Geospatial Assessment of Flyover Construction Impacts on Travel Time, Traffic Flow, and Socio-Economic Activities in Ile-Ife, Nigeria

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ABSTRACT

Urban flyover construction projects aim to improve mobility and reduce congestion but often trigger short-term disruptions in traffic and socio-economic activities. This study assesses the impacts of the ongoing flyover construction in Ile-Ife, Nigeria, using geospatial analysis and socio-economic surveys. Travel time data, traffic counts, GPS coordinates, and questionnaires were analyzed with ArcGIS tools to evaluate alternative routes and congestion hotspots. Findings reveal that secondary roads, which dominate Ile-Ife's network, constituted the dominant component of the road network through which diverted traffic was distributed. The Mayfair–Sabo and Lagere–Ooni Palace corridors recorded the highest congestion indices (92% and 83%), underscoring severe peak-hour disruptions. Socio-economic analysis highlighted reduced business patronage, accessibility challenges, and increased transport costs. The study recommends integrating GIS-based monitoring with strategic traffic management and community engagement to mitigate short-term disruptions while ensuring long-term infrastructural resilience**.**

KEYWORDS: Flyover construction, Geospatial analysis, Traffic congestion, Travel time variability, Socio-economic impacts

INTRODUCTION

Urban infrastructure development, particularly road and flyover construction, plays a pivotal role in enhancing mobility, connectivity, alleviating traffic congestion, stimulating economic development, and supporting sustainable urban growth (UN-Habitat, 2013; Oyedele, 2018). In Nigeria and other developing countries, infrastructural development is not only a response to urban expansion but also a catalyst for economic revitalization and regional integration (UN-Habitat, 2013; World Bank, 2020). However, during the execution of such projects, especially in dense urban environments, significant but temporary disruptions often occur, affecting travel behavior, altering traffic distribution patterns, increasing traffic congestion, and generating socio-economic impacts on business operations. The ongoing flyover construction in Ile-Ife exemplifies such dual-edged impact, promising long-term mobility benefits while simultaneously causing short-to-medium-term spatial, economic, and social challenges.

According to UN-Habitat (2022), urban infrastructure must not only address the immediate needs of mobility and economic access but must also be resilient enough to accommodate the uncertainties that accompany construction and transition phases. In recent years, urban centers like Ile-Ife have experienced increasing traffic congestion, especially around major intersections such as Lagere, Mayfair, and Sabo. The introduction of a flyover, while aimed at decongesting traffic and improving road safety, has inadvertently led to road diversions, prolonged travel times, altered traffic flow, and reduced accessibility to key commercial areas.

Flyover construction projects typically involve large-scale changes to traffic patterns and accessibility networks.

As noted by Gwilliam (2019), infrastructure development in urban environments must be critically assessed for its short-term consequences, particularly where traffic management and economic livelihood are intertwined. In the case of Ile-Ife, the construction has necessitated the redirection of vehicles to alternative routes such as Oduduwa Road, Ife-Ibadan Expressway, and minor inner-city streets. These changes raise crucial questions about the adequacy of such routes, their effect on daily commuting time, and their impact on traffic congestion levels across the town.

Recent studies using geospatial technologies have underscored the power of spatial analysis in understanding the real-time effects of infrastructure projects. According to Magdy et al. (2021), GIS enables urban planners to identify congestion points, monitor route efficiency, and evaluate the accessibility of essential services during construction periods. In Ile-Ife, the integration of GIS tools can provide valuable insights into how alternative routes perform under increased traffic pressure and how spatial patterns of congestion emerge during different times of the day.

These tools also allow for the visualization of business accessibility, pedestrian mobility, and disruptions in delivery logistics all critical factors for small and medium enterprises (SMEs). The ongoing construction of the flyover in Ile-Ife has significantly altered transportation and commercial dynamics in the area. With primary routes disrupted, commuters are compelled to use alternative paths that are often longer or not adequately designed to accommodate increased traffic volumes. This has resulted in notable changes in travel time, heightened traffic congestion, and potential declines in business patronage due to reduced accessibility. Therefore, the objectives of this study are: assessing the impact of identified alternative routes during construction on travel time and traffic patterns and identifying hotspots of traffic congestion during the construction period.

Study Area

Ile-Ife (Figure 1) is a major economic and cultural hub in Osun State, Nigeria. Key economic activities include Agriculture, with crops such as yam, cassava, maize, and cocoa commonly cultivated in the area. Trade and Commerce thrive in the city with vibrant markets, including Oja-Ife, where various goods are traded. Education is an important component of the local economy, particularly because of the presence of Obafemi Awolowo University (OAU), which contributes through employment, student expenditure and research activities.

Art and Craft in Ile-Ife is famous for its historical bronze and terracotta sculptures, which still influence local artisans today. Small and Medium Enterprises (SMEs) such as tailoring, carpentry, and food processing thrive. Ile-Ife is considered the cradle of the Yoruba civilization and the spiritual homeland of the Yoruba people. According to mythology, it is the birthplace of humanity, where Oduduwa, the progenitor of the Yoruba race, descended. The town was an important city in the Oyo Empire and remains a significant cultural and religious center for the Yoruba. It is known for its ancient bronze and terracotta sculptures dating back to the 12th–15th centuries. According to the latest estimates from the World Population Review, based on UN data, the population of Ile-Ife in 2025 is projected to be approximately 438,074 people.

The town has a mix of students, traders, civil servants, and artisans. The presence of Obafemi Awolowo University significantly influences the population dynamics, with a high number of students and academic staff. Ile-Ife has a tropical wet and dry climate (Aw in the Köppen classification). It experiences two distinct seasons: Rainy Season (March – October): Characterized by heavy rainfall and high humidity. Dry Season (November – February): Marked by lower humidity, harmattan winds, and minimal rainfall. Temperature Range is 22°C – 34°C on average throughout the year. Ile-Ife falls within the tropical rainforest zone, featuring dense forests with a mix of hardwood trees and undergrowth. Common vegetation includes oil palm, Iroko, Mahogany, and Rubber trees.

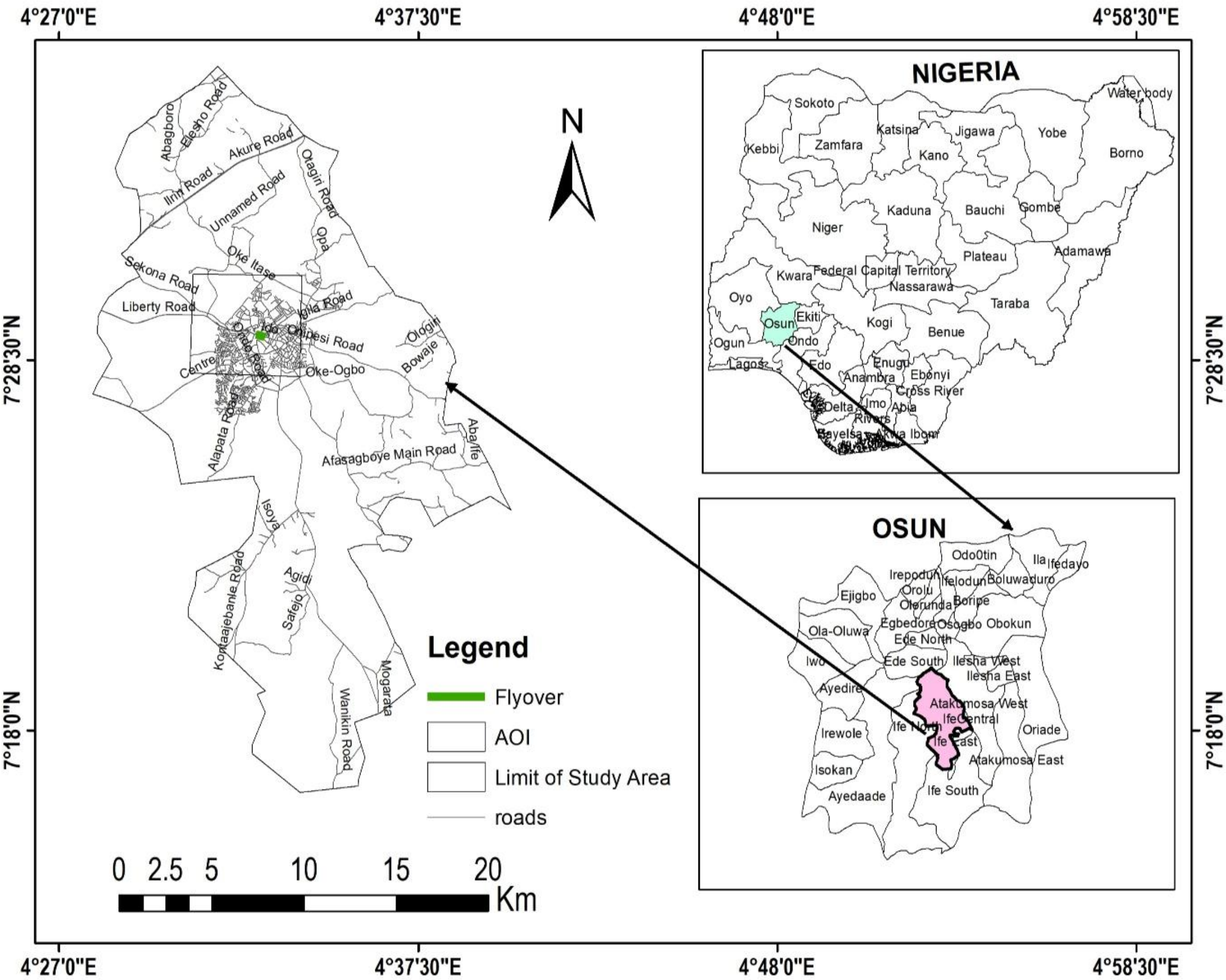

Figure 1: Study Area

LITERATURE REVIEW

Infrastructure development plays a crucial role in enhancing economic growth, facilitating mobility, and improving quality of life. However, the construction of essential structures such as flyover can lead to significant disruptions within the urban environment, impacting travel patterns, traffic flow, and local economies (Berger et al., 2020). In recent years, there has been increased attention on the geospatial impacts of construction activities, particularly in urban areas where congestion and accessibility issues are prevalent. This literature review explores the existing body of knowledge on the geospatial assessment of flyover construction impacts, with a focus on travel time, traffic patterns, congestion hotspots, disruptions, accessibility patterns, resilience, and socio-economic implications.

The construction phase of a flyover can cause considerable disruptions to normal traffic flow, necessitating the identification of alternative routes. Research by Li et al. (2019) emphasizes that construction-induced alternative routes can lead to increased travel times and altered traffic patterns due to road closures or diversions. The use of advanced geospatial technologies, such as Geographic Information Systems (GIS) and remote sensing, has become instrumental in analyzing these changes effectively (Kumar & Vaidya, 2021). Such tools allow for real-time monitoring of traffic conditions and provide valuable data for planners and decision-makers.

Identifying and mapping hotspots of traffic congestion during construction is another critical aspect of geospatial assessment. Previous studies, such as those conducted by Zhao et al. (2020), have highlighted the role of predictive models in understanding congestion dynamics. By utilizing historical traffic data and employing machine learning algorithms, researchers can identify potential congestion-prone areas and inform

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mitigation strategies. This approach is particularly relevant in urban contexts where existing infrastructure is often strained under increased demand.

In addition to identifying traffic disruptions, assessing accessibility patterns is vital, especially for vulnerable populations. According to studies by Cervero (2018), disruptions in transportation networks can disproportionately affect those who rely on public transit or non-motorized transport. GIS tools can help visualize accessibility changes and facilitate the identification of support measures for affected communities (Gutiérrez et al., 2021). Furthermore, resilience – the capacity of a community to recover from construction-related disruptions – must be evaluated as part of the overall impact assessment. Research shows that community engagement and adaptive planning can enhance resilience during major infrastructure projects (Pendall et al., 2020).

The socio-economic impact of construction activities extends beyond immediate disruptions to transportation networks. Various studies, including those by DeGraaf et al. (2019), have explored the economic ramifications of construction on local businesses, property values, and community wellbeing. The perception of construction among local residents can also shape social dynamics and impact overall satisfaction with urban living conditions. Evaluating these elements requires a nuanced understanding of the social fabric and economic landscape of affected areas (Rogers et al., 2021).

In this research, Traffic Flow Theory was the major theory used which focuses on understanding how vehicles move along roadways to optimize road utilization and improve safety. It encompasses various models that explain the relationships among three primary parameters: flow (vehicles/hour), density (vehicles/km), and speed (km/h) (May, 1990).

Modern technology plays a pivotal role in real-time traffic data collection and monitoring. Devices such as Global Positioning Systems (GPS), Bluetooth sensors, Automatic Number Plate Recognition (ANPR) systems, and mobile apps provide data on speed, congestion, and travel time with spatial and temporal precision (Herrera et al., 2010). Navigation applications like Google Maps and Waze dynamically reroute users based on real-time congestion and incidents. These apps aggregate crowd-sourced traffic data, enabling more accurate route choice during construction-related disruptions (Zhang et al., 2011). In construction zones, these tools can reduce congestion by spreading traffic loads across multiple detour paths. Evaluating the impact of flyover construction on mobility requires a temporal analysis of travel times before, during, and after construction. Floating car method also called test car or probe car method; this involves using a vehicle equipped with instruments (e.g., GPS or stopwatch) to drive along a roadway segment to measure travel time and speed. Islam (2024) demonstrated its effectiveness in capturing delay patterns and average speed across urban corridors using GPS-equipped vehicles. Another method is Bluetooth/GPS tracking**.** These are passive tracking techniques that collect real-time movement data from vehicles or mobile devices. Wang et al. (2024) applied hybrid models combining GPS data and machine learning to forecast travel time with high temporal accuracy

METHODOLOGY

The study employed a mixed-methods approach, integrating quantitative spatial analysis with qualitative socio-economic assessments. GIS and remote sensing techniques were used for spatial data analysis and mapping, temporal traffic pattern analysis, while survey instruments (questionnaires and interviews) were utilized for socio-economic data collection.

Data Requirements and Sources

The data required for this study were both primary and secondary in nature. These datasets were essential for achieving the objectives which focused on assessing the impact of flyover construction in Ile-Ife on travel time, traffic flow, disruption patterns, and socio-economic activities.

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The primary data used in this study were obtained directly from field observations and surveys conducted within the study area. These datasets provided firsthand, location-specific information required for analyzing travel time, traffic flow, disruption patterns, and socio-economic impacts associated with the ongoing flyover construction in Ile-Ife. The primary data include the following:

Travel Time Data

Travel time measurements were collected along selected routes before and during the construction period using a stopwatch and field observations. Measurements were conducted during peak and off-peak periods to capture variability in travel time. These data were used to assess how construction activities influenced travel efficiency, route performance, and temporal delay across alternative paths.

Traffic Count Data

Manual vehicle counts were conducted at selected road intersections and junctions within the study area. Observations were made at different times of the day to account for variations in traffic flow. The traffic count data were used to determine vehicular volume, flow intensity, and to identify congestion-prone locations during the construction period.

Socio-Economic Data

Socio-economic information was collected from business owners, commuters, and residents situated along and around the flyover corridor through the administration of structured questionnaires. The data covered indicators such as changes in sales turnover, customer volume, accessibility to business premises, and general economic performance during construction. The respondents were selected using a purposive sampling technique to ensure that only those directly affected by the construction were included in the survey. These data were analyzed to assess the economic and livelihood impacts of the project.

Field GPS Coordinates

Geographic coordinates of road intersections, alternative routes, and observed congestion points were captured using a handheld Global Positioning System (GPS) device. These coordinates were used to georeference locations for mapping, network analysis, and spatial overlay within a GIS environment.

The secondary data used in this study consisted of existing spatial, statistical, and administrative datasets obtained from reputable institutions and online repositories. These data complemented the primary datasets and provided the necessary spatial framework and contextual information for geospatial analysis. These include the following:

Satellite Imagery

High-resolution Google Earth Pro imagery was used for visual interpretation and digitization of roads.

Topographic Maps and Administrative Shapefiles

Base maps at a scale of 1:50,000 and administrative boundary shapefiles were obtained from COOPERATIVE INFORMATION NETWORK (COPINE), ILE-IFE. These datasets were used for georeferencing, map layout, and spatial referencing of all geographic features within the study area.

Road Network and Land Use Data

Existing road layout maps and land use information were obtained from COOPERATIVE INFORMATION NETWORK (COPINE), ILE-IFE. Also, road network dataset was acquired from BBBike for validation. These datasets supported validation for network and overlay analysis to identify affected routes caused by the flyover construction.

Traffic and Infrastructure Records

Secondary traffic volume data and reports on road maintenance and diversions were obtained from the Federal Road Safety Corps (FRSC) and Osun State Traffic Management Agency (OSTMA). These records were used to validate field observations and traffic count results.

Demographic and Economic Data

Supporting information on population, and general economic conditions in the study area was obtained from the National Population Commission (NPC, 2006), and the National Bureau of Statistics (NBS, 2021). These data provided the demographic and economic context for analyzing the socio-economic impacts of the flyover construction.

Data Collection Instruments

A combination of instruments was employed to collect both primary and secondary data required for this study. These instruments ensured accuracy, reliability, and spatial precision in the acquisition of data on travel time, traffic flow, socio-economic impacts, and spatial changes within the study area.

Questionnaire/Study Population and Sample Size

Socio-economic data were collected using a structured questionnaire administered to business owners, residents and commuters who were directly exposed to the effects of the ongoing flyover construction. The survey focused specifically on the immediate construction corridor and its surrounding areas rather than the general population of Ile-Ife. This delimitation was necessary because the objective of the socio-economic component was to document the localized effects of construction-related disruption on accessibility, customer flow, business performance and mobility among stakeholders with direct experience of the project.

During the reconnaissance survey, approximately 400 potentially affected stakeholder units, including businesses, households and other relevant users of the construction corridor, were identified within the immediate vicinity of the construction corridor. This figure constituted the estimated operational population for determining the questionnaire sample and was not treated as the total population of Ile-Ife. Using Yamane's (1967) sample-size formula,

$$n = N / (1 + N(e)^2)$$

where ‘n’ is the required sample size, ‘N’ is the estimated population of directly affected units (400), and ‘e’ is the selected level of sampling error (0.08), the calculated sample size was approximately 112 respondents. The study therefore administered 120 questionnaires, providing a modest increase above the calculated minimum and allowing for adequate coverage of the identified affected corridor.

The selection of respondents was purposive rather than purely random because the study specifically sought individuals with direct knowledge or experience of construction-related disruption. The survey area was spatially stratified into three proximity zones: 0–100 m (immediate construction corridor), 100–300 m (adjacent corridor), and 300–500 m (outer impact zone). Respondents were selected from these zones based on their direct exposure to changes in accessibility, customer visits, transportation conditions, business operations or related socio-economic effects. The survey consequently represents a targeted assessment of stakeholders within the construction-influence area rather than a probability sample of the entire population of Ile-Ife.

The use of 120 respondents should therefore be interpreted in relation to the defined study population and analytical purpose. The sample was sufficient to describe patterns of perceived and observed socio-economic disruption within the affected corridor and to support the descriptive and exploratory statistical analyses undertaken in the study. However, because purposive sampling was employed, the socio-economic findings are not intended to provide statistically generalizable estimates for the entire population of Ile-Ife. Instead, they constitute a localized case study of the immediate flyover corridor and provide spatially grounded evidence of how construction-related disruptions were experienced by affected stakeholders. This limitation is explicitly acknowledged when interpreting the socio-economic findings.

The completed questionnaires were coded and analyzed using descriptive statistics and relevant inferential procedures in SPSS, while the respondents' locations and the identified impact zones were integrated into the GIS environment to examine the spatial distribution of socio-economic effects.

- Field Observation Checklist: An observation checklist was used to systematically record physical evidence of construction-related disruptions such as road diversions, blockages, alternative routes, and traffic buildup. The checklist ensured consistency in data collection and allowed the researcher to document non-verbal indicators and visual changes across different sites within the study area.
- Stopwatch and Pedometer: These instruments were used for measuring travel time and distance along selected routes during the construction period. The stopwatch provided precise timing of trips, while a mobile distance-measurement application was used to estimate distances covered along selected routes. These data were used to analyze route performance, travel efficiency, and the effect of construction on travel time and traffic patterns.
- Global Positioning System (GPS) Receiver: A handheld GPS device was used to capture geographic coordinates of key features such as road intersections, alternative routes, business clusters, and congestion hotspots. These coordinates were later imported into the GIS environment for georeferencing, spatial mapping, and network analysis. The GPS instrument ensured positional accuracy and spatial referencing of field observations

Geospatial Analysis and Tools Used

Geospatial analysis formed the core analytical framework of this research, integrating both spatial and non-spatial datasets to evaluate the impacts of the ongoing flyover construction in Ile-Ife on travel time, traffic flow, and socio-economic activities. The study employed a suite of GIS and Remote Sensing tools to process, analyze, and visualize data for decision support and impact assessment.

ArcGIS 10.8: For spatial data processing, map generation, overlay analysis, network analysis, buffer analysis, and kernel density estimation (KDE). Also, Google Earth Pro was used for high-resolution image extraction, digitization of road networks, and validation of spatial features. Finally, SPSS and Microsoft Excel were used for descriptive and inferential statistical analysis of field-obtained socio-economic data.

Network Analyst of ArcGIS was used to model the road network, identify alternative routes, and compute travel time along various paths during construction. This technique was used in achieving the first objective by assessing the spatial efficiency of diversions. The Overlay Analysis was applied to integrate multiple spatial datasets such as traffic flow, land use, and business activity layers. This helped in identifying overlapping areas of high disruption and congestion. Likewise, buffer zones of 100 m, 300 m, and 500 m were generated around the construction corridor to determine the extent of socio-economic and mobility impacts. Finally, Kernel Density Estimation (KDE) of the ArcGIS was employed to generate heat maps that visualized traffic congestion hotspots, thereby achieving the second objective.

RESULTS AND DISCUSSION

Functional Road Classification and Its Role in Construction-Induced Traffic Diversions

To assess the impact of identified alternative routes during construction on travel time and traffic patterns functional classification of the road network within the study area was done. The classification was conducted using digitized road segments and stratified based on functional hierarchy and connectivity models. The network was categorized into primary roads (401 segments), secondary roads (8,588) segments and tertiary roads (263 segments) as detailed in Table 1 and Figure 2

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This hierarchical structure revealed a dominance of secondary roads (92.82%), indicating a network highly dependent on feeder and distributor routes. Such a configuration has critical implications during construction activities. When primary roads are obstructed, traffic is diverted to secondary and tertiary routes, which often lack the capacity and signal coordination to absorb increased volumes. Memarian et al. (2020) developed an optimization-based diversion model showing that construction closures can increase travel time by up to 40% if alternative routes are not strategically planned. Similarly, studies in Lagos, Nigeria, found that diverted traffic during roadworks led to significant delays and reduced average speeds, particularly on secondary roads. These findings underscore the importance of understanding road hierarchy when evaluating the effectiveness of alternative routes.

As represented in Figure 2, the spatial classification map of the road segments distribution network within the (AOI) as carried out in ArcGIS environment, using three different symbology colour visually reinforces the numerical findings. The dense web of secondary roads, marked in black, forms the backbone of the transportation network. Primary roads (red) appear as strategic connectors, while tertiary roads (green) are scattered and localized. This hierarchy influences traffic patterns, emergency response times, and even economic activity distribution. Furthermore, the spatial configuration of the road types revealed critical insights into the urban morphology, accessibility dynamics, and infrastructural priorities. The dominance of the secondary roads, coupled with the limited presence of primary and tertiary roads, shapes not only traffic behavior but also socio-economic interaction across the region. The high proportion of secondary roads (92.82%) indicates a dense, locally oriented road network and highlights the importance of secondary routes in maintaining neighborhood-level connectivity during periods of disruption.

Table 1: Functional Road Classification

Road Category	Number of Segments	% Total
Primary roads	401	4.34
Secondary roads	8588	92.82
Tertiary roads	263	2.84
Total	9252	100

Source: Author’s classification, 2025.

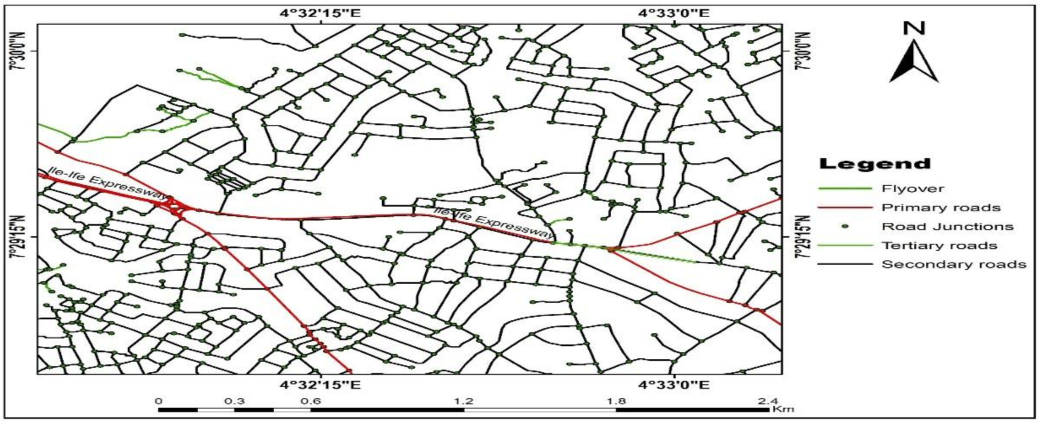

Figure 2: Spatial Classification of Road Segments Network within Area of Interest

Source: Author’s analysis, 2025.

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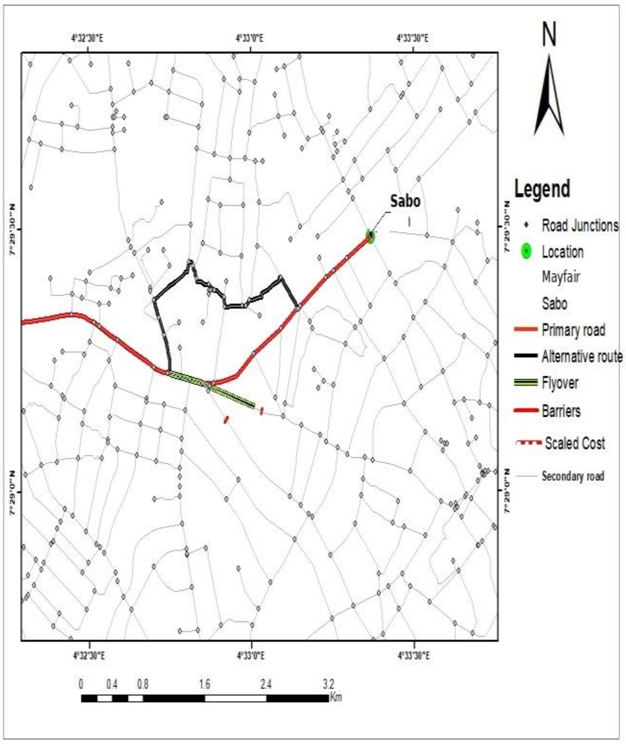
Identification and Analysis of Alternative Routes

The spatial analysis (network analysis) revealed that travel time and traffic patterns are significantly influenced by infrastructure elements such as flyovers, restrictions, and barriers. Routes passing through institutional or market zones (e.g., OAUTH, Sabo) exhibit higher congestion during peak hours. These findings are consistent with Chukwurah et al. (2025), who demonstrated that peak-hour traffic volumes in Enugu were highest in zones with clustered junctions and restricted access.

Alternative routes provided diversion options during construction, but their performance varied considerably in terms of travel time, delay and congestion. Bukar et al. (2025) emphasized the utility of UAV and GIS integration in identifying modal differences and intersection bottlenecks, which are evident in the Campus–OAUTH–Sabo network.

Furthermore, Gbadebo et al. (2025) underscored the role of urbanization and land use in shaping travel behavior, a dynamic clearly reflected in the OAU–Ayala Lane corridor. The findings suggest that strategic traffic management and infrastructure planning are essential to optimize route efficiency. Figure 3 - 6 depict the alternative routes respectively.



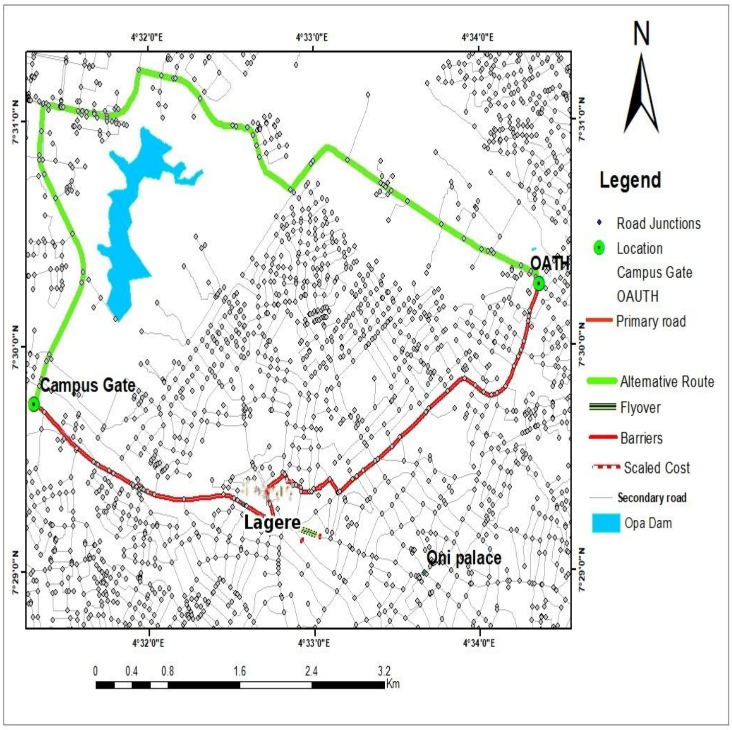


Figure 3: Alternative route between Mayfair

Figure 4: Alternative route between OAU and Sabo

Campus to OAU teaching Hospital Complex

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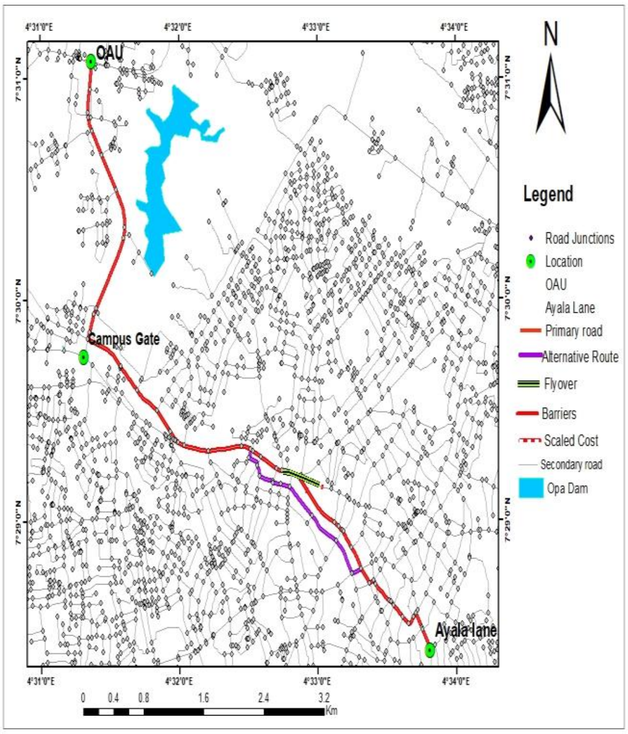

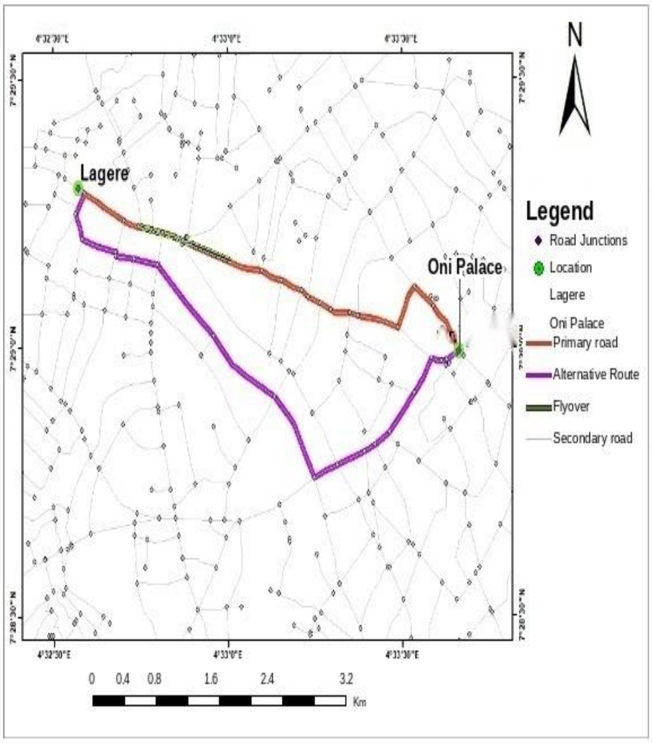

Figure 5: Alternative Route between OAU Campus gate and Ayala Lane

Figure 6: Alternative Route between Lagere and Ooni Palace

Source: Author’s analysis, 2025.

Assessment of Alternative Routes on Travel Time using Travel Time Variability between Peak and Off-peak Periods

Travel time data were collected during both peak and off-peak periods, and congestion levels were quantified using a Congestion Index (% change), which reflected the relative increase in travel time during peak hours compared to off-peak conditions. The delay (min) was calculated as the difference between peak and off-peak travel durations. As detailed in Table 2, the Mayfair–Sabo and Lagere–Ooni Palace corridors exhibited the highest congestion indices and delay values, indicating severe traffic buildup during peak hours. These routes are located adjacent to the construction zone and serve as major urban connectors, making them particularly vulnerable to construction-induced disruptions. The elevated congestion levels and delays observed during peak periods can be attributed to several construction-related factors: Lane narrowing and diversions due to heavy machinery and temporary barriers; Stop-and-go traffic conditions caused by intermittent work activities and material deliveries; Reduced network capacity, forcing vehicles onto secondary roads not designed for high-volume flow. These findings are consistent with Wani et al. (2019), who examined the mobility impacts of flyover construction in Srinagar, India. Their study emphasized that construction activities near sensitive urban zones such as schools, hospitals, and commercial centers can lead to elevated congestion, reduced accessibility, and increased travel time variability.

Table 2 Computed delay and congestion index (% change) from Peak and Off-peak

Route Name	**Peak Time (min)**	**Off Peak Time (min)**	**Delay (min)**	**Congestion Index (% change)**
Mayfair-Sabo	25	13	12	92

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Lagere-Ooni Palace	11	6	5	83
OAU-Ayala Lane	32	27	5	19
OAUGate-(OAU Intl. Sch)-OAU THC	19	16	3	19
OAU Gate-Sabo-OAU THC	45	38	7	18

Source: Author's analysis, 2025.

Comparative Analysis of Delay and Congestion Index Across Routes

To deepen the understanding of travel time dynamics during the construction phase, each alternative route was evaluated by comparing its travel delay (minutes) against its corresponding congestion index (% change) as shown in Figure 7. This route-specific pairing provides insight into how congestion levels translated into actual time lost, and which routes imposed the greatest burden on commuters.

Mayfair–Sabo

This route recorded both the highest congestion index and highest delay time, indicating severe traffic buildup and prolonged travel time. The strong alignment between high congestion and delay suggests that this route was the least efficient during the construction period.

Lagere–Ooni Palace

While congestion index dropped slightly compared to Mayfair–Sabo, the delay remained relatively high. This implies that although traffic density improved, operational inefficiencies (e.g., frequent stops or poor road surface) continued to affect travel time.

OAU–Ayala Lane

This route showed a sharp drop in congestion index, yet the delay time did not decrease proportionally. This mismatch suggests that while traffic flow improved, other factors such as route length or intersection delays may have offset the potential time savings.

OAU Gate–OAU Int'l School–OAU THC

Both congestion index and delay remained relatively stable, indicating moderate performance. The route did not significantly worsen travel time, but it also did not offer substantial relief.

OAU Gate–Sabo–OAU THC

Similar to the previous route, this alternative showed minimal variation in both metrics, suggesting a consistent but unimproved travel experience.

Comparative Impact of the Alternative Routes on Travel Time

When comparing across all routes, the graph plots delay (in minutes) against congestion index (%) across five strategic corridors (Figure 7), offering a dual-metric assessment of route performance. The result indicate that peak-period travel time was higher than off-peak travel time across all five routes, demonstrating substantial temporal variation in route performance during the construction period. Among the routes, Mayfair–Sabo recorded the highest delay (12 minutes) and congestion index (92%), suggesting it was the most severely affected. This route likely absorbed a significant volume of diverted traffic and lacked sufficient structural capacity to mitigate congestion, resulting in prolonged travel times and elevated congestion levels.

In contrast, OAU Gate–Intl School–OAU THC and OAU Gate–Sabo–OAU THC exhibited the least delay (3 and 7 minutes) and lowest congestion indices (19% and 18%), implying better traffic absorption and relatively stable flow conditions. These findings demonstrated that not all alternative routes performed equally under pressure, and some were more resilient to increased traffic volumes than others. This comparative insight underscores the uneven performance of alternative routes and validates the broader analysis in this section. It highlights the importance of strategic traffic planning and route optimization during infrastructure projects, especially in medium-sized urban centers like Ile-Ife. The results also reinforce the need for pre-construction traffic impact assessments to ensure that diversion routes are structurally and operationally equipped to handle redirected traffic.

This analysis supports Litman (2021), who emphasizes that congestion metrics must be interpreted alongside delay data to accurately assess route performance. It also aligns with Aderamo (2012), who advocated for multi-dimensional evaluation in urban transport planning, especially during infrastructure disruptions.

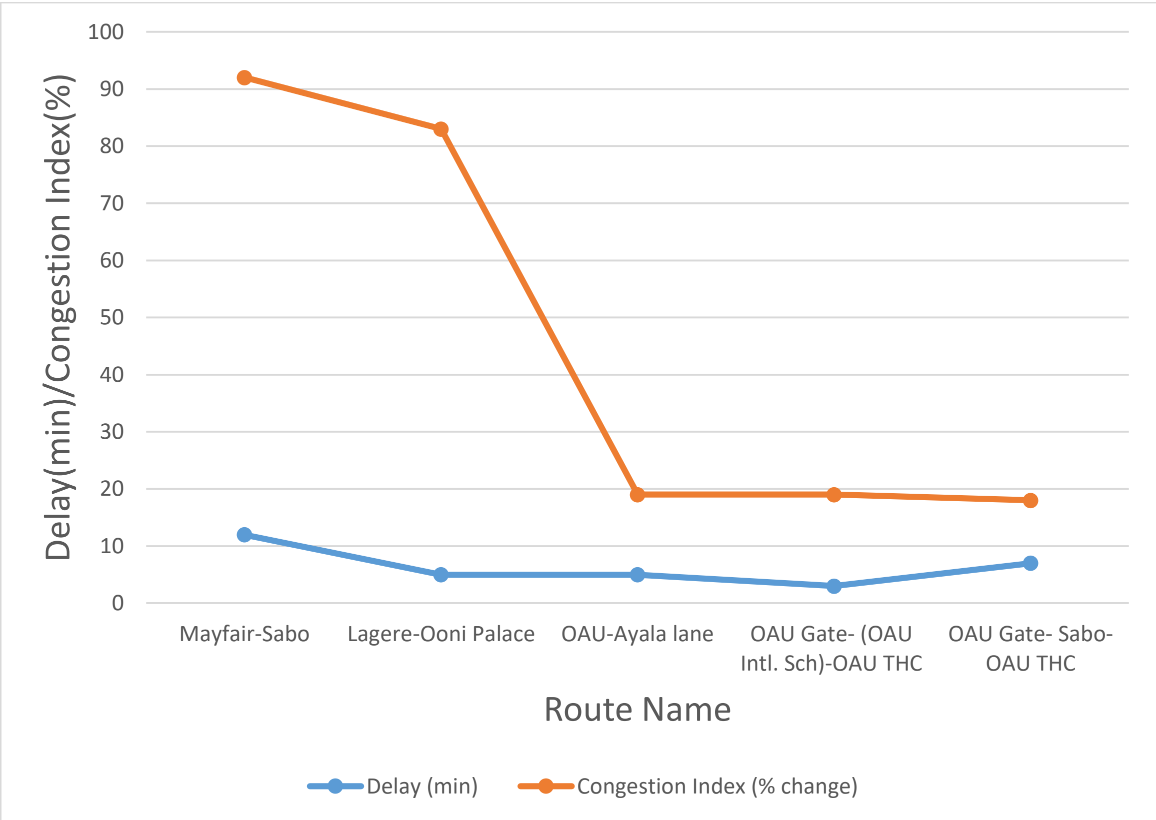

Figure 7: Delay and congestion index across alternative routes.

Source: Author's analysis, 2025. Survey-Based Analysis

Demographic Characteristics of Respondents

Table 3 presents the summarized demographic profile of respondents based on dominant responses. The majority were male (58%) and within the 30–39 age group (40%), indicating a young adult and economically active population. Most respondents had attained secondary education (43%), while business owners constituted the largest reported occupational category (35%). Notably, 50% had resided in Ile-Ife for over ten years, suggesting a population with substantial familiarity with the area and its transport dynamics. These

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demographic characteristics are significant, as long-term residents and business owners are more likely to perceive and articulate the nuanced impacts of infrastructural changes. Aderamo and Salau (2013) emphasized that urban transport interventions disproportionately affect economically active populations, especially in Nigerian cities where informal businesses dominate.

Travel Time and Traffic Patterns

Table 4 highlights the summarized impact of the flyover construction on travel behavior based on dominant responses. Among the surveyed respondents within the flyover impact corridor, 82% reported increased travel time, with 52% indicating an additional 11–20 minutes due to detours. The dominant mode of transport was motorcycles (38%), reflecting a shift toward more flexible and agile means of commuting in response to congestion. Furthermore, 58% reported increased travel costs, while 63% reported a decline in commuting ease. The avoidance of the construction zone by 57% of respondents underscores the extent of disruption. These findings align with Litman (2011), who argued that infrastructure upgrades must be accompanied by effective traffic management strategies to mitigate short-term inefficiencies.

Alternative Routes and Adaptation

Table 5 presents the most frequently reported alternative routes used by respondents. The Mayfair–Sabo route was the most frequently used (40%), followed by Lagere–Ooni Palace (20%). While these routes provided temporary relief, earlier data indicated that 50% of respondents rated current routes as “Poor,” suggesting that these alternatives were suboptimal.

This highlights the need for better route planning and public communication during infrastructure projects. Gwilliam (2003) emphasized that integrated transport planning is essential during infrastructure transitions to ensure accessibility and minimize disruption.

Table 3: Demographic Characteristics of Respondents

Variable	**Category**	**Frequency**	**Percentage (%)**
Gender	Male	70	58
	Female	50	42
Age Group	Under 18	6	5
	18–29	30	25
	30–39	48	40
	40–59	24	20
	60+	12	10
Education	Secondary	52	43
Occupation	Business Owner	42	35

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Relationship	Resident	45	38
Duration in Ile-Ife	10+ years	60	50

Source: Author's field survey analysis, July 2025.

Table 4: Travel Time and Traffic Patterns

Indicator	**Dominant Response**	**Frequency**	**Percentage (%)**
Mode of Transport	Motorcycle	45	38
Travel Time Change	Increased	98	82
Daily Trips	2–3	60	50
Avoid Construction Zone	Yes	68	57
Extra Time via Alternative Route	11–20 min	62	52
Travel Cost Increased	Yes	70	58
Ease of Commuting	Worse	75	63
Reliability of Current Route	Poor	60	50

Source: Author's field survey analysis, 2025.

Table 5: Most Frequently Used Alternative Routes

Route Used Most Frequently	**Frequency**	**Percentage (%)**
Mayfair–Sabo	48	40
Lagere–Ooni Palace	24	20

Source: Author's field survey analysis, 2025.

Traffic Pattern and Alternative Route Performance Analysis

Traffic counts were analysed to assess the performance of the alternative routes during the flyover construction. Peak and off-peak traffic volumes, together with speed and delay, were used to evaluate traffic conditions at the three critical junctions—Eleyele, Olubuse, and Palace—and to assess their relative performance. The results are presented in Table 6.

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Eleyele Junction recorded the highest peak traffic volume (155 vehicles), the lowest peak speed (18 km/h), and the longest peak delay (12 minutes), indicating the most severe congestion among the three junctions. Olubuse Junction recorded a peak volume of 118 vehicles, a speed of 20 km/h, and a delay of 10 minutes, indicating moderate congestion. Palace Junction recorded the lowest peak volume (99 vehicles), a higher speed (22 km/h), and the shortest peak delay (8 minutes), indicating better traffic conditions during the peak period and suggesting its potential as a relief corridor during construction.

Off-peak conditions improved at all three junctions, with lower traffic volumes, higher speeds, and shorter delays. Palace Junction again recorded the best off-peak conditions, with a speed of 37 km/h and a delay of 3 minutes, followed by Olubuse Junction with 35 km/h and 4 minutes, while Eleyele Junction recorded 32 km/h and 5 minutes. These results reinforce the potential of Palace Junction as an alternative route for relieving traffic pressure during construction.

Based on the ranking presented in Table 6, Eleyele Junction is ranked first as the most critical junction requiring intervention, followed by Olubuse Junction and Palace Junction. The ranking therefore reflects the relative level of traffic pressure rather than indicating that Rank 1 has the best traffic performance. The findings suggest that strategically directing traffic towards the less congested Palace corridor could help alleviate pressure on Eleyele during the construction period. This is consistent with Aderamo (2012), who emphasized the importance of junction efficiency in urban traffic management. Olayemi et al. (2019) similarly highlighted the importance of strategic diversion through less congested corridors during infrastructural upgrades.

Table 6: Performance Assessment and Ranking of Critical Junctions Based on Peak and Off-Peak Traffic Conditions

Junction	Volume (Peak)	Speed (km/h)	Delay (min)	Volume (Off-Peak)	Speed (km/h)	Delay (min)	Ranking
Eleyele junction	155	18	12	120	32	5	1
Olubuse junction	118	20	10	94	35	4	2
Palace junction	99	22	8	84	37	3	3

Source: Author’s field survey analysis, 2025.

Impact of Alternative Routes on Junction-Level Traffic Patterns

Figure 8 presents the traffic conditions at three major junctions—Palace Junction, Olubuse Junction, and Eleyele Junction—based on peak traffic volume and delay time. This analysis provides an indication of how the introduction of alternative routes during the construction phase influenced traffic patterns at key intersections within the study area.

The results indicate that Eleyele Junction experienced the greatest traffic pressure, recording the highest peak traffic volume and the longest delay among the three junctions. This suggests that a substantial proportion of diverted traffic was channelled through Eleyele, possibly because of its strategic position within the road network and its connection to important residential, commercial and institutional areas. The resulting concentration of traffic at the junction may have created an unintended bottleneck during the construction period.

Olubuse Junction experienced a comparatively lower traffic volume and moderate delay, indicating that the junction was also affected by diverted traffic but was able to accommodate the additional demand more effectively than Eleyele. Palace Junction recorded the lowest traffic volume and shortest delay among the three locations, suggesting relatively better traffic absorption and less severe disruption.

Overall, the findings demonstrate that the use of alternative routes during flyover construction produced uneven effects on junction-level traffic performance. While some junctions were able to accommodate diverted traffic with relatively limited delays, others experienced substantial increases in traffic pressure. These variations provide the basis for the subsequent identification and ranking of congestion hotspots within the study area. This finding supports the view of Desai et al. (2022) that multi-metric assessment is useful for identifying pressure points within urban road networks and is consistent with Regidor and Teodoro (2005), who emphasised the importance of Traffic Impact Assessment in infrastructure planning and mitigation.

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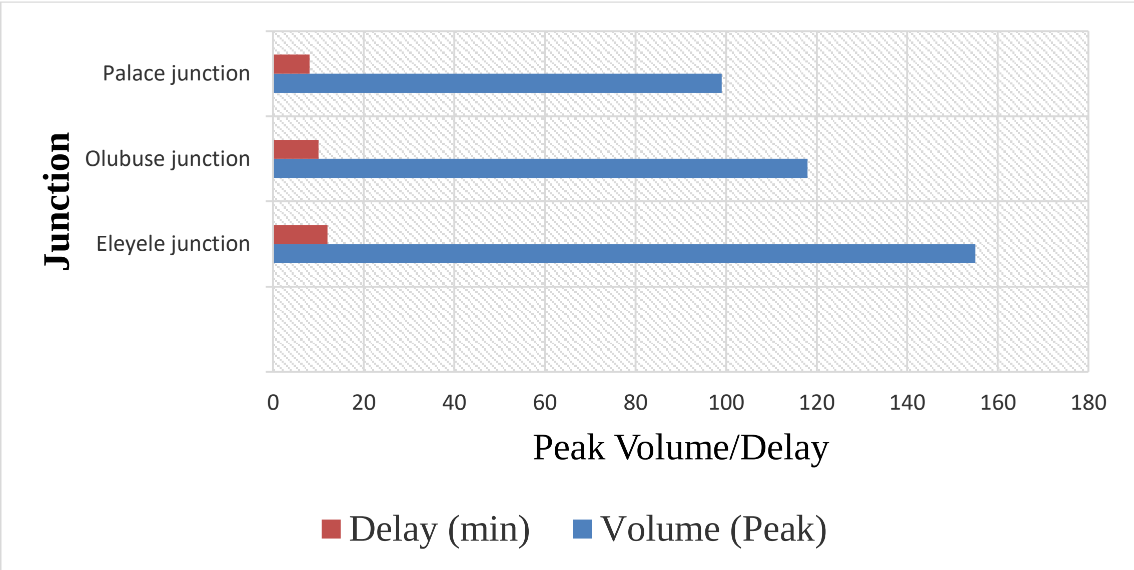

Figure 8: Ranking of Junctions Based on Peak Traffic Volume and Delay Time

Source: Author's analysis, 2025

Identification, Ranking and Mapping of Congestion Hotspots

Identification of Congestion Hotspots

Following the assessment of alternative-route performance and junction-level traffic patterns, the observed traffic counts were further analysed to identify congestion hotspots within the study area. Peak and off-peak vehicle counts recorded at the critical junctions were used to determine locations experiencing relatively high traffic concentrations. The results are presented in Table 7.

Table 7: Peak and Off-Peak Traffic Counts for Identification of Congestion Hotspots

Junction	Vehicle Count (Peak)	Vehicle Count (Off-Peak)
Eleyele	155	120

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Olubuse	118	94
Palace	99	84

Source: Author's analysis, 2025.

The results in Table 7 show that Eleyele Junction recorded the highest traffic count during both peak and off-peak periods, followed by Olubuse Junction and Palace Junction. Eleyele recorded 155 vehicles during the peak period and 120 vehicles during the off-peak period, while Olubuse recorded 118 and 94 vehicles, respectively. Palace recorded the lowest counts, with 99 vehicles during the peak period and 84 vehicles during the off-peak period.

The relatively high traffic volumes recorded at Eleyele indicate a concentration of traffic demand and identify the junction as a potential congestion hotspot. The persistence of relatively high traffic volumes during both peak and off-peak periods further suggests that the junction was under sustained traffic pressure rather than experiencing congestion only during peak periods. The comparatively lower traffic volumes at Palace indicate a lower level of traffic concentration, although the increase between off-peak and peak periods still indicates susceptibility to congestion.

The observed pattern is consistent with the view that junctions characterised by high directional demand and constrained road capacity are more likely to experience traffic bottlenecks during periods of construction and route diversion (Adebayo and Olayemi, 2021). The traffic-count results were therefore used as the basis for further ranking of the identified congestion hotspots

Ranking Congestion Hotspots Using Peak-To-Off-Peak Ratio

To further assess the temporal intensity of traffic concentration at the identified junctions, the peak-to-off-peak traffic ratios were calculated. The results are presented in Table 8.

Table 8: Peak-to-Off-Peak Ratios from Vehicle Counts

Junction	Vehicle Count (Peak)	Vehicle Count (Off-Peak)	Peak-to-Off-Peak Ratio
Eleyele	155	120	1.29
Olubuse	118	94	1.26
Palace	99	84	1.18

Source: Author's analysis, 2025

The results in Table 8 show that all three junctions recorded peak-to-off-peak ratios greater than 1.0, indicating higher traffic volumes during peak periods than during off-peak periods. Eleyele recorded the highest ratio of 1.29, followed by Olubuse with 1.26 and Palace with 1.18.

The ratio of 1.29 for Eleyele indicates that peak-period traffic was approximately 29% higher than off-peak traffic, making it the junction with the greatest relative increase in traffic demand. Olubuse also recorded a substantial increase of approximately 26%, while Palace recorded an increase of approximately 18%. These results indicate that Eleyele experienced both the highest absolute traffic volume and the greatest relative increase in peak-period traffic.

The pattern suggests that construction-related traffic redistribution and the use of alternative routes increased pressure on the major junctions, particularly Eleyele. The results are consistent with the volume-to-capacity concept, which indicates that congestion becomes more pronounced as traffic demand approaches or exceeds available road capacity (Papacostas and Prevedouros, 2001). The comparative ranking of the junctions is further illustrated in Figure 9.

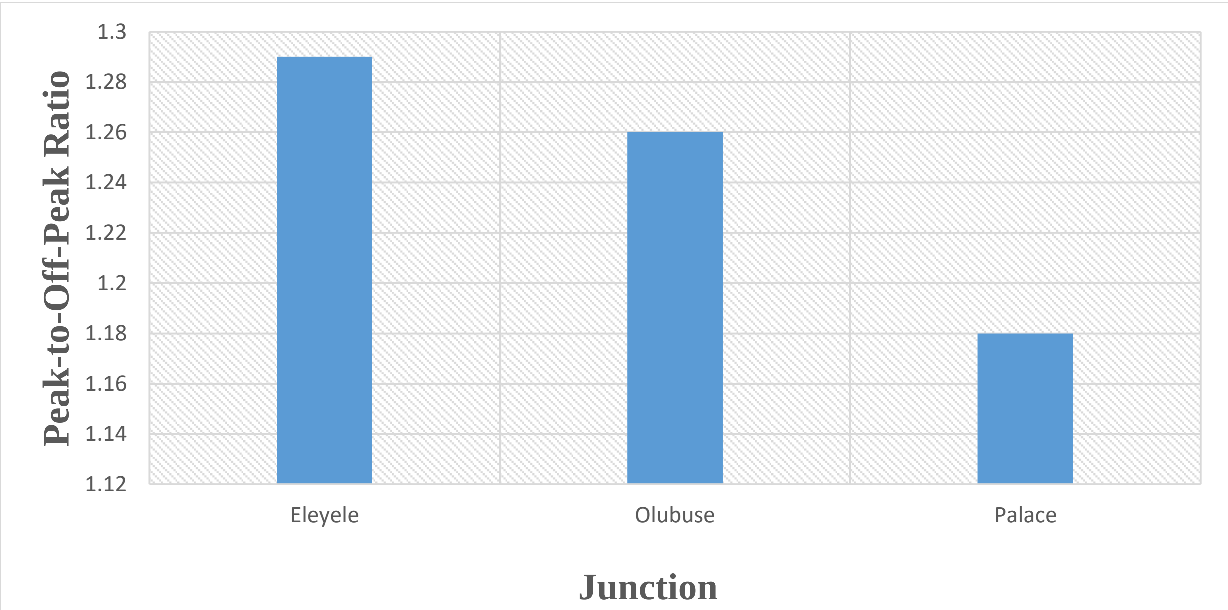

Figure 9: Ranking of Congestion Hotspots Using Peak-to-Off-Peak Traffic Ratios

Source: Author's analysis, 2025.

Spatial Identification of Traffic Congestion Hotspots

The spatial distribution of the identified congestion hotspots is presented in Figure 10. The map identifies three levels of congestion within the study area based on the results of the traffic-volume and peak-to-off-peak analyses.

High Congestion Zone – Eleyele Junction:

Eleyele Junction represents the most critical congestion hotspot. Its classification as a high-congestion zone is supported by its highest peak and off-peak traffic volumes and the highest peak-to-off-peak ratio. The junction is located at the intersection of important routes connecting Obafemi Awolowo University Road and Sabo Road. The concentration of traffic at this location may be associated with its strategic position within the road network, high vehicular demand and the redistribution of traffic resulting from the flyover construction.

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Moderate Congestion Zone – Olubuse Junction:

Olubuse Junction represents a moderate congestion zone. Although it recorded lower traffic volumes than Eleyele, its location within an important activity area and its connection with feeder routes expose it to traffic interactions associated with commercial, institutional and other urban activities. The relatively lower peak-to-off-peak ratio indicates less pronounced temporal variation in traffic demand compared with the other identified junctions.

Lower Congestion Zone – Palace Junction:

Palace Junction represents the lowest congestion zone relative to Eleyele and Olubuse junctions based on the spatial classification presented in Figure 10. Although Olubuse recorded the second-highest peak and off-peak traffic volumes and a peak-to-off-peak ratio of 1.26, its spatial classification should be interpreted in relation to the overall hotspot-mapping criteria used in the study. The availability of alternative routes and the surrounding road-network configuration may have contributed to its ability to distribute traffic demand.

The spatial pattern therefore demonstrates that congestion during the flyover construction period was not uniformly distributed across the study area. Rather, traffic pressure was concentrated at particular junctions, with Eleyele emerging as the most critical hotspot. The spatial identification of these locations provides a basis for understanding the relationship between construction-induced route diversion, traffic redistribution and junction-level congestion.

The hotspot ranking based on the peak-to-off-peak traffic ratio placed Eleyele Junction first (1.29), followed by Olubuse Junction (1.26) and Palace Junction (1.18). However, the spatial hotspot classification derived from the GIS analysis categorised Eleyele Junction as a high congestion zone, Olubuse Junction as a moderate congestion zone, and Palace Junction as the lowest congestion zone. The difference between the numerical ranking and the spatial classification reflects the fact that the hotspot classification considers the spatial distribution and concentration of congestion rather than the traffic ratio alone.

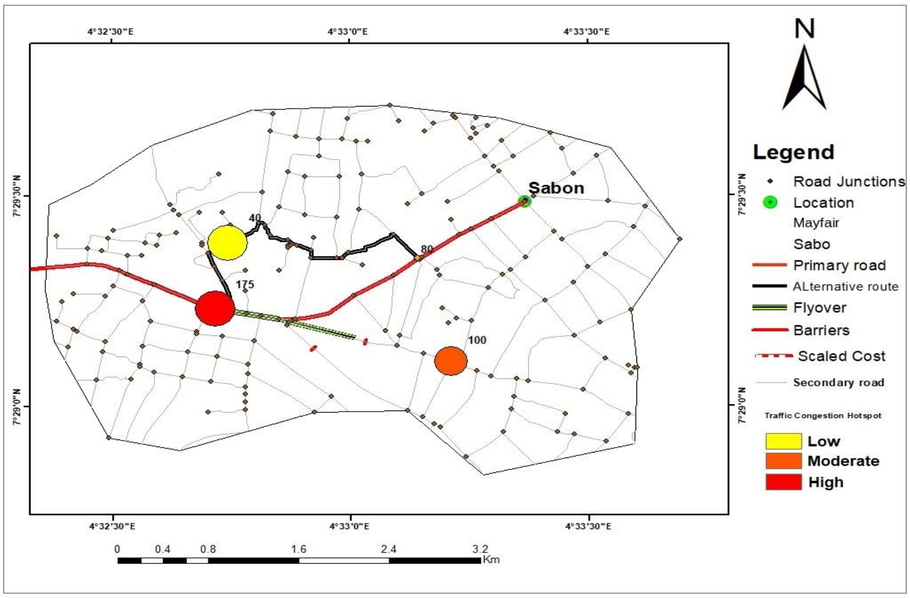

Figure 10: Hotspots of Traffic Congestion during the Construction Period

Source: Author's analysis, 2025.

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Congestion Hotspots Intensity

The KDE result as shown in Figure 11 revealed a clustering of very high congestion around Eleyele Junction, particularly in areas characterized by dense road networks and commercial activity. This spatial concentration highlights Eleyele as a critical congestion hotspot within the study area. These zones are characterized by: High vehicular throughput, especially during peak hours. Limited alternative routes, causing traffic funneling. Proximity to commercial and institutional centers, increasing trip generation rates. This finding aligns with Subair et al. (2024), who reported that urban corridors with limited modal diversity and high trip density tend to exhibit persistent congestion patterns. Moderate congestion zones, reflect transitional traffic behavior, often influenced by feeder roads and merging lanes. These areas may benefit from traffic signal optimization and improved lane discipline (Olayemi & Adebayo, 2022). Low congestion zones, typically located in residential area like Green Top Street, show minimal traffic intensity. This is consistent with Ajayi et al., (2021), who found that residential street networks with multiple dispersal points reduce congestion by decentralizing traffic flow.

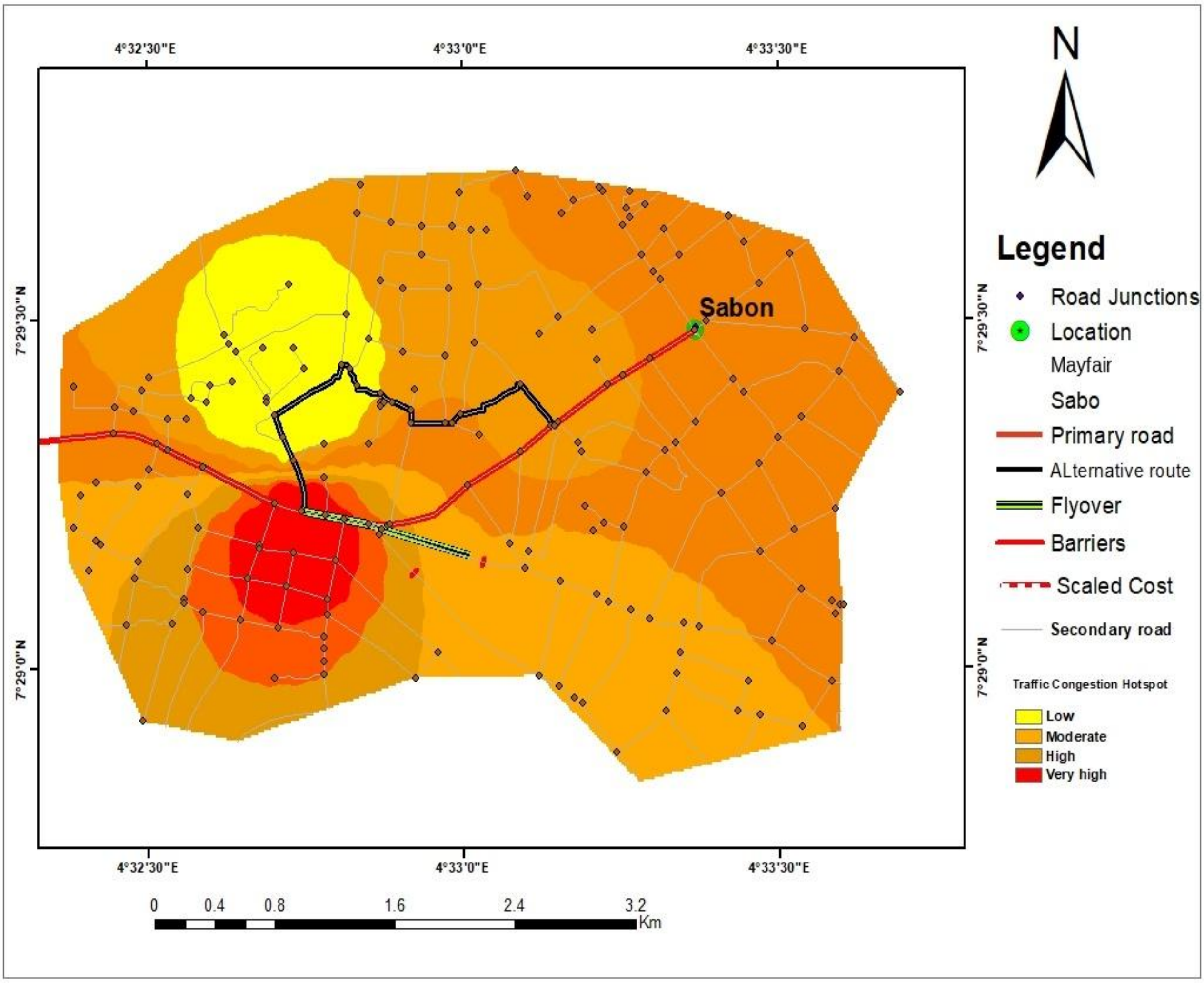

Figure 11: Congestion Hotspots Intensity

Source: Author's analysis, 2025.

POLICY AND PRACTICAL RECOMMENDATIONS

Based on the findings of the study, several practical measures are recommended to improve traffic management during major urban road construction projects. First, traffic signal timings at intersections receiving diverted traffic should be reviewed and optimized according to observed traffic volumes and peak-period demand. Intersections experiencing increased traffic from construction-related diversions should be monitored regularly, with green-time allocation adjusted where necessary to reduce excessive queues and delays. Such adjustments should be reviewed periodically as construction activities and traffic diversion patterns change.

Second, temporary diversion signage should be provided at strategic locations along and around the construction corridor. Advance warning signs should be installed before closure points to provide motorists with sufficient time to identify and select alternative routes. Directional signs should clearly indicate available diversion routes and major destinations, while signs should be highly visible, standardized and maintained throughout the construction period. Where diversion arrangements change, existing signs should be promptly relocated or supplemented to prevent motorists from being directed towards restricted or closed sections.

Third, traffic authorities and project contractors should develop and implement a temporary traffic-management plan before major construction activities commence. The plan should identify designated diversion routes, critical intersections, pedestrian crossing points and emergency-access routes. GIS-based network analysis should be incorporated into the planning process to identify alternative routes and anticipate locations where diverted traffic may concentrate.

Fourth, traffic conditions along major diversion routes should be monitored throughout the construction period using periodic traffic counts, travel-time observations and field assessment of queues and delays. Where monitoring indicates that congestion has shifted from the construction site to an alternative route, traffic signal timings, diversion arrangements and other traffic-control measures should be reviewed and adjusted accordingly. This adaptive approach would enable traffic-management interventions to respond to changing construction and traffic conditions.

Finally, the study recommends that accessibility to businesses, residences and pedestrian facilities within the construction corridor be considered in temporary traffic-management plans. Clearly marked pedestrian routes and safe crossing points should be maintained, while access to affected businesses should be preserved where practicable. Advance communication of road closures and changes to diversion arrangements should also be provided to road users and affected stakeholders.

These measures would enhance the practical application of GIS-based traffic and socio-economic assessment in managing construction-related disruption. For urban planners and traffic-management authorities, integrating network analysis, field traffic observations and spatial impact assessment into construction planning can support more effective diversion management, traffic signal optimization and maintenance of accessibility within affected urban corridors.

CONCLUSION

This study assessed the geospatial impacts of flyover construction on travel time, traffic flow, and socio-economic activities in Ile-Ife, Nigeria, using GIS-based network analysis, traffic observations, and socio-economic survey data. The findings demonstrate that the construction period was associated with substantial variations in route performance, particularly in terms of travel time, delay, traffic volume, and accessibility. Peak-period travel times were consistently higher than off-peak travel times across the five assessed routes, with the Mayfair–Sabo route recording the highest congestion index (92%), followed by the Lagere–Ooni Palace route (83%). These findings highlight the uneven effects of construction-related traffic conditions across the road network.

The analysis further identified Eleyele, Olubuse, and Palace junctions as important traffic hotspots, with peak-period traffic volumes of 155, 118, and 99 vehicles, respectively. The peak-to-off-peak traffic volume ratios of 1.29, 1.26, and 1.18 also demonstrate differences in traffic intensity among the junctions. The spatial hotspot analysis complemented these traffic observations by identifying Eleyele as a high-intensity hotspot, Olubuse as a moderate hotspot, and Palace as a relatively lower-intensity hotspot. Together, these results demonstrate the usefulness of geospatial techniques for identifying locations experiencing different levels of traffic pressure during urban infrastructure construction.

The road network analysis showed that secondary roads constituted the dominant component of the study area's road network, accounting for 92.82% of the 9,252 mapped road segments. This indicates that secondary roads represented an important component of the network available for traffic diversion and movement during the construction period. However, the performance of alternative routes varied considerably, indicating that the availability of alternative roads alone does not necessarily guarantee efficient mobility. Their effectiveness depended on travel time, delay, congestion conditions, and junction-level traffic performance.

The socio-economic findings also indicate that the construction affected the accessibility and mobility of residents, commuters, and business operators within the study area. A substantial proportion of respondents reported increased travel time (82%), increased travel costs (58%), reduced ease of movement (63%), and poor route reliability (50%). The concentration of reported alternative-route use around the Mayfair–Sabo and Lagere–Ooni Palace corridors further demonstrates the importance of these routes during the construction period. These effects have implications for businesses and other socio-economic activities located within areas affected by changes in accessibility and traffic circulation.

Overall, the study demonstrates that flyover construction can produce interconnected spatial, traffic, mobility, and socio-economic effects within an urban road network. The integration of GIS-based network analysis, traffic hotspot assessment, and socio-economic survey data provides a useful framework for identifying these effects and supporting evidence-based transport planning. Future urban infrastructure projects in Ile-Ife and similar urban environments should therefore incorporate geospatial traffic assessment, effective alternative-route planning, junction-level traffic management, and measures to reduce accessibility and socio-economic disruptions throughout the construction period.

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