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ROAD TRANSPORT INFORMATION SYSTEM: A PANACEA FOR ROAD TRANSPORT FACILITY MANAGEMENT IN KATSINA LOCAL GOVERNMENT, KATSINA STATE, NIGERIA

MUHAMMAD ZILKIFLU DABO AND SULAIMAN YUNUS

Department of Geography, Bayero University Kano

Authors email: syunus.geog@buk.edu.ng and zmdabo@yahoo.com

ABSTRACT

This study aimed at examining the spatial pattern of RTF within Katsina Local Government with a view to developing a comprehensive Road Transport Facility Information System (RTFIS) to enable efficient management and planning for sustainable development. Analogue record (maps and attributes) of the existing RTF were obtained from the relevant departments, and were updated with the data obtained through field and GPS surveys, and Google Earth image (2019). QGIS 3.8 software was used for Nearest Neighbor Analysis, developing comprehensive database and series of spatial and attributes queries in order to demonstrate the capability of Geospatial technology in efficient management of RTF information. The result revealed a dispersed distribution pattern of Roundabouts within the study area with nearest neighbor ratio of 1.3 and z-score value of 2.9. It is therefore recommended that the departments involved in RTF management should embrace Geospatial technology as one of the contemporary methods for efficient managing, manipulating, retrieving and updating RTF records for sustainable urban development.

Keywords: Road Transport Facility, Nearest Neighbor Analysis, Hyperlink, Spatial Queries

INTRODUCTION

GIS-based road Transport Information System (TIS) is a product of integration of the concepts of Geographic Information System (GIS) and Transportation Information System (TIS). Winter et al. (2010) states that TIS includes the interdisciplinary fields of mobility science (data-driven modeling of human and animal dynamics using location data) and computational transportation science (the application of computer science to understand and manage transportation systems). It is therefore not hyperbole to state that there is a revolution in the human sciences, including transportation and urban sciences, fueled by a stunning advancement in capabilities to capture, store and process data, as well as communicate information and knowledge derived from these data (Miller and Shaw, 2015). Transportation is one of the fastest growing of many fields in which GIS is used (Rodrigue et al, 2006). Diverse areas of transportation, including high-way and rail-way infrastructure management, international shipping, airport management, fleet logistics, traffic management and intelligent transportation systems (ITS), transit bus and rail service planning, transportation modeling, supply chain modeling, and others, are applying GIS to their work (ESRI, 2003). The breadth of the field of integration of GIS and transportation system provides large opportunities for the development of new and innovative applications in transportation system of different transportation organizations (Curtin, 2003). Since GIS have a seamless relation with space and location, given that their main objective as a tool is to store, retrieve, and facilitate the analysis of spatial data (Goodchild and Janelle, 2004), they have become one of the most powerful tools to support transportation studies and applications. Capitalizing on this relationship both academics and practitioners have focused their attention on research/work that makes use of GIS in transportation applications.

Road transport in Nigeria (like in most countries of the world) is by far the most dominant mode of transportation, carrying well over 90% of passenger and freight traffic, and serving as a true backbone for Nigeria's economy (Transport Research Board, 2017). Because a well maintained road transport asset is very important for the economic development of the nation, Road Management Information System is a crucial for successful and sustainable management of road transport facilities. Geospatial data are foundation for relevant and critical information for planning, engineering, asset management, and operations associated with every transportation mode at all levels of government and administration (Transport Research Board, 2017). Nigeria has the largest road network in West Africa and the second largest south of the Sahara with roughly 108,000 km of surfaced roads in 1990 (67,112 miles) (Miller and Shaw, 2015). Out of this total, 30,000 kilometers (18,642 miles) were paved, 25,000 kilometers (15,535 miles) were gravel, and 53,000 kilometers (32,935 miles) were unimproved earth. Much of the road system is in disrepair and barely useable. Massive traffic jams are very common in the large cities, there are also long delays in the movement of goods. Highway accidents and deaths are frequent, and have reached more than 30,000 and 8,000, respectively. However, they are poorly maintained and are often cited as a cause for the country's high rate of traffic fatalities. In 2004 Nigeria's Federal Roads Maintenance Agency (FERMA) began to patch the 32,000-kilometre federal roads network, and in 2005 FERMA initiated a more substantial rehabilitation. With respect to the quality of overall infrastructure, Nigeria was ranked number 125 out of 142 countries, with a value of 3.0 (1.3 below the mean value). Cameroon was ranked at 122 and Ghana at 90 (TIO, 2014). With regard to road quality, Nigeria was ranked at 120, with port infrastructure at 117, railroad quality at 104 and air transport quality at 104. There are almost 200,000 km of roads in Nigeria, 15 % of them paved (2012). There are over 3,500 km of railway and much of the network is single track (TIO, 2014).

Currently, comprehensive record about the number and other important attributes (such as length, width, type, category, date of construction, expiry date, and last date of maintenance) of road transport infrastructure in most Nigerian cities and Katsina town inclusive are seriously lacking. The few available ones are mostly in analogue form (paper based) and scattered between different offices within the transport ministry and other related departments. This makes it difficult to manage, manipulate, retrieve and update the information. Additionally, information on uses/functions (if available) of transport facilities are unstructured and as a result makes it time-consuming for end-users to extract information about specific functions or uses of the facilities. Records (spatial and attributes) about other related transport infrastructures such as bridges, flyovers, culverts and underpasses is also necessary especially for planning and development purposes. Comprehensive database on road traffic signs, junctions and U-turns which are also very important safe transport system and for future and sustainable development are also lacking. Some of the related studies conducted includes Cortes *et al.,* (2013); Herstein *et al.,* (2011); ESRI. (2011); Id and Morshed, (2007); Anderson *et al.,* (2010); Ryley *et al.,* (2014); Loidl *et al.,* (2016); Hasegawa, (2015); John, (2012); Strano *et al.,* (2012); Indira *et al.,* (2013).

In order to develop a functional and sustainable road transport management system, a comprehensive and digital GIS-based TIS is required to support decision-making process for sustainable urban development. This will enable the integration of spatial and attribute data of all available transport infrastructures. It will also provide for transport related data collection, integration, manipulation, analysis, spatial database design, and database queries in order to retrieve and update the information system whenever is necessary. This justifies the significance of this study.

MATERIALS AND METHODS

Study Area

Urban Katsina is the capital of Katsina State, it is located between latitude 12^0 45^1N and 13^0 15^1N and Longitude 7^0 30^1 and 8^0 00E. The location is at the extreme part of northern Nigerian, some 30km from the Nigeria-Niger boarder. The city is administratively headed by an emir, with district and ward as sub units for administrative convenience. Urban Katsina comprises of two local government areas, Katsina and some part of Batagarawa Local Government areas (Zayyana 2010). The main ethnic groups are the Hausa's and Fulani's. the Fulani has primarily settled or semi-settled cattle herders, and sometimes with some limited crop production activities. The Hausa's are largely crop cultivators, but who also often keep some animals. A history of association and interaction between the two ethnic groups has led to merger of culture and tradition, mainly the unifying influence of Islam, the Hausa language and inter-marriages. In addition, other ethnic groups with lower but still significant important in Katsina

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towns social and economic development include Igbo, Yoruba, Nupe, Kanuri Tiv and others (Zayyana 2010).

Population and Settlements

Urban Katsina has a fairly large population, enjoys Sub-Sahara African rate of population increase with average birth and deaths trates of 4.2% and 1.6% respectively (Zango, 2010). As of 1952 census, the population figure was 52,672 and rose to 223,644 in 1991, by then it had already acquired the status of a state capital. The population figure after the 2006 census was recorded to be 327,376 (National Population Commission, 2006). The settlement pattern has characterized by two categories base on population density. The first category is the high to medium density settlement is which include the Cikin Birni (Old City) with their peripheral areas respectively. While the second category is the low-density settlement of Government Reservation Areas (GRA), Kofar Marusa, Low Cost and New Layout among other. The Cikin Birni which is the old city and the most densely populated area in the metropolis have a unique cultural setting that affects the people in the area. Most buildings are made up of mud and clay, closely packed together and surround with walls (Hassan, 2008)

Land Use

Land use in the study area is dominated by urban activities, such as residential, institutional, commercial and industrial land use, with small area mostly undeveloped for farming. Aside from major urban land use mentioned above, other land use such as livestock production and gathering are also carried out in the area. Residential area covers most part of the study area, different land uses such as commercial, institutional, and educational are all located within the residential areas. *Sabuwar Unguwa* extension is the major area functioning as industrial layout. Industries such as steel rolling, packaging, beverage processing etc are found in this area. Commercial activities happened to be growing very fast in the area. There are many smalls and major central market. The popular markets here are Katsina central market, *Kofar Marusa* markets and the old market (*Tsohuwar Kasuwa)*. Also there are many department store shopping centers and supermarkets-where local, national and foreign commodities are sold. Institutional land uses can be found at various locations within urban Katsina. Tertiary institutions include Umaru Musa Yar'adua University, Fedral College of Education, Hassan Usman Katsina Polyethnic and School of Nursing and Midwifery in addition to numerous nursery/primary and secondary school both governmental and privately owned

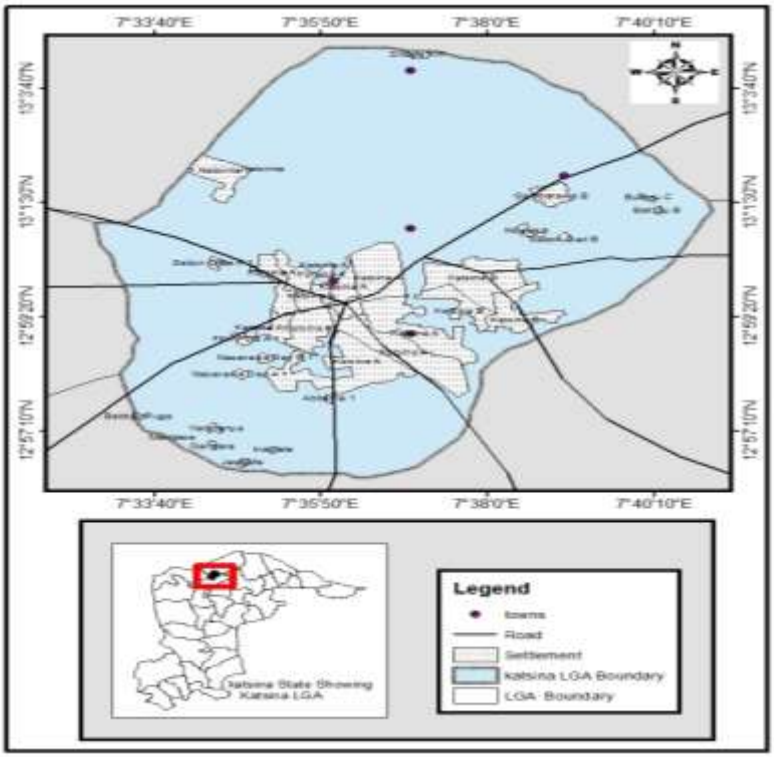


Figure 1: Katsina Local Government Area of Katsina State Source: Dept of Geog, BUK) (2019)

MATERIALS AND SOFTWARE USED

The various materials and software used for data collection and analysis are summarized and presented in Table 1.

Table1: Materials and Software used

Hardware/Software	Usage
Global Positioning System (GPS)	Used for collecting the spatial attributes/coordinates (lat & long) of road transport facilities to enable spatial mapping using the GIS software
Camera	Remote Sensing sensor mounted on Techno K9 platform (8 mega pixel) was used for capturing the images of the facilities in order to enable using hyper link to link the spatial data with the images
HP Laptop Computer (windows 8, processor: intel Pentium and system)	HP Laptop was used for processing and analyzing all the data gathered for the study.
Microsoft Word and Excel 2013	Used for compiling attribute information of the transport facilities and preparing locational data for onward importing into the GIS environment.
QGIS 3.8	Used as for mapping, designing, analysis, querying, and creation of geodatabase for RTFMS.

Types and Sources of Data

Both spatial and attribute data about road transport infrastructures were collected using GPS, and also consulting records from the related ministries. Satellite images from Google earth and road transport map of Katsina, documents on culverts, bridges and flyovers of Katsina LGA were also obtained from the related ministries and departmnts. The overall data types and sources are summarized in Table 2.

Table 2: Data types, sources and usage

Data required	Sources	Usage
Road transport base map	Ministry of Works Katsina State	Serve as basemap which was georeferenced and digitize. Used to identify, characterize and delineate the roads transport facilities for geospatial database creation.
Google Earth image	Google Applications, 2019	Used to update the analogue basemap from the ministry.
Road information Documents (attribute data)	Ministry of Works Katsina State	Provided the attribute data of the existing facilities to be used for inventory creation and database develpoment.
GPS and Camera	Field survey	For collecting coordinates points of the infrastructures and pictures for hyperlinking in order to see the nature of some of the facilities.

Methods of Data Analysis and Presentation
Nearest Neighbor Analysis was conducted to determine the spatial distribution of road transport infrastructures within the study area. Three stages (conceptual, logical and physical design) were used in designing and building the Geodatabase. Spatial join and hyperlink were used to integrate the spatial and non-spatial data to create road and other facility layers so as to develop the GIS-based RTIMS. Hyperlink tool was used to integrate displays (pictures showing the nature or condition of an infrastructure) for proper management of the system. Series of spatial and attribute queries based on different criteria were used in demonstrating various methods of retrieving information from the database developed.

RESULTS AND DISCUSSIONS

This section presents and discussed the results from the analysis conducted under the following subheadings: Updated RTF types and characteristics, spatial distribution of roundabouts, RTF spatial database and RTF database queries.

Updated RTF types and characteristics
Figure 2 present the updated RTF map of Katsina Local Government and were characterized using various symbols layer properties in the QGIS software. The road were categories into three classes (the Primary, Secondary and Tertiary roads) and the roundabouts and bridges/culverts were represented as point feature using different symbols respectively. The figure provides synoptic view of all available RTF within the study area and their topological relationships.

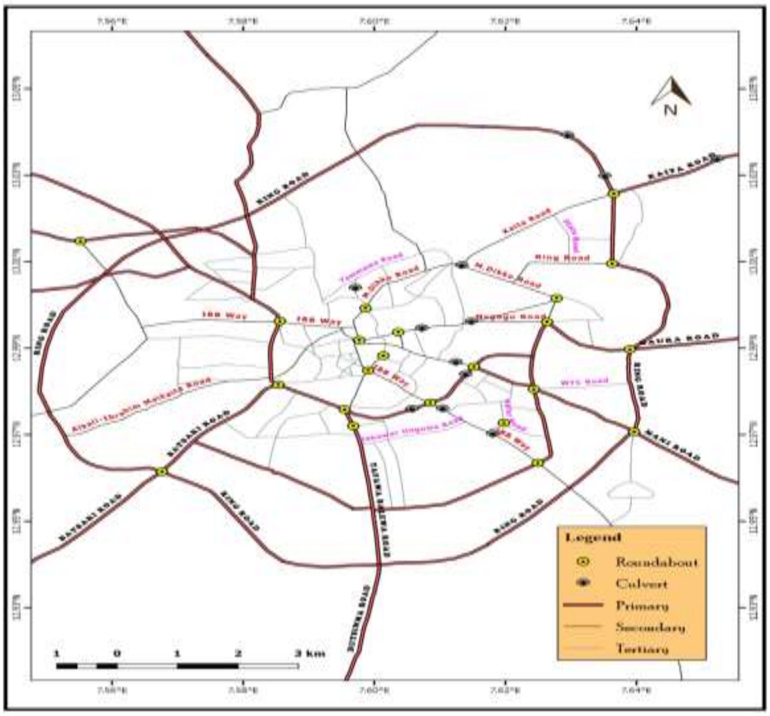


Figure 2: Road Transport Facilities in Katsina Local Government (Source: Author’s Analysis 2019)

Spatial Pattern of Roundabouts within Katsina LGA.
The distribution pattern of roundabouts in the study area was determined by Average Nearest Neighbor in QGIS 3.8 software interface. Figure 3 presented the average nearest neighbor summary for roundabouts in the study area. The result shows a dispersed distribution pattern of roundabouts in the area with nearest neighbor ratio of 1.340667 with critical value (z-score) of 2.914580 at 0.003562 level of significance (p-value). The dispersed pattern of roundabouts indicates low level of complexity in the transport system, while a clustered pattern signifies a complex transport system.

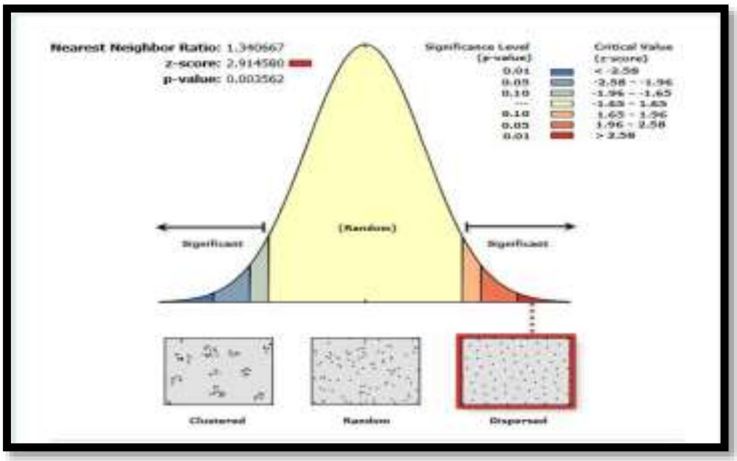


Figure 3: Distribution Pattern of Roundabout within Katsina LGA (Source: Author's Analysis 2019)

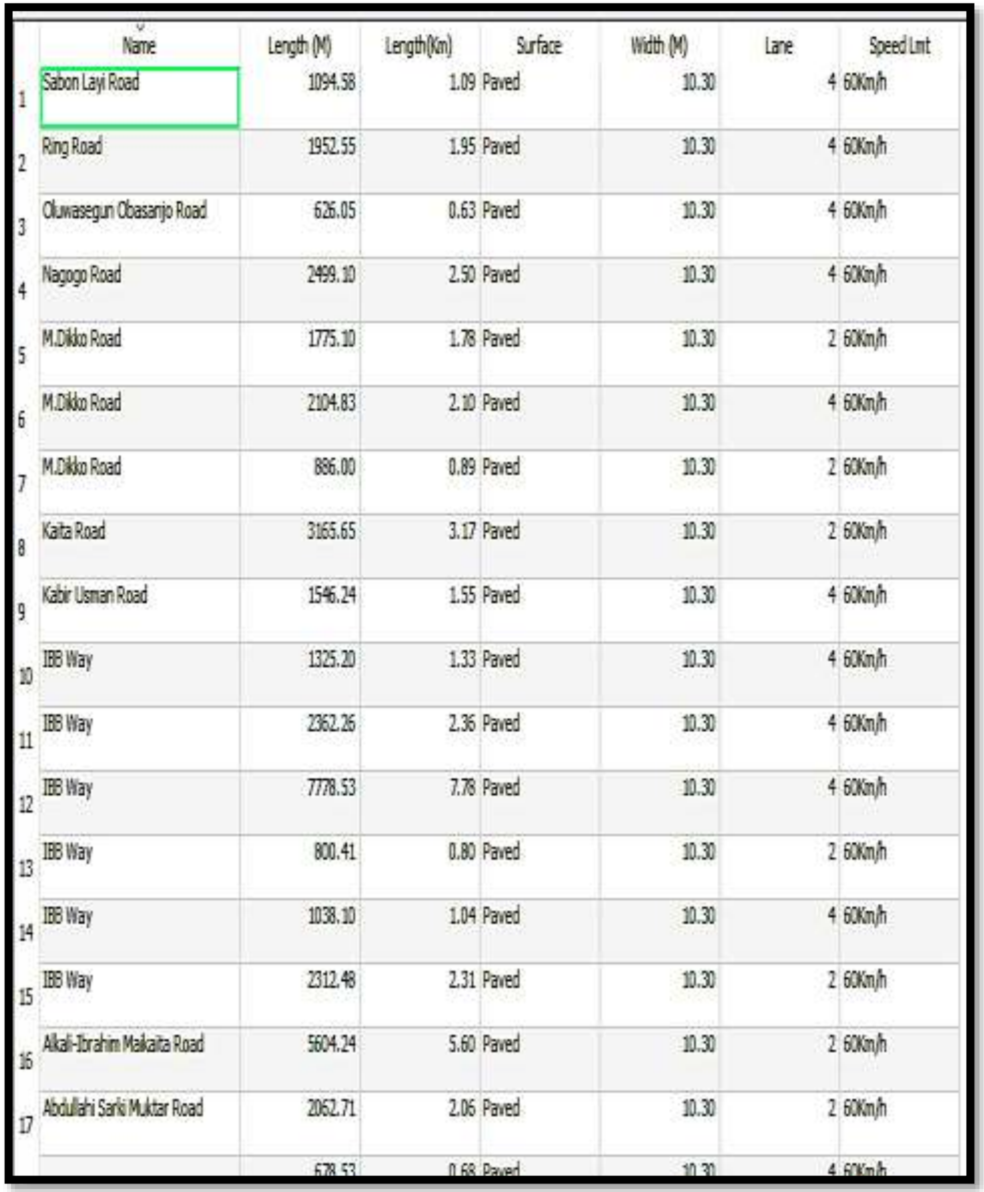
RTF Spatial Database in Katsina LGA

The data collected in the form of spatial, non-spatial and photographs were used to develop a comprehensive geodatabase of transport facilities in the study area. The interphase from the software showing the attributes of various RTI is presented in figures 4-8.

	Name	Length (M)	Length(Km)	Carriage	Lane	Surface	Width (M)	Speed Lmt
1	Yahaya Madawaki Road	1569.53	1.57	Dual	4	Paved	19.60	100km/h
2	Yahaya Madawaki Road	1203.93	1.20	Dual	4	Paved	19.60	100km/h
3	Yahaya Madawaki Road	1097.36	1.10	Dual	4	Paved	19.60	100km/h
4	Tafawa Balewa Road	4039.50	4.04	Dual	4	Paved	19.60	100km/h
5	Steel Rolling Road	3071.79	3.07	Dual	4	Paved	19.60	100km/h
6	Sarkin Aburahman Way	1649.31	1.65	Dual	4	Paved	19.60	100km/h
7	Ring Road	2132.29	2.13	Dual	4	Paved	19.60	100km/h
8	Ring Road	2008.53	2.01	Dual	4	Paved	19.60	100km/h
9	Ring Road	3114.89	3.11	Dual	4	Paved	19.60	100km/h
10	Ring Road	3828.83	3.83	Dual	4	Paved	19.60	100km/h
11	Ring Road	7527.03	7.53	Dual	4	Paved	19.60	100km/h
12	Murtala Muhammed Way	1697.40	1.70	Dual	4	Paved	19.60	100km/h
13	Murtala Muhammed Way	1269.74	1.27	Dual	4	Paved	19.60	100km/h
14	Murtala Muhammed Way	2910.02	2.91	Dual	4	Paved	19.60	100km/h
15	Murtala Muhammed Way	16656.28	16.66	Dual	4	Paved	19.60	100km/h
16	Mani Road	12558.61	12.56	Dual	4	Paved	19.60	100km/h
17	Kaita Road	9162.36	9.16	Dual	4	Paved	19.60	100km/h
18	Ibrahim Shehu Shema Way	1016.23	1.02	Dual	4	Paved	19.60	100km/h
19	Hassan Usman Road	2018.22	2.02	Dual	4	Paved	19.60	100km/h
20	Dutsinma Road	7300.71	7.30	Dual	4	Paved	19.60	100km/h
21	Daura Road	4663.53	4.66	Dual	4	Paved	19.60	100km/h
	Daura Road	4231.14	4.23	Dual	4	Paved	19.60	100km/h

Show All Features

Figure 4: Attributes of the Primary Roads (Source: Author's Analysis 2019)



	Name	Length (M)	Length(Km)	Surface	Width (M)	Lane	Speed Lmt
1	Sabon Layi Road	1094.58	1.09	Paved	10.30	4	60Km/h
2	Ring Road	1952.55	1.95	Paved	10.30	4	60Km/h
3	Oluwasegun Obasanjo Road	626.05	0.63	Paved	10.30	4	60Km/h
4	Nagogo Road	2499.10	2.50	Paved	10.30	4	60Km/h
5	M.Dikko Road	1775.10	1.78	Paved	10.30	2	60Km/h
6	M.Dikko Road	2104.83	2.10	Paved	10.30	4	60Km/h
7	M.Dikko Road	886.00	0.89	Paved	10.30	2	60Km/h
8	Kaita Road	3165.65	3.17	Paved	10.30	2	60Km/h
9	Kabir Usman Road	1546.24	1.55	Paved	10.30	4	60Km/h
10	IBB Way	1325.20	1.33	Paved	10.30	4	60Km/h
11	IBB Way	2362.26	2.36	Paved	10.30	4	60Km/h
12	IBB Way	7778.53	7.78	Paved	10.30	4	60Km/h
13	IBB Way	800.41	0.80	Paved	10.30	2	60Km/h
14	IBB Way	1038.10	1.04	Paved	10.30	4	60Km/h
15	IBB Way	2312.48	2.31	Paved	10.30	2	60Km/h
16	Alkali-Ibrahim Makaita Road	5604.24	5.60	Paved	10.30	2	60Km/h
17	Abdullahi Sarki Muktar Road	2062.71	2.06	Paved	10.30	2	60Km/h
		678.53	0.68	Paved	10.30	4	60Km/h

Figure 5: Attributes of the Secondary Roads (Source: Author's Analysis 2019)

	Name	Lane	Width (M)	Speed Lmt	Length (M)	Length(Km)
1	Yarkutungu Road	2	1.50	60Km/h	1076.19	1.08
2	Yammawa Road	1	1.50	60Km/h	3733.79	3.73
3	WTC Road	2	1.50	60Km/h	1600.41	1.60
4	Waziri Zayyana Road	2	1.50	60Km/h	1445.54	1.45
5	Unguwar Alkali Road	2	1.50	60Km/h	659.83	0.66
6	Tsohowar Kasuwa Road	2	1.50	60Km/h	609.64	0.61
7	State Road	1	1.50	60Km/h	1294.59	1.29
8	State Road	2	1.50	60Km/h	716.88	0.72
9	State Road	1	1.50	60Km/h	940.16	0.94
10	Shararrar Pile Road	2	1.50	60Km/h	1153.30	1.15
11	Sarki Dikko Road	2	1.50	60Km/h	1275.78	1.28
12	Sabuwar Unguwa Road	1	1.50	60Km/h	1853.16	1.85
13	Sabowar Kasuwa Road	1	1.50	60Km/h	849.34	0.85
14	Medical Centre Road	1	1.50	60Km/h	1570.78	1.57
15	Lawrence Onoja Road	2	1.50	60Km/h	1552.24	1.55
16	Korau Street	2	1.50	60Km/h	1024.06	1.02
17	Kankia Road	2	1.50	60Km/h	454.40	0.45
18	Kafur Road	2	1.50	60Km/h	1382.14	1.38
19	Jibia Road	2	1.50	60Km/h	579.81	0.58
20	Guga Road	1	1.50	60Km/h	958.27	0.96
21	Dutsinma Street	1	1.50	60Km/h	626.03	0.63
	Daki Tara Road	1	1.50	60Km/h	767.18	0.77

Show All Features

	X	Y	Name	Date of Co	Name of Co	Remark	Picture
1	7.638530859008120	13.025720750566700	Shinkafi Rounabout	2012-2014	Mother Cat	Uncompleted	C:\Users\Hp User\Desktop\L.LAW...
2	7.638287701977290	13.009518389010401	Government House Roundabout	2012-2014	Mother Cat	Uncomplited	IMGs/Round_About/Government H...
3	7.640994849935250	12.989697040713301	Airport Roundabout	2012-2014	Borini Prono	Uncompleted	IMGs/Round_About/Airport.png
4	7.641651373841220	12.970645689589899	General Hospital Roundabout	2017-2018	China Civil	Completed	IMGs/Round_About/General Hospit...
5	7.552315082512970	12.975494856209799	General Hospital Roundabout	2017-2018	China Civil	Completed	IMGs/Round_About/General Hospit...
6	7.557165500000000	13.014763600000000	Army Barrack Roundabout	2012-2014	Mother Cat	Uncompleted	IMGs/Round_About/Army Barracks...
7	7.629817733066890	13.001538786720900	GRA Roundabout 2	1990-1996	Julius Berger	Completed	IMGs/Round_About/GRA 2.png
8	7.628358791053620	12.996063701554700	GRA Roundabout 1	1990-1996	Julius Berger	Completed	IMGs/Round_About/GRA 1.png
9	7.626348693168660	12.980509758646200	WTC Roundabout	2004-2006	Borini Prono	Uncompleted	IMGs/Round_About/WTC.png
10	7.626946454132430	12.963444189707900	Steel Rolling	1990-1996	Julius Berger	Completed	IMGs/Round_About/Steel Rolling.png
11	7.621757078443560	12.972682129483200	Layout Roundabout	2004-2006	Borini Prono	Uncompleted	IMGs/Round_About/Layout.png
12	7.610541461716530	12.977366954392799	Kofar Kaura Roundabout	1990-1996	Julius Berger	Completed	IMGs/Round_About/Kofar Kaura.png
13	7.617187753110320	12.985695081718500	Mai Pencil Roundabout	1990-1996	Julius Berger	Completed	IMGs/Round_About/Mai Pencil.png
14	7.598790899614870	12.971966842632700	Babowar Tasha Roundabout	2017-2018	China Civil	Uncompleted	
15	7.597469746539290	12.975812775886901	Kofar Kwaya Roundabout	1990-1996	Julius Berger	Completed	IMGs/Round_About/Kofar Kwaya...
16	7.587342257397160	12.981559386372400	Kofar Yandaka Roundabout	1990-1996	Julius Berger	Completed	IMGs/Round_About/Kofar Yandaka...
17	7.587595545941130	12.996254174539500	Kofar Guga Roundabout	1990-1996	Julius Berger	Completed	IMGs/Round_About/Kofar Guga.png
18	7.601065937286580	12.984833900669100	Sabon Layi Roundabout 1	1990-1996	Julius Berger	Uncompleted	IMGs/Round_About/Sabon Layi 1...
19	7.603371369613800	12.988255828898300	Sabon Layi Roundabout 2	2012-2014	Mother Cat	Uncompleted	IMGs/Round_About/Sabon Layi 2...
20	7.599713883038870	12.991842394680500	Masallacin Sarki Roundabout	1990-1996	Julius Berger	Completed	IMGs/Round_About/Masallacin Sar...
21	7.605655019126230	12.993682282663899	Wapa Roundabout	1990-1996	Borini Prono	Completed	IMGs/Round_About/WAPA.png
	7.600652063805730	12.999222209697800	General Hospital Roundabout	2017-2018	China Civil	Completed	IMGs/Round_About/General Hospit...

Show All Features

Figure 6: Attributes of the Tertiary Roads (Source: Author's Analysis 2019)

Figure 7: Atrributes of some Roundabouts (Source: Author's Analysis 2019)

	Name	X	Y	Width (M)	Name of Co	Date of Co	Material	Road Type	Remark	Picture
1	Kofar Sauri	7.6153295	13.0089932	10.30	Julius Berger	1990-1996	Concrete	State Road	Good	IMGs/Culvert/Kof...
2	Kofar Durbi	7.616799	12.9960144	10.30	Julius Berger	1990-1996	Concrete	State Road	Good	
3	Kerau Yar Gada	7.60926023891421	12.9944661963899	10.30	Borini Prono		Concrete	State Road	Good	IMGs/Culvert/Yar...
4	Yahaya Madaki 3	7.6200943	12.9700299	19.30	Julius Berger	1990-1996	Concrete	State Road	Good	IMGs/Culvert/Ya...
5	Yahaya Madaki 4	7.612426	12.9758658	19.30	Julius Berger	1990-1996	Concrete	State Road	Good	IMGs/Culvert/Ya...
6	Kofar Kaura	7.6077446	12.9757758	10.30	Julius Berger	1990-1996	Concrete	State Road	Good	IMGs/Culvert/Kof...
7	Yammawa	7.59910652384554	13.0037839534338	10.30	Mother Cat	2012-2014	Concrete	State Road	Good	IMGs/Culvert/Ya...
8	Lambun Sarki	7.6159367	12.9837854	10.30	Julius Berger	1990-1996	Concrete	State Road	Good	IMGs/Culvert/La...
9	Lambun Sarki 2	7.6144481	12.9866055	10.30	Julius Berger	1990-1996	Concrete	State Road	Good	IMGs/Culvert/La...
10	Yahaya Madaki 2	7.63717375429682	13.0296588773802	19.30	Mother Cat	2012-2014	Concrete	State Road	Good	IMGs/Culvert/Ya...
11	Yahaya Madaki 1	7.631472	13.0390864	19.30	Mother Cat	2012-2014	Concrete	State Road	Good	IMGs/Culvert/Ya...
12	Shinkafi	7.65431548190957	13.0336088700174	10.30	Julius Berger	1990-1996	Concrete	State Road	Fair	IMGs/Culvert/Shi...

Figure 8: Attributes of some culverts (Source: Author's Analysis 2019)

Figures 4,5 and 6 shows the information contained in the database about the three road categories within the study area. This includes the caption/name of the roads, length (m/Km), number of lanes, surface type, the width and permissable speed limits. This forms the basis for queries based various criteria and also provides for future upating of the database. Figures 7 and 8 presents the locational coordinates of roundabouts and culverts/bridges, their captions, date of construction, contractors, status (completed or not) and the pictures displaying their present status.

3.4 Identification of RTI using Identify Tool

The identify tool in the QGIS software enables retrieving information about each infrastructure directly from the display of the screen, thereby presenting addresses and all other attributes of each infrastructure including the addresses and the pictures. Figures 9-13 presents the use of identify/select tool to retrieve information about various infrastructures within the study area, and hyperlink to join the attributes of a facility with its picture.

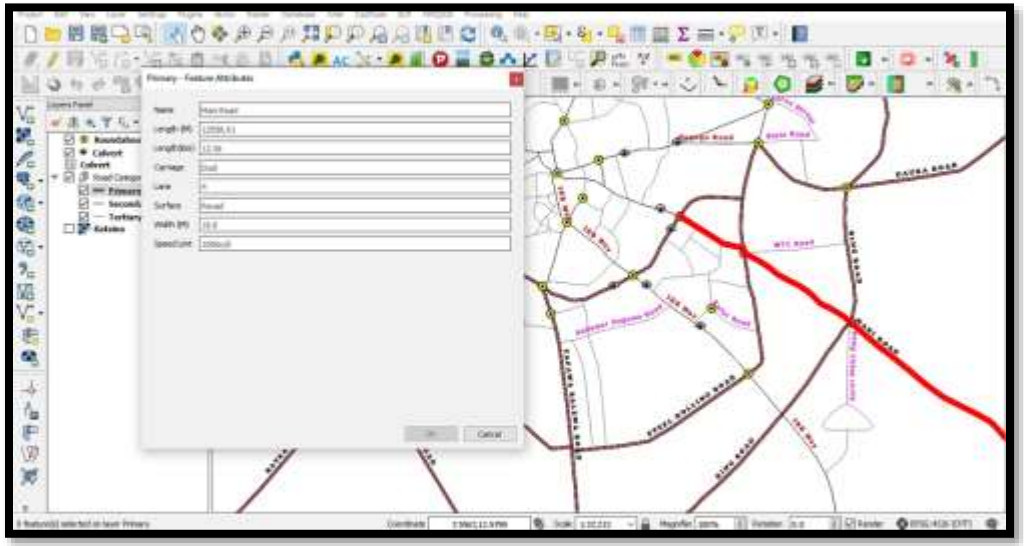


Figure 9: Primary Road Identification in Katsina LGA

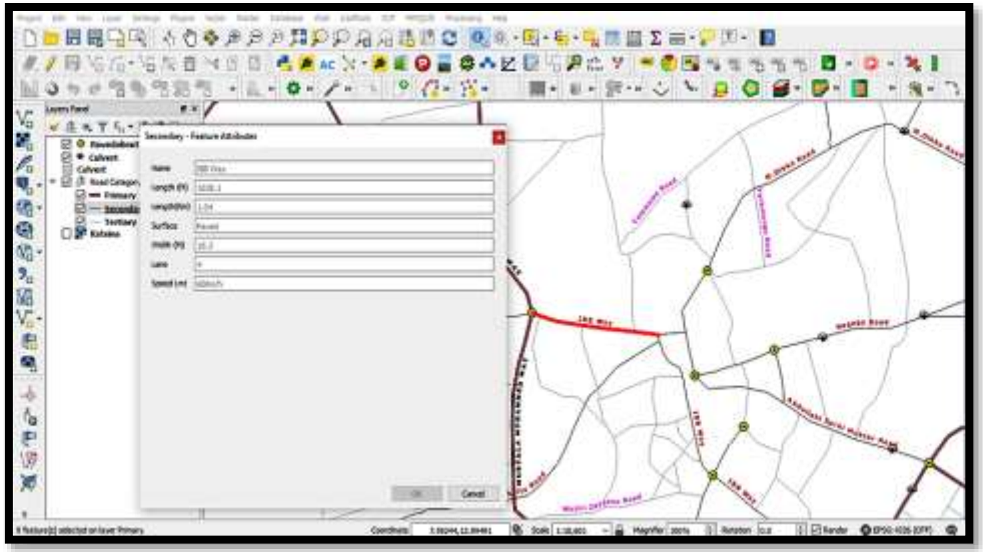


Figure 10: Secondary Road Identification in Katsina LGA

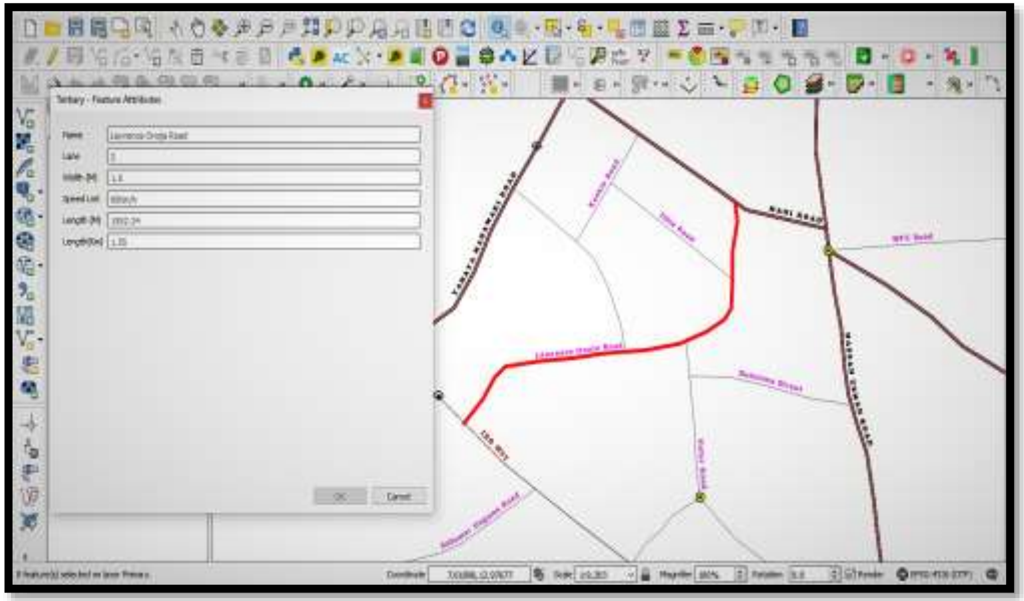


Figure 11: Tertiary Road Identification in Katsina Local Government

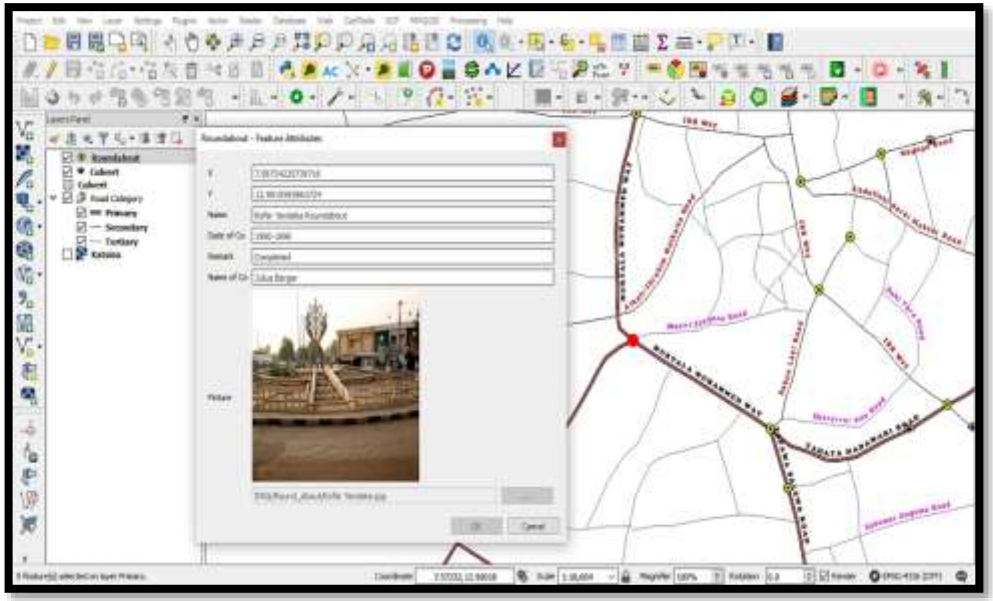


Figure 12: Major Round-about Identification in Katsina Local Government

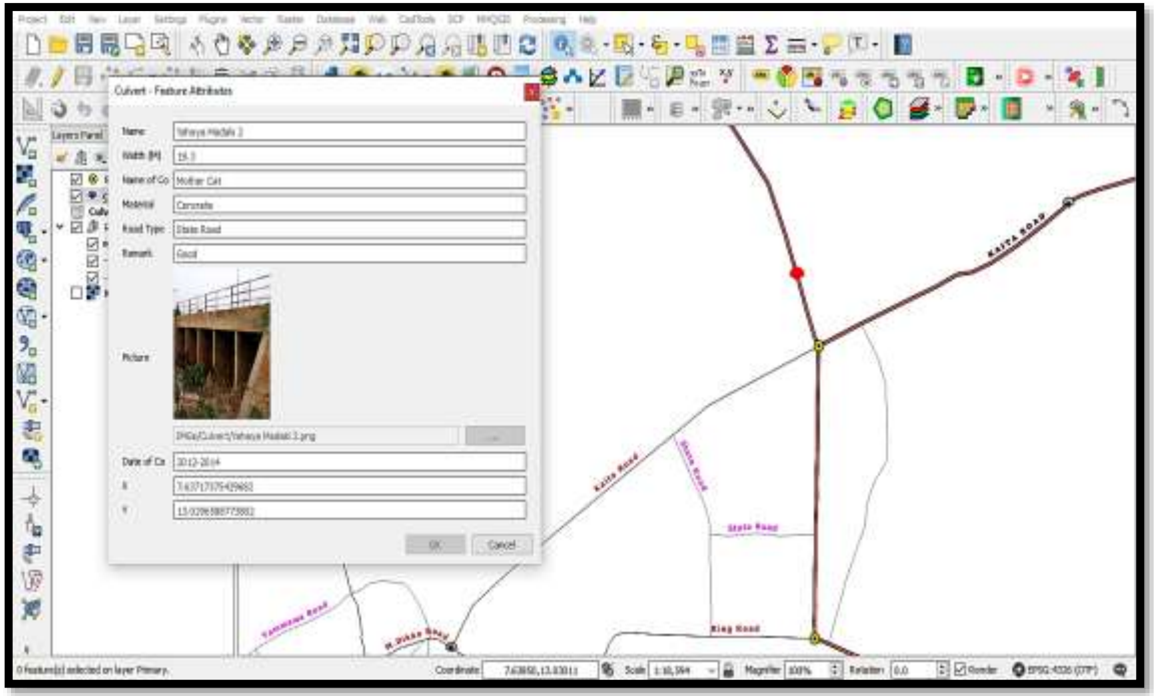


Figure 13: Major Culvert/Bridge Identification in Katsina Local Government

RTIS Queries

Both simple and complex queries can be conducted to retrieve information from the RTIS depending on the nature of information required. Figure 14 shows a simple SQL syntax for retrieving information about the primary roads that are above 5km long. Figure 15 on the other hand shows the result of the query instruction presented in Figure 14. Many more complex queries can be performed in attempting to retrieve various information for the database created.

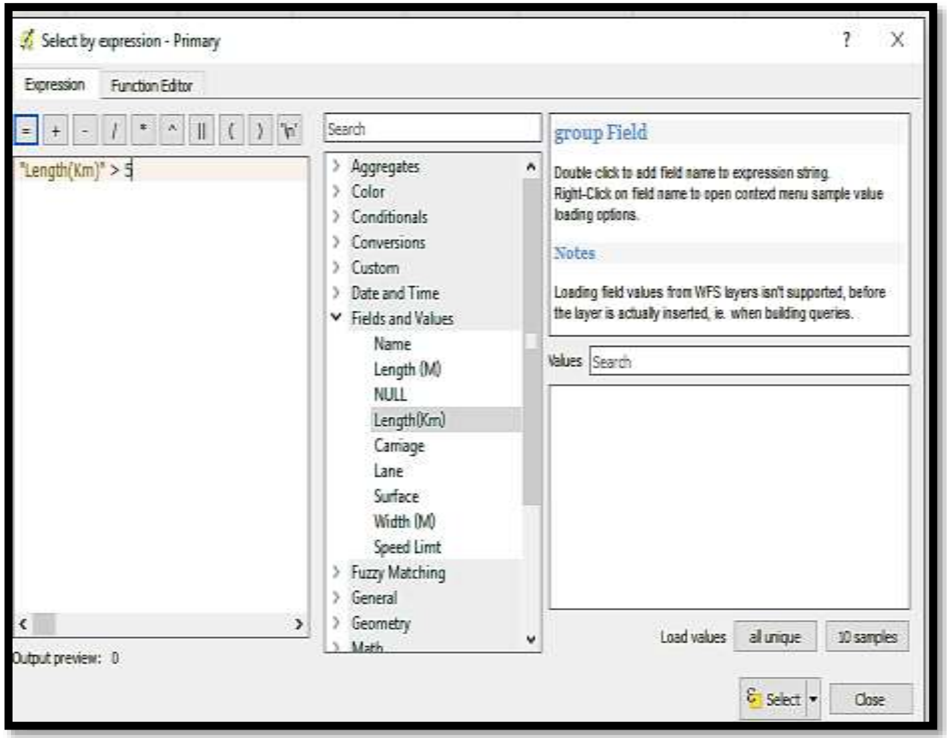


Figure 14: SQL syntax for retrieving Primary Roads above 5km length

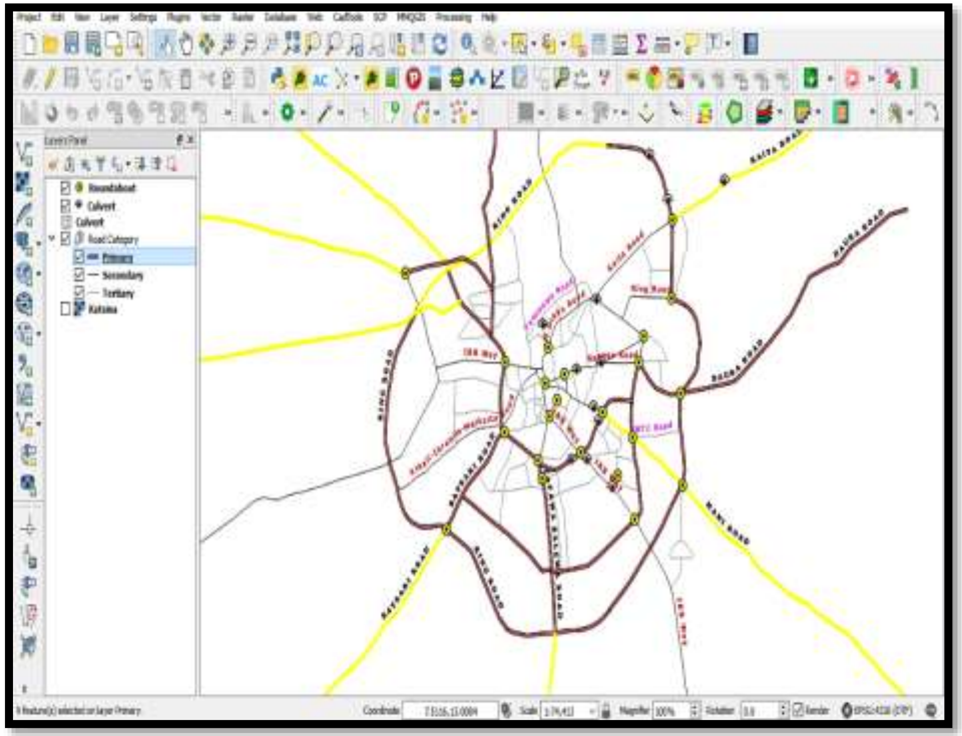


Figure 15: Showing Primary Roads that are more than 5 Km in Length

CONCLUSION AND RECOMMENDATIONS

The study concluded that the role of GIS technology in RTFIM cannot be over emphasized as it is one of the sophisticated technology that enables road traffic infrastructure data capture, storage, retrieval updating, manipulation and simulation for efficient monitoring and optimum management. It is therefore recommended that the departments responsible for monitoring and managing RTI in Katsina Local government should embrace this technology for sustainable transport development within the study area.

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