reveals that technical problems (M = 3.7069) were perceived by vehicle owners as challenges limiting the adoption of ITS in transportation system of Minna. These findings align with the work of Waqar *et al.* (2023), who believed that non-acceptance of ITS was due to technical problems. Lack of technical support to provide adequate maintenance of the technology may also hinder adoption. Lack of consistency in public project investment (M = 3.6655) was another key factor limiting the adoption of ITS in Minna. The finding suggests that long-term sustainability and commitment to ITS adoption and improvement require stable funding and consistent budget allocation.

Moreover, it can be observed from table 4 that non-registration of vehicle plate numbers (M = 3.6897) could hinder the adoption of ITS. This finding implied regulatory lapses affect ITS adoption. The findings advocated for stronger enforcement mechanisms, such as digital plate number tracking and integration with the Intelligent Transport System. This may enhance the system's efficiency.

Similarly, lack of competent personnel (M = 3.6517) affects the adoption of ITS. Currently, there is a shortage of personnel specialized in maintaining and installing the technology. Educational institutions may help bridge this gap. The findings corroborate the work of Waqar *et al.* (2023), who posited that a shortage of competent staff may hinder the adoption of ITS in transportation system of Minna.

Finally, the analysis in table 4 recorded that there is a possibility of ITS being sabotaged by touts (M = 3.6552), indicating potential resistance from informal transport operators. This finding suggests that such groups should be engaged during the planning of ITS, offered alternative employment, and that informal public transport should be integrated into the intelligent transport framework to mitigate resistance.

Table 5 presents the total variance explained by the Principal Component Analysis (PCA), showing the contribution of each bottleneck to the overall variation in vehicle owners'/operators' perception of Intelligent Transport System adoption challenges. According to the eigenvalues, any value less than 1 indicates a low contribution to the poor adoption of ITS, while any value equal to or greater than 1 indicates a high contribution to the challenges.

From the analysis in table 5, unhealthy or absence of government policy regarding ITS adoption, poor awareness of ITS benefits, and financial issues accounted for 53.25%, 20.62%, and 12.09% of the variance, respectively, indicating the key challenges to ITS adoption in Minna. These outcomes highlight policy gaps, a lack of awareness among motorists regarding ITS benefits, and cost-related concerns. Other minor concerns that may hinder the adoption of ITS in Minna, include: inconsistent public project investment (7.19%), technical problems (3.02%), lack of competent personnel (1.38%), and the possibility of ITS infrastructure being sabotaged by touts (0.633%). While these had a lower impact, they still contribute to the challenges associated with ITS adoption in Minna.

Table 4: Challenges of adoption of ITS in Minna

	N	Mean	Std. Deviation
Unhealthy /lack of government policy regarding ITS adoption	290	3.8759	.67283
Poor awareness of ITS benefits	290	3.7517	1.85441
Financial issues	290	3.8345	.61485
Lack of consistency in public project investment	290	3.6655	.64587
Technical problem	290	3.7069	.60013
Non registration of vehicle plate numbers	290	3.6897	.64991
Lack of competent personnel	290	3.6517	.64391
Possibility of ITS being sabotaged by touts	290	3.6552	.58681
Valid N (listwise)	290		

Sources: Field Survey (2025)

Table 5: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component factors	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Unhealthy/lack of government policy regarding ITS adoption	4.260	53.249	53.249	4.260	53.249	53.249
Poor awareness of ITS benefits	1.650	20.619	73.868	1.650	20.619	73.868
Financial issues	1.368	12.094	85.962	1.368	12.094	85.962
Lack of consistency in public project investment	.575	7.192	93.153			
Technical problem	.242	3.024	96.177			
Non registration of vehicle plate numbers	.145	1.808	97.986			
Lack of competent personnel	.111	1.381	99.367			
Possibility of ITS being sabotaged by touts	.051	.633	100.000			

Extraction Method: Principal Component Analysis.

Sources: Field Survey (2025)

5. CONCLUSION AND RECOMMENDATIONS

The analysis of vehicle owners' and operators' perceptions regarding the challenges of ITS adoption in Minna metropolitan area utilized a survey research design to examine the key issues hindering the adoption and acceptance of ITS in Minna's public transport system. The results enabled the study to conclude that there are eight major challenges limiting the adoption of ITS in Minna metropolis. However, the outcome of the PCA enabled the study to identify three key factors hindering ITS adoption: the absence or inadequacy of government policy on ITS, poor awareness of ITS benefits, and financial constraints.

The study therefore, recommends that:

Policymakers should draft ITS-specific policies. This will ensure legal backing and the integration of intelligent transport systems into broader transport planning.

The government, through relevant agencies, should create public awareness about the benefits of ITS. This can be achieved through media campaigns, workshops, and awareness programs.

Both government and private organizations should introduce subsidies, flexible financial options, and incentives to reduce the financial burden on vehicle owners.

Government and private organizations should provide training for ITS professionals and implement regulatory measures to enforce vehicle registration. These actions will further enhance ITS adoption.

Consistent training programs for ITS professionals and enforcement of vehicle registration regulations can further support adoption.

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