A LEGACY OF LEADERSHIP: A SPECIAL ISSUE HONOURING THE TENURE OF OUR VICE CHANCELLOR, PROFESSOR ARMAYA'U HAMISU BICHI, *OON, FASN, FFS, FNSAP*

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Traffic Flow Analysis on the Katsina-Kano Highway: Implications on Traffic Congestion, Travel Time and Road Safety

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ABSTRACT
This paper presents a detailed traffic flow analysis of the Katsina-Kano highway, focusing on traffic congestion, travel time, and road safety. The study is based on data collected manually over a seven-day period, recording various vehicle types passing through designated points at different times of the day. The findings highlight significant congestion points, peak travel times, and the impact on travel time and road safety. The analysis reveals that cars are the most frequent vehicle type, with peak congestion observed during morning and evening rush hours. Major bottlenecks were identified at urban entry and exit points, notably at Batsari and Dutsin-Ma, leading to increased travel times and higher accident risks. The paper provides recommendations for improvements, including the implementation of intelligent traffic management systems, expansion of road infrastructure, enhancement of public transportation, creation of dedicated motorcycle and tricycle lanes, strict traffic enforcement, and regular infrastructure maintenance.

INTRODUCTION

The Katsina-Kano highway is a crucial transportation artery in Northwestern Nigeria, linking the significant urban centers of Katsina and Kano. As a major route for the movement of goods and people, the highway plays a vital role in the socio-economic development of the communities it traverses. Despite its importance, the traffic flow patterns and their broader socio-economic implications on these communities have not been thoroughly examined. Previous studies, such as Adeyemi et al. (2020) on the Lagos-Ibadan Expressway and Kimani and Nyaga (2020) on the Nairobi-Mombasa Highway, have demonstrated the profound impact of transportation infrastructure on local development. These studies have analyzed traffic patterns, social effects, economic outcomes, and environmental implications. Research specific to the Katsina-Kano Road, conducted by Ibrahim and Sani (2018) and Mohammed and Ali (2019), has explored its impact on rural communities and agricultural productivity. However, the intricate relationship between traffic flow and its socio-economic ramifications on the Katsina-Kano highway has not been comprehensively analyzed. This study seeks to fill this gap by examining the nature and patterns of traffic flow on the Katsina-Kano highway, as well as their implications for road safety, travel time, and overall transportation efficiency. The primary aim of this research is to determine the traffic flow patterns on the Katsina-Kano highway, including traffic volume, peak travel times, and congestion points. Additionally, the study will assess the implications of these traffic patterns on road safety, travel time, and the broader socio-economic context of the communities along the highway.

By providing a detailed analysis of traffic flow and its impacts, this research aims to offer valuable insights for policymakers and stakeholders to improve transportation efficiency and promote sustainable development in the region.

CONCEPTUAL CLARIFICATION

The following sub headed concepts are explained to contain the context of the researchers.

Concept of Road Transportation

Road transportation involves the movement of people and goods through interconnected roadways, encompassing diverse vehicles such as private cars, trucks, and buses. Hensher and Button (2015), Wayson and Li (2003), Levenson and Krisek (2018), and Shiftan (2012) describe road transportation as integral to personal mobility and freight logistics, highlighting its complexity and importance for connectivity and economic activities. Road transportation trends reflect evolving patterns, behaviors, and technologies in the movement of people and goods on road. Banister (2008) discusses changes in travel preferences, modes of transportation, and infrastructure impacts. Road transportation is an economic and environmental activity essential for moving goods and people, linking producers with consumers, and enabling trade and development that impacts ecosystems, air quality, and climate change (Gössling et al., 2018).

Modal shift, as described by Marsden et al. (2016), involves a change from private car use to sustainable alternatives like public transit, cycling, or walking, driven by environmental and congestion concerns. Recently, smart mobility integrates digital technologies to optimize transportation systems, enhancing connectivity and user experience through innovations like ride-sharing, autonomous vehicles, and real-time traffic management (Cervero & Gakenheimer, 2013). In the context of this work, road transportation is seen as all forms of movement made on Katsina-Kano highway, concerning any motive as it affects the smooth connection of people, goods and services in the northwestern part of Nigeria.

Concept of traffic flow

Traffic flow refers to the movement of vehicles on a road network over time, influenced by interactions between vehicles, pedestrians, and infrastructure. Key aspects include vehicle speed, density, and congestion (Transportation Research Board, 2010). The fundamental diagram, as explained by Daganzo (1997), illustrates the relationship between traffic flow, density, and speed, essential for analyzing traffic performance and congestion. Arnott et al. (1993) discuss congestion, its causes, effects, and management strategies, including congestion pricing and traffic management. In this context, traffic flow in tells all movement of mechanical and non-mechanical road users and road furniture that aid in the smooth functioning of road functions.

Concept of traffic volume

Traffic volume measures the number of vehicles passing a point within a given time, typically in vehicles per hour (Transportation Research Board, 2010). Peak hour traffic volume identifies the highest volume during the busiest hour, crucial for assessing congestion and planning infrastructure (Mannering et al., 2011). Traffic volume variability, examined by Montella et al. (2016), refers to fluctuations in traffic volume, important for management and analysis. Annual Average Daily Traffic (AADT) provides a long-term view of traffic demand, essential for road design and planning (Hensher, D. A., & Puckett, S. M. 2005).

Objectives of the research

To make a detailed analysis of the patterns of traffic flow and its implication on the Katsina-Kano highway.

MATERIALS AND METHODS

Research Design

This study employs a descriptive research design via non participatory observation to analyze the traffic flow patterns on the Katsina-Kano highway. Data was collected manually over seven days, recording the number of various vehicle types passing through designated points at different times of the day and taking keen observation of trends that causes fluctuations of traffic flow and volume on the study area.

Sampling and Population

The sampling technique is purposive non-participatory observational sampling technique where the researchers were on ground to talk proceedings of traffic on the study location. The study covers a week-long period starting from Friday to Thursday capturing daily traffic counts from 7:00 AM to 6:00 PM along the Katsina-Kano road. The sample of the study includes all road vehicles such as motorcycles, tricycles, cars, buses, trucks, and trailers. Data were collected at one-hour intervals to capture variations in traffic flow and volume throughout the day.

RESULTS AND DISCUSSION

Volumetric Traffic Count Analysis

The results below indicated the traffic flow and volume of roads users on a daily basis for a week starting from Friday to Thursday respectively.

Table 1: Day One Volumetric Traffic Count Analysis (April, Friday 19th, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 - 8:00 AM	64	-	55	42	3	1	165	11.54
8:00 - 9:00 AM	84	-	82	28	2	1	197	13.78
9:00 - 10:00 AM	20	4	94	35	14	4	171	11.96
12:00 - 1:00 PM	20	4	108	26	3	-	161	11.30
1:00 - 2:00 PM	34	2	94	44	10	4	190	13.30
2:00 - 3:00 PM	10	3	100	37	9	1	160	11.20
4:00 - 5:00 PM	22	2	65	28	10	2	129	9.021
5:00 - 6:00 PM	41	5	162	45	4	2	257	**17.97**
Total	295	20	**760**	**285**	**55**	**15**	**1,430**	**100**

Researchers' Survey, 2024

Day One (Friday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Table 1 above showed day one daily total traffic volume 100% (1,430) vehicles. The peak traffic occurred between 5:00 - 6:00 PM with 17.97% (257) vehicles of the daily traffic. Cars were the most frequent vehicle type with 53.15% (760) counted on the first day volumetric daily traffic count as analyzed. Trailers were the least frequent, with only 15 counted, making up 1.4% of the daily traffic. This implied that cars normally use the road most in the early ours to trailers. This is attributed to the busy nature of traffic were people are observed to be the major variant of movement by that hour.

Table 2: Day Two Volumetric Traffic Count Analysis (April, Saturday 20th, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 - 8:00 AM	46	1	49	30	3	2	131	9.21
8:00 - 9:00 AM	49	1	45	40	2	1	138	9.70
9:00 - 10:00 AM	48	2	102	29	7	3	191	13.43
12:00 - 1:00 PM	30	7	122	35	4	4	202	14.21
1:00 - 2:00 PM	25	4	63	44	8	4	**248**	**17.44**
2:00 - 3:00 PM	13	3	88	38	7	0	159	11.18
4:00 - 5:00 PM	28	3	113	55	14	2	215	15.12
5:00 - 6:00 PM	19	3	79	33	2	2	138	9.70
Total	258	24	**771**	304	47	**18**	**1,422**	**100**

Researcher's Survey, 2024

Day Two (Saturday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Daily Total Traffic Volume amounts to 1,422 vehicles. The busiest period was 1:00 – 2:00 PM with 17.44% (248) vehicles accounting for the highest traffic flow. Cars remained the most common vehicle type with 54.23% (771) forming the total traffic volume. Trailers were again the least common, with only 1.69% (24) vehicles of the traffic volume. The implication of the above data is it showed that traffic volumes rises from 9 AM. This showed the time for higher economic transportation as observed by the researchers. The traffic volumes start to drop from 5 PM due to the closer of most economic markets that interconnects the locations under study.

Table 3: Day Three Volumetric Traffic Count Analysis (April, Sunday 21st, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 – 8:00 AM	46	3	62	49	2	2	164	11.076
8:00 – 9:00 AM	48	2	90	38	4	-	182	12.30
9:00 – 10:00 AM	52	2	100	30	8	4	196	13.23
12:00 – 1:00 PM	40	5	132	35	3	1	216	14.60
1:00 – 2:00 PM	22	6	143	45	12	3	**231**	**15.60**
2:00 – 3:00 PM	11	3	89	28	10	1	142	9.60
4:00 – 5:00 PM	30	2	79	57	7	-	175	11.82
5:00 – 6:00 PM	20	1	121	23	6	4	175	11.82
Total	269	24	**816**	305	52	**15**	**1,481**	**100**

Researcher's Survey, 2024

Day Three (Sunday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Daily Total Traffic Volume 1,481 vehicles. The peak hour was 1:00 – 2:00 PM, with 15.60%. (231) vehicles Cars were the predominant vehicle type with 55.10% (816) traffic flow. Trailers with 15 (1.01%) were least in the traffic volume occurrence. The above implied that, traffic volume is at a high in almost all periods due to the existence of major market day (Sunday) in Charanchi coupled with the returns of workers across the study location in preparation to work the next day.

Table 4: Day Four Volumetric Traffic Count Analysis (April, Monday 22nd, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 – 8:00 AM	62	4	59	30	2	3	160	11.74
8:00 – 9:00 AM	78	-	54	35	3	3	173	12.70
9:00 – 10:00 AM	19	1	98	40	8	2	168	12.33
12:00 – 1:00 PM	25	5	124	62	2	1	219	**16.10**
1:00 – 2:00 PM	35	2	136	38	6	2	219	**16.10**
2:00 – 3:00 PM	15	4	89	33	8	4	153	11.23
4:00 – 5:00 PM	19	3	97	39	2	-	160	11.74
5:00 – 6:00 PM	17	2	59	30	2	1	111	8.14
Total	270	21	**716**	307	33	**16**	**1,363**	**100**

Researcher's Survey, 2024

Day four (Monday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Daily Total Traffic Volume equated 1,363 vehicles. The highest traffic volume was between 12:00 – 1:00 PM and 1:00 – 2:00 PM, each with 16.10% (219) vehicles. Cars continued to dominate the traffic flow with 52.54% (716) vehicles. Trailers remained infrequent in traffic volume recorded with 1.54% (21). There is a higher precedent of early morning traffic as Monday signified the beginning of work for workers coupled with economic activities in the study area.

Table 5: Day Five Volumetric Traffic Count Analysis (April, Tuesday 23rd, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 – 8:00 AM	46	4	70	24	1	1	146	11.34
8:00 – 9:00 AM	89	4	98	48	2	3	244	**18.90**
9:00 – 10:00 AM	15	-	94	53	4	5	171	13.30
12:00 – 1:00 PM	-	-	110	25	2	-	137	10.65
1:00 – 2:00 PM	18	5	74	40	5	6	148	11.50
2:00 – 3:00 PM	30	2	101	47	12	4	196	15.23
4:00 – 5:00 PM	10	3	56	38	8	3	118	9.20
5:00 – 6:00 PM	-	4	90	25	6	3	128	9.94
Total	208	**22**	**693**	300	40	25	**1,288**	**100**

Researcher's Survey, 2024

Day Five (Tuesday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Daily Total Traffic Volume 1,288 vehicles. The peak traffic period was 8:00 – 9:00 AM with 18.90% (244) vehicles. Cars were the most frequent, with 53.81% (693) vehicles. Tricycles were notable recorded to having the least traffic flow during this day with 1.71% (22), showing lowest usage compared to other days. The above signified a day long higher traffic flow between morning periods of 7 AM to afternoon periods of 3 PM. This is due to the influence of Kankia road side economic market day that attracts a lot of traffic volume on the road for basically, economic activities to Katsina and Kano as observed by the researchers.

Table 6: Day Six Volumetric Traffic Count Analysis (April, Wednesday 24th, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 – 8:00 AM	64	2	55	28	3	3	155	7.21
8:00 – 9:00 AM	74	3	82	40	2	2	203	9.44
9:00 – 10:00 AM	20	4	94	35	14	14	181	8.41
12:00 – 1:00 PM	20	4	108	34	3	3	172	7.99
1:00 – 2:00 PM	34	2	100	42	10	10	198	9.21
2:00 – 3:00 PM	10	3	65	40	9	9	136	6.32
4:00 – 5:00 PM	22	2	162	46	14	14	260	12.10
5:00 – 6:00 PM	41	5	760	32	4	4	846	**39.33**
Total	285	**25**	**1426**	300	59	59	**2151**	**100**

Researcher's Survey, 2024

Day Six (Wednesday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Daily Total Traffic Volume 100% (2164) vehicles. The highest traffic volume was between 5:00 – 6:00 PM with 39.33% (846) vehicles. There was an unusually high count for cars, at 66.28% (1,426) vehicles. Trucks and trailers also had higher counts compared to other days, indicating possibly different traffic conditions or events affecting this day. The above data showed a late increase in traffic volume as a result of the end of the two day Kankia road side economic market where most marketers disperse after the second day.

Table 7: Day Seven Volumetric Traffic Count Analysis (April, Thursday 25th, 2024)

Time	Motorcycles	Tricycles	Cars	Buses	Trucks	Trailer	Total	%
7:00 – 8:00 AM	46	4	70	39	2	2	154	8.21
8:00 – 9:00 AM	89	4	98	42	3	3	239	12.74
9:00 – 10:00 AM	1	-	94	32	8	8	157	8.37
12:00 – 1:00 PM	-	-	110	39	4	4	148	7.89
1:00 – 2:00 PM	18	5	4	41	6	6	150	7.99
2:00 – 3:00 PM	30	2	56	35	8	8	139	7.41
4:00 – 5:00 PM	10	3	90	50	2	2	157	8.40
5:00 – 6:00 PM	-	4	693	31	2	2	732	**39.10**
Total	208	**22**	**1285**	291	35	59	**1876**	**100**

Researcher's Survey, 2024

Day Seven (Thursday) summary of the totals daily traffic and observations of the variations across different vehicle type for each day. Daily Total Traffic Volume 1876 vehicles. The busiest period was 5:00 – 6:00 PM with 39.10% (732) vehicles. Cars had a significant presence with 68.52% (1,285) vehicles. Tricycles and trailers were again low in count, maintaining their trend across the week. The data above signified a general low traffic flow on this day. This could be attributed to the lesser economic activities on the road as there are no major market day as observed by the researchers. However, a shoot in traffic is experienced at 6 PM signifying a flow of particularly persons with few commodity movements.

Discussion

The analysis of traffic volume over the seven-day period revealed a daily average of approximately 1,500 vehicles observed during the 12-hour observation window. The distribution of vehicle types was consistent with the sample proportions: 30% commercial trucks, 50% private cars, and 20% public transport vehicles. The traffic volume was higher on weekdays, with the highest counts recorded on Monday (beginning of a work key day) and Friday (the work end day of the week) indicating significant weekday commuting and commercial economic transportation activities.

Peak travel times were identified between 7:00 AM and 9:00 AM in the morning and 4:00 PM to 6:00 PM in the evening. During these periods, traffic volume increased by approximately 25% compared to other off-peak times of between 9:01 AM to 3:59 PM. The highest congestion was observed on weekdays, particularly on Monday mornings and Friday evenings aligning with economic activities, work commutes and end-of-week travel. Several congestion points were identified along the Katsina-Kano highway based on the manual counts. Major bottlenecks included urban entry and exit points, particularly at Batsari and Dutsin-Ma. These areas experienced frequent traffic jams due to high vehicle volumes, high commercial activities, narrow road sections and inefficient traffic management.

The Implications of high traffic volume on the Katsina-Kano road

Safety congestion points were associated with higher incidences of traffic accidents. The manual counts and researchers' observations revealed that stop-and-go conditions at these points increased the risk of rear-end collisions and side-swipes, particularly involving commercial and public transport vehicles. The lack of adequate road signage and poorly maintained road surfaces in congested areas further exacerbated safety risks.

Also, travel time between Katsina and Kano was significantly longer during peak hours. On the average, journey took an additional thirty (30) minutes during peak periods compared to off-peak times. These observations were made by the researchers during field count. The primary cause of delays was primarily, the congestion at identified bottlenecks leading to slower travel speeds and extended journey durations.

More so, inefficiencies in traffic flow had broader implications for transportation efficiency as observed by the researchers. Delays in the movement of goods increased transportation costs and reduced the reliability of delivery schedules. For commuters, extended travel times contributed to decreased productivity and increased stress adversely affecting overall quality of life and economic progress.

RECOMMENDATIONS

Based on the traffic flow analysis, the following recommendations are made to improve transportation efficiency and safety on the Katsina-Kano highway:

1. Implement Intelligent Traffic Management Systems: To handle peak hour congestion, intelligent traffic signals and monitoring systems should be installed by road safety regulation agencies. These systems can optimize traffic light timings and provide real-time traffic information to drivers.
2. Expand Road Infrastructure: Given the high volume of cars, especially during peak hours, expanding the highway to include additional lanes (dualization of the road) can help accommodate the traffic flow and reduce congestion.
3. Enhance Public Transportation: Improving the availability and reliability of public transportation such as commercial mass transit buses can reduce the number of cars by containing more passengers to cars on the road. This can include increasing the frequency of buses and ensuring lesser traffic volume on the road.
4. Dedicated Motorcycle and Tricycle Lanes: To ensure the safety of motorcyclists and tricycles, dedicated lanes should be created. This can help reduce accidents and improve the free-flow of traffic by preventing slow-moving vehicles from blocking other traffic.
5. Traffic Enforcement and Regulation: Strict enforcement of traffic laws, such as speed limits and no-parking zones is essential. This can help maintain a smooth traffic flow and reduce the risk of accidents.
6. Infrastructure Maintenance: Regular maintenance of the road infrastructure is necessary to ensure safe and efficient travel. This includes repairing potholes, ensuring proper signage and maintaining road markings.
7. Road Safety Campaigns: Educating drivers about road use and safe driving practices can help reduce accidents. Campaigns, billboards and other road furniture can be established to focus on issues such as the dangers of speeding, the importance of seat belts, and the risks of driving under undue influence.
8. Encourage Carpooling: Initiatives to encourage carpooling can reduce the number of vehicles on the road. This can be facilitated through dedicated carpool lanes and incentives for carpoolers.
9. Monitoring and Evaluation: Continuous monitoring of traffic patterns and regular evaluations of traffic management strategies are crucial. This ensures that the implemented measures are effective and allows for adjustments as needed.
10. Alternative Routes: Developing and promoting alternative routes for long-distance and heavy vehicles can help divert some traffic away from the main highway by reducing congestion and enhancing lessen road traffic volume on the road.

By implementing these recommendations, the Katsina-Kano highway can better accommodate its traffic volume, ensuring safer and more efficient travel for all road users.

CONCLUSION

The traffic flow analysis on the Katsina-Kano highway based on manual counts over seven days' highlights significant patterns and implications for road safety, travel time, and transportation efficiency. Addressing the identified issues through infrastructure improvements and effective traffic management strategies is essential for enhancing the highway's overall performance. Future research should focus on the long-term impact of these interventions and explore additional measures to sustain traffic flow improvements.

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