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Spatial Distribution of Accident Black Spots along Kaduna-Zaria Expressway, Nigeria

Mamman Saba Jibril, Ph.D.[1*], Jediel Wabundani[2]
1.Department of Geography, Faculty of Arts and Social Sciences, Nigerian Defence Academy
P.M.B 2109, Kaduna-Nigeria
2.Patrol Department, Federal Road Safety Corps, Kaduna, Nigeria
E-mail: dumamana2@yahoo.com

Abstract
An accident black spot has been explained in this paper as a place where accidents are concentrated. Potholes, feeder roads and sagging have been identified among other factors that cause road accidents along the study route. The devastating effects of these traffic crashes on the victims and properties cannot be over emphasised. This paper is therefore, a worthwhile effort to present stages that would mitigate future occurrence of road crashes to its barest minimum along the study route. Satellite images and Digital Elevation Model (DEM) of the study area were interpreted using ERDAS imagine version 9.1 to identify features termed to be accident black spots. In fact, seven different black spots were interpreted from the image. Arising from this, it is recommended that road infrastructure should be adequately maintained and road signs provided along the entire route.
Keywords: Black Spots, Sagging, Pothole, Ground Truthing, Road Infrastructure, Road Design.

1. Introduction

Permanent International Association of Road Congress (PIARC) (2003) explains that an accident black spot is a term used in road safety management to denote a place where accidents are concentrated. Sayer (1994) views an accident black spot as a term used in road safety management to explain where accidents have been historically concentrated. It may have occurred for a variety of reasons, such as sharp drop of corner in a straight road, in such a way that an incoming traffic is concealed, a hidden junction on a fast road and poor or concealed warning signs at a cross road. Other factors of accident black spot are; potholes, settlement along the highways, narrow bridges and U-turns.

The Wikipedia Free Encyclopedia (2008) defines accident as specific, unpredictable, unusual and unintended external actions that occur at a particular time and place with no apparent and deliberate cause. Commission for Global Road Safety (CGRS)(2006), viewed Road Traffic Accidents (RTAs), as a situation that occur when a road vehicle collides with another vehicle, pedestrian, animal and road debris or other geographical or architectural obstacles.

Road traffic accidents cause injuries, death and losses of properties in addition to damage on vehicles; it is one of the problems faced by the modern societies of the world today (Gordon and James, 2009). Death and injuries from road traffic crashes are the major and growing public health epidemic with significant record from developing nations of the world (CGRS, 2006). According to the World Health Organization in collaboration with World Bank (2004), an estimated 1.2million people were killed with as many as 50million others injured in 2002. The two organizations forecasted 65% increase in the next 20 years to come.

In Nigeria, Chidoka (2010), pointed out that 4,519 persons died and 15,770 others injured in 2005, 10,000 persons died and 33,000 injured in 2006. Also, in 2010, Nigeria lost over 1,800 persons and not fewer than 8,700 were maimed on the road resulting from road traffic crashes in six months (Mustafa, 2010).

This trend of road traffic accident is however on increase due to rapid increase in vehicular movement on Nigeria roads. This might not also be unconnected with the bad road conditions nationwide. The road problems range from the development of potholes, sagging, numerous U-turns. Others are narrow bridges, no or inadequate informative and warning signs. Following from the aforementioned analysis, there is need to identify the black spots of frequent occurrence of road traffic accidents along the study route, with a view to sensitise the road users and transport relevant authorities (agencies) of the places where accidents are concentrated along Kaduna- Zaria Expressway. In many instances, several road users (motorists) don't have geospatial knowledge of roads they use. Such road users cannot therefore, site or/identify likely black spots along such road(s). In such a situation, the motorist finds it difficult to dodge the black spots or take caution against them, hence, frequently leading to avoidable fatal accidents.

In line with the foregoing, road infrastructures (bridges, Culverts, Zebra Crossing, Divides, Drainages, Traffic light and road signs) should be adequately and always maintained and better still, improved upon. Strict adherence to this, can drastically reduce or completely eliminate road accidents black spots in the study area.

2. Location of the Study Area

The study route is in Kaduna State of Nigeria and passes through three local government areas of the state:

Kaduna North, Igabi and Zaria. It cuts across latitudes 10° 30'N and 11°10'N, and longitudes 7°20'E and 7°50'E. The whole area through which the expressway passes is in the northern part of Kaduna state, Nigeria and equally shares boundaries with Kaduna South, Chikun, Soba, Kajuru, Giwa and Birnin Gwari local government areas of the state (figures 1&2).

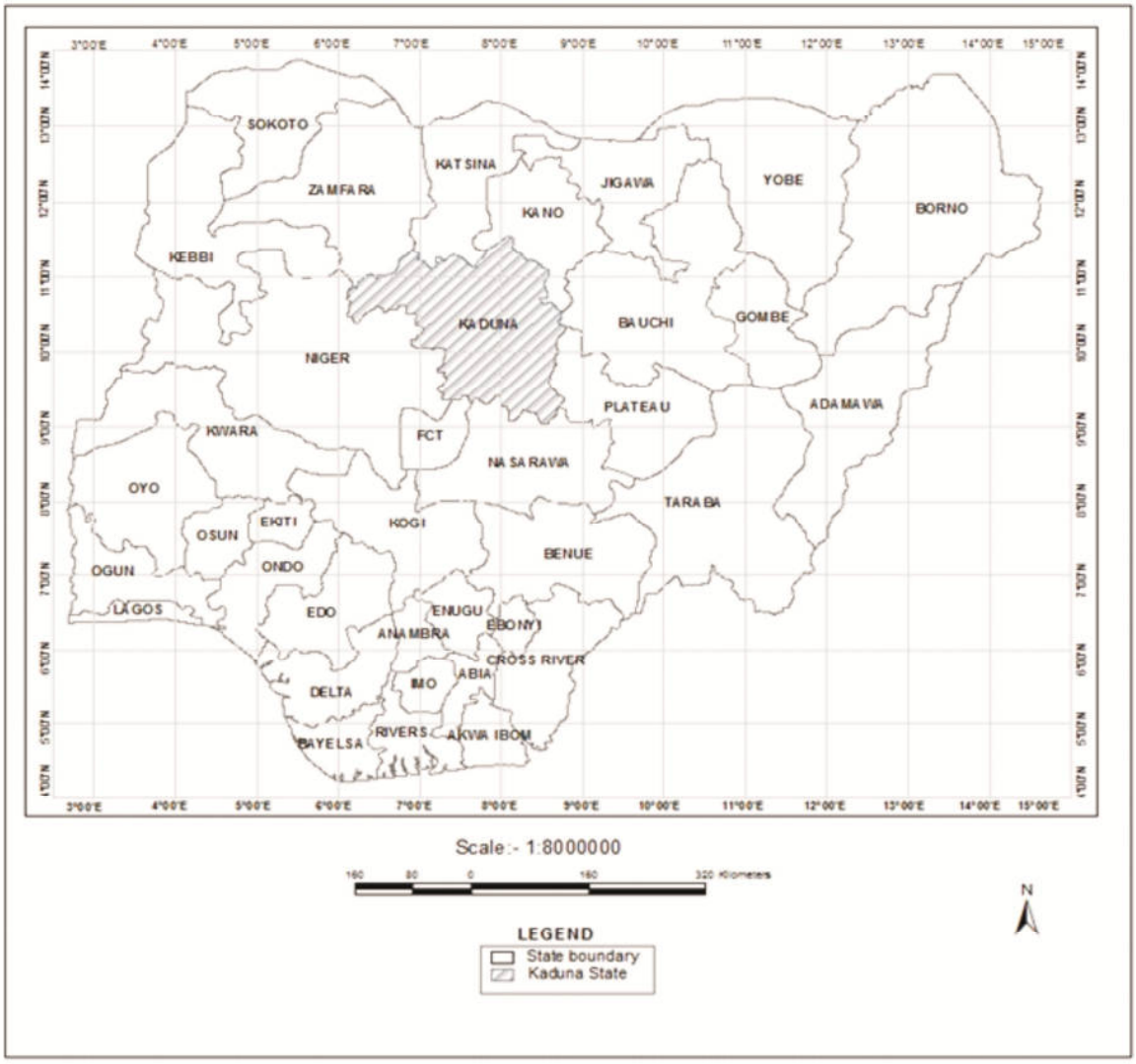

Figure 1: Nigeria Showing Kaduna State
Source: KEPA (2006)

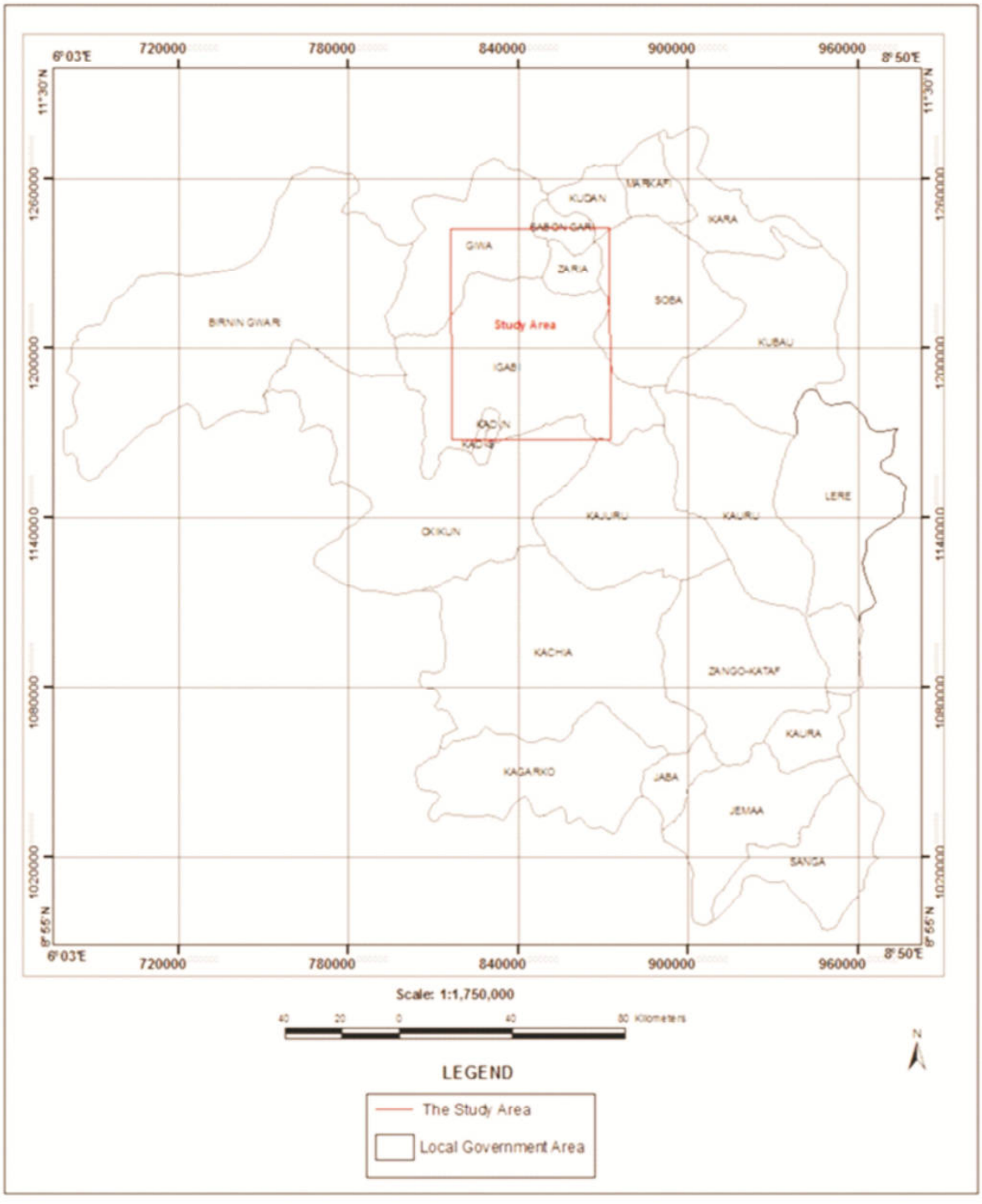

Figure 2: Kaduna State Showing the Study Area
Source: KEPA (2006)

The study area lies between 800 – 1000 meters above mean sea level. Following the extended patches of the rising hills within this region of the state, there is also a low lying depression, which paves way for well drained rivers and streams that lead to emergence of river Kangimi and river Ribako that cut across the study route (expressway), this leads to the construction of several bridges across the expressway. For instance, Trade fair complex bridge, Rigachukun, Jaji and Farakwai, and Poly Bridges.

The area within which the study route cuts across, by climatic classification, experiences the tropical continental climate. It is characterized by two distinct alternating wet and dry seasons. The rainy season usually begins from March/April and runs through September/October. The rainfall amounts falls between 1100 - 1300 mm. The rainfall type is convectional with a single regime of maximum peak usually occurs in August/September at a stretch (Parkman International Studies, 1997).

The vegetation of the study area falls within Sudan savannah zone, which is also, characterized by grasses and some scattered short trees. During the dry season, the tress shades their leaves while the grasses wither and die. Common trees include share butter and locust bean and other related savannah vegetation trees. The effect of the vegetation on the road cannot be over emphasized, as uninterrupted vegetation along the major road impaired a clear view from a distance by the road users (motorists) especially, on the bends.

2.1 Road Network of the Study Area

The road network of the study area is classified as major road. It was duallized between 1988 and 1992 by president Gen. Ibrahim Badamasi Babangida led military government. There are several feeder roads linking the expressway at various locations. Notable amongst these feeder roads are the Zangon Aya road, Kangimi and Sabon Birni road. The study route which extends up to 73.96km long has several characteristics such as sharp bends, bridges, undulation and U-turns. The study route is depicted in fig 3 below. There are several settlements along the study route, some of which are are Maraban Jos, Birnin Yaro and Jaji, others are Farakwai, Gwarigwaji, and Dan Magaji. The road sides of these settlements are always busy with parked vehicles, which are nuisance to the moving vehicles.

3. Methodology

The possible causes of road traffic accidents were presented as black spots on the route via the use of satellite image and Digital Elevation Model (DEM) of Kaduna State from which analysis were carried out using ERDAS imagine version 9.1. The study route and accident black spot like sagging, sharp bends, and emerging feeder roads were digitised from the raster image of the study area. Some other route features such as bridges and rivers were also identified.

3.1 Data Analysis

Data analysis was carried out through the use of correlation and ANOVA method of statistical analysis from SPSS (17.0), a Statistical Package for Social Sciences for hypothesis testing. The results were then presented in Table format. Other results from questionnaire administration were also presented in Tables and graphs.

3.1.1 Correlation Test

The spatial data obtained from satellite images and ground truthing such as the numbers of feeder roads, bends, bridges, sagging, U-turns and all the variables of slopes identified were collated and imputed in to computer Microsoft excel. Later, it was copied into SPSS 17.0 version excel sheet and run a bi-variant analysis between each of the variables against the total RTA frequencies spanning the period of research. This was to determine the relationship between spatial attributes and road accidents frequencies.

4. Results and Discussion

4.1. Spatial Distribution of RTA Frequency on Black Spots along Kaduna-Zaria Expressway.

After a technical routine as presented under the methodology, fig 4 below indicates an analysed image, featuring road accident black spots extracted from the image and ground truthing exercise. From Table 1, seven different possible accident black spots were identified in the process of image interpretation. The entire route of study area was divided into three segments based on the major settlements along the route to ease the analysis.

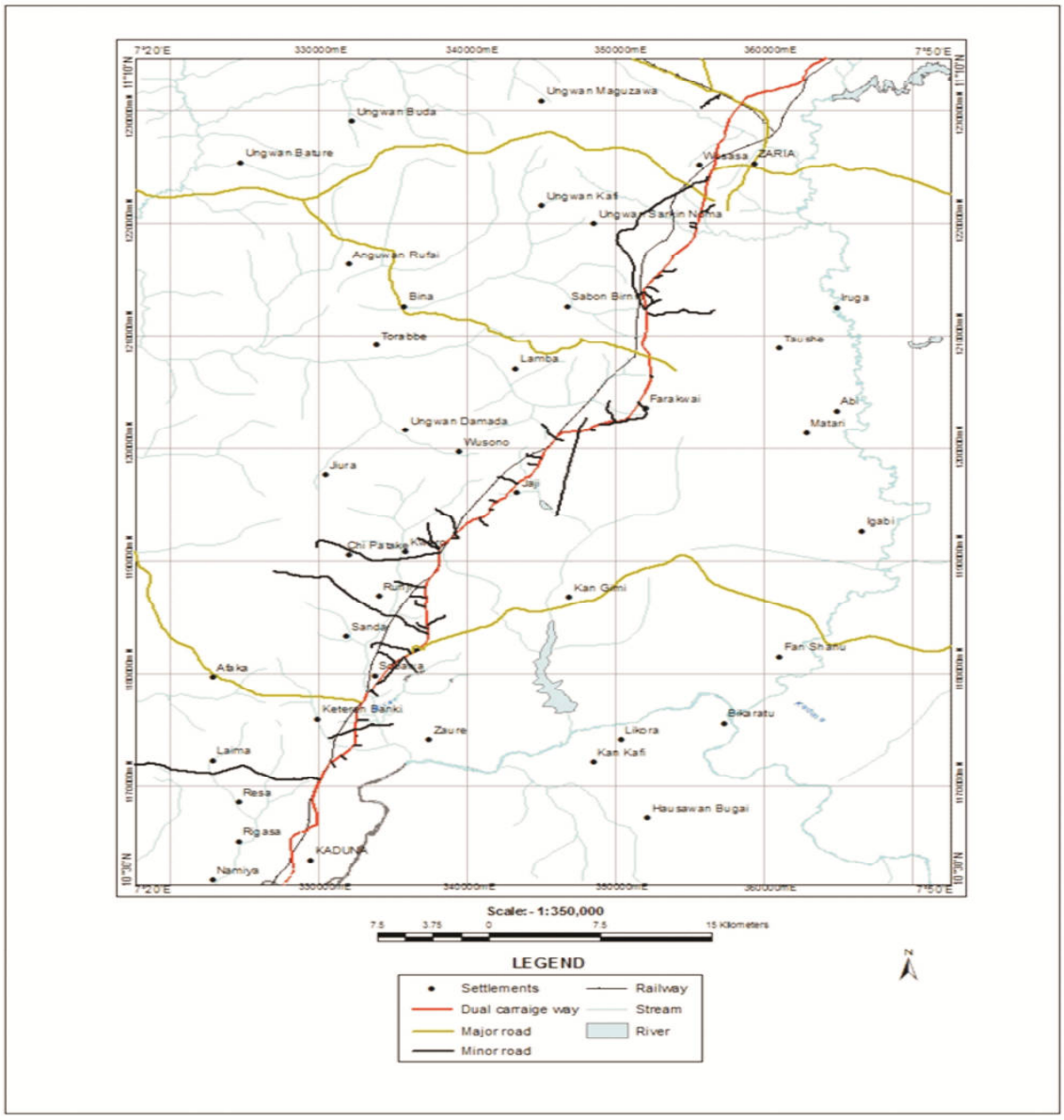

Figure 3: The Study Area
Source: Authors' Analysis of SPOT 5 imagery 2005

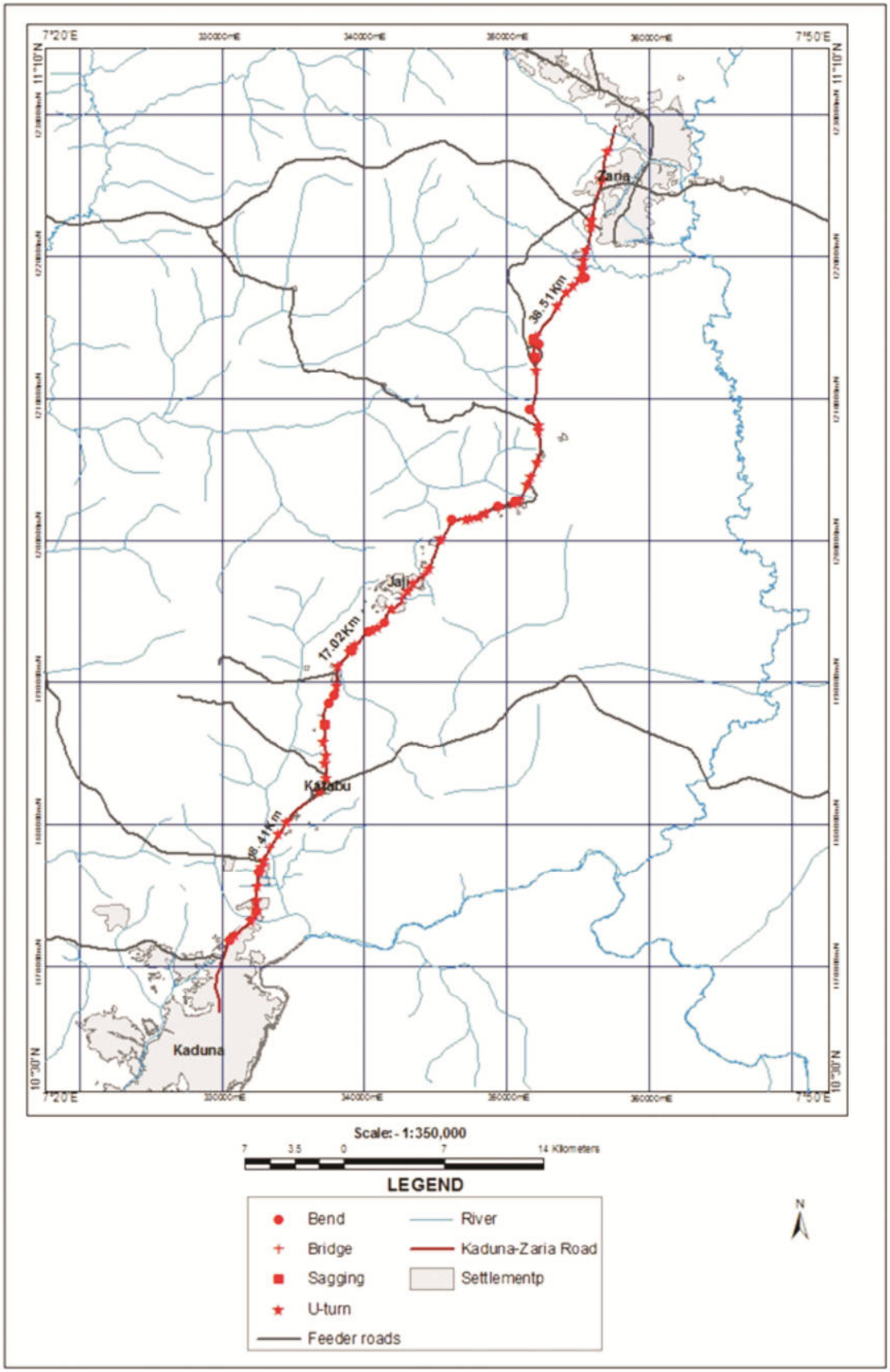

Figure 4: Accidents Black Spots on the Study Route
Source: Authors' Analysis of SPOT 5 imagery 2005

Table1: Road Accidents Black Spots Data along Kaduna-Zaria Road.

Segment	Feeder road	Bend	Bridge	Sagging	U-Turn	POT-Hole	Slope %	
							0-0.47%	0.47-2.34
KAD-KAT	23	3	2	0	9	5	21	21
KAT-JAJI	14	4	1	2	13	52	14	14
JAJI-ZAR	28	6	2	1	26	33	39	40
Total	**55**	**13**	**5**	**3**	**48**	**110**	**74**	**75**

Source: Satellite Image, DEM and Field Observation.

The Mobile GPS device was used to obtain the coordinates of each of the RTA scenes on the route and superimposed the frequencies of occurrence on the spatial data generated on the field. The superimposed frequencies of RTA on the spatial features are shown in figure 5 below.

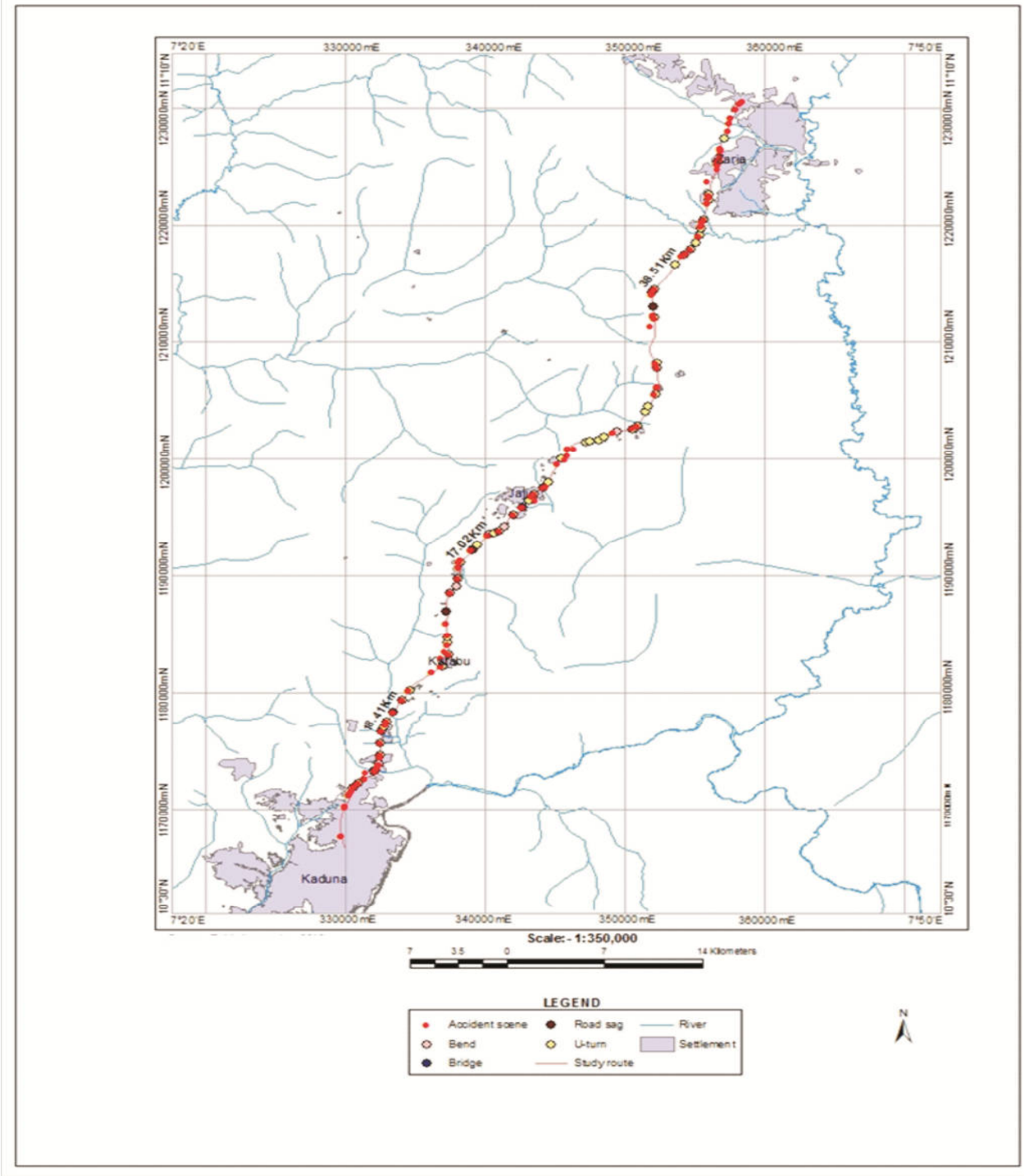

Figure 5: Scenes of Road Accidents
Source: Authors' Analysis of SPOT 5 imagery 2005

Figure 5 above shows the spatial distribution of road accident frequencies along Kaduna-Zaria expressway overlaid on the possible causes of RTAs along the route. This revealed that the concentration of the menace are not evenly distributed along the route as more of the occurrences appear to be regular at some flash points such as where there are sharp bends, sagging, U-turns and bad sections of the expressway. Also, the study depicts other major crash occurrence within the settlements of Rigachuku area of Kaduna State, Katabu, Jaji and Zaria. At such places of various road conditions, over speeding drivers usually find it difficult to control their vehicles, which may eventually result to road traffic accident.

For instance, fig 5 shows that the concentration of RTA are more at the bends and U-turns than on the bridges and sagging, while the potholes that constitute other bad sections of the road forms part of the places of high frequency. The test of relationship between the classes of RTA black spots is discussed below.

4.1.1. Classification of Accidents Black Spots

Road accident black spots as identified on the image and authenticated during the ground truthing exercise have been classified into three basic groups in order to ease analysis and determination of the role of each variable in the frequency of the occurrence of road traffic accidents. These classes are:

i. Road design
ii. Road condition
iii. Slope.

To ascertain the extent of relationship between each of the above three classes of accident black spots and road traffic accident frequencies, correlation analysis was employed to test the significance relationship between the variables of each category and the total cases of RTA within the period under review. Also, the decision as to either to accept or reject the test result was determined at 0.05 level of significant.

4.1.2. Effect of Road Design on RTA.

In this subsection, road design has been identified as one of the contributing factors of RTA along the study route. These are U-turns, Bends and Bridges. Statistics on these variables were identified and correlated with road accidents data. The statistics on these accidents black spots on road design is presented in Ta.ble 2 below

Table 2: Components of Road Design on Kaduna-Zaria Road

Route segments	**U-Turns**	**Bends**	**Bridges**	**Total**
Kad-Kat (km18.41)	9	3	2	14
Kat-Jaji (km17.02)	13	4	1	18
Jaji-Zar (km38.96)	26	6	2	34
Total RTC	**48**	**13**	**5**	**66**

Source; Spot 5 satellite imagery, 2005.

In order to examine relationship between each of the variables (U-turns, bend and bridges) and the frequency of occurrence of road traffic accident, correlation matrix was run to test the extent of relationship between road accidents frequencies and the components of road design. The hypothesis test shows that calculated values revealed that bends and U-turns are significant at 0.021 and 0.047 respectively. And since both of the values are less than 0.05, the result is hereby accepted hence, there is significant relationship between bend and U-turns with RTA frequency within the period of study. While the bridge with calculated value of 0.350is greater than 0.05 level of significant and the result is rejected. The result of hypothesis testing is shown in Table 3 below.

Table 3: Correlation Matrix of the Variables of Road Design and Road Traffic Accident Frequencies.

	Bends	U-Turns	Bridges
Accident	Pearson Correlations	0.997	0.799	0.853
	Sig.(2-tailed)	0.021	0.047	0.350
	N	3	3	3

Correlation is significant at 0.05level (2-tiled).LOS (p) = NS<0.05, >0.05, <0.05 and <0.01

4.1.3. The Contribution of Road Condition on RTA

This section evaluates the elements of road condition and its contribution to road accidents frequency on Kaduna-Zaria expressway spanning 2007 to 2010. During these periods, practical investigation have revealed that potholes, feeder roads and sagging have been identified among other factors such as human and mechanical that have great influence on road accidents occurrence along the study route. This might have been due to the poor knowledge of the road users on the route or the nonchalant attitudes of the motorist toward these spatial elements. Also, others might have a limited knowledge of traffic rules and regulations guiding the use of highways. Most times, motorists enter junctions (U-turns) without caution, traffic drills, and speeds. The resultant consequences are RTAs. Table 4 below presents the various elements of road condition on Kaduna-Zaria expressway.

TABLE 4: Element of Road Condition of the Study Route.

CATEGORY	Kad-Kat	Kat-Jaji	Jaji-Zaria	Total
POTHOLES	25	52	33	110
SAGGING	0	2	1	3
FEEDER ROAD	13	14	28	55
TOTAL	38	68	62	168

Source: Spot 5 Satellite imagery 2008.

However, to examine the relationship between each of the above spatial elements of road condition as a factor of road traffic accidents causation along Kaduna-Zaria expressway, data on each of the elements and road traffic accidents frequencies were correlated. The test result shows that the calculated value of potholes was arrived at 0.037, which is less than 0.05level of significance. Therefore, Hi: is here by accepted and Ho is rejected. Hence, road condition (pothole) is among other spatial elements responsible for high rate of road traffic accidents. There are numerous potholes at the tollgate, Foundation, km3 after Jaji, Kamfanin Zango, Dumbi Dutse and Hanwa GRA along the study route. These usually cause accidents because motorists fall into them while on speed. Many other potholes have been spotted in patches, which spread along the route and are captured in statistics used in the analysis.

Table 5: Correlation Matrix between the Variables of Road Condition and Road Traffic Accident Frequency.

		Potholes	Sagging	feeder roads
Accidents	Pearson correlation	0.998	0.470	0.853
	2-tailed	0.037	-0.344	0.350
	N	3	3	3

Correlation is significant at 0.05level (2-tailed). LOS (p) = <0.05, >0.05, <0.05 and <0.01

From the test result of road design and condition, three components of potholes, U-turns and bends tend to be statistically significance in road accidents causation along Kaduna-Zaria expressway.

4.1.4. Effects of Slopes on RAT along the Study Route

Slope was one of the physical factors identified among other spatial characteristics of road accident causation on the route during field observation and analysis of Digital Elevation Model (DEM) of the study route as shown in fig 6 below. This sub section therefore, evaluates the validity of each of the two components of slopes identified after 15meters buffer on both sides of the dual carriage way. The result identified two categories of slopes from the nine different categories on the entire area of the study measured in percentage (%), from which statistics have been obtained and examined the relationship of each and RTA frequency through correlation matrix as presented in figure 6.

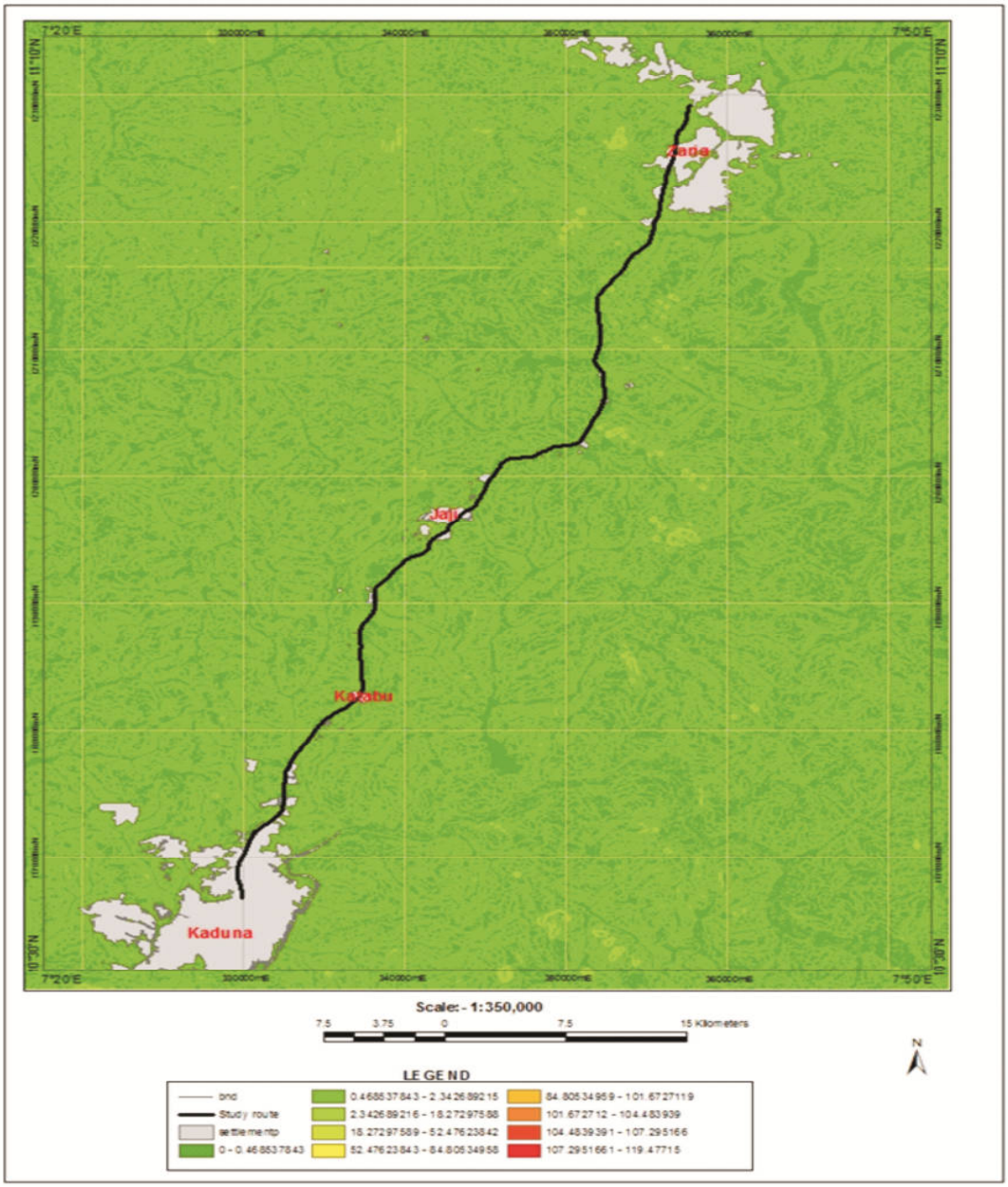

Figure 6: Slopes of the Study Area (Percentage)
Source: Authors' Analysis of SPOT 5 imagery, 2005

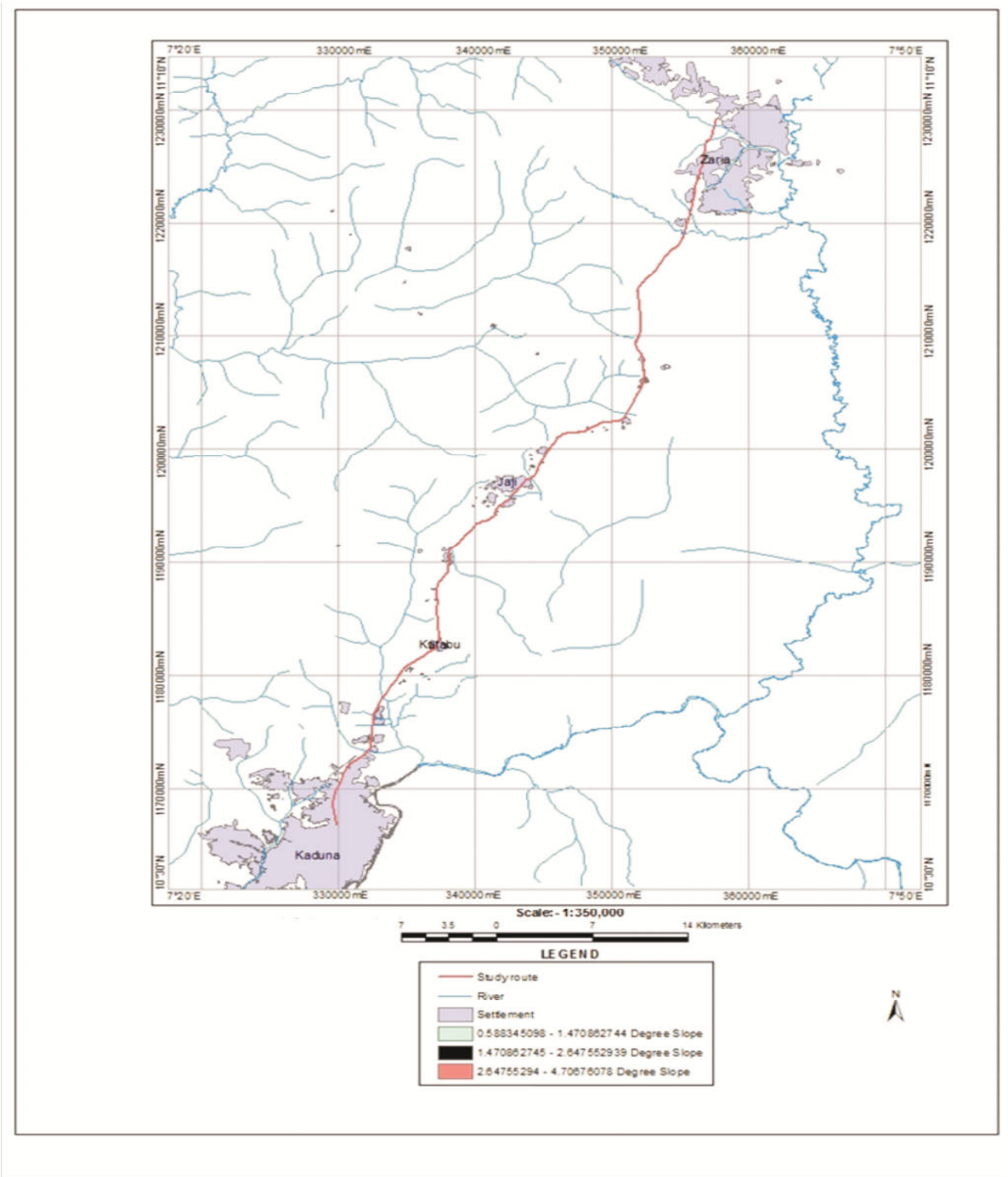

Figure 7: Slopes of the Study Route (Degrees)
Source: Authors' Analysis of SPOT 5

Table 6: Slope Category of Slope along the Study Route

Category	Kad-Kat	Kat-Jaji	Jaji-Zaria	Total
0% -0.47%	21	14	39	74
0.47%-2.34%	21	14	40	75
Total	42	28	79	149

SOURCE Digital Elevation Model (DEM), 2006.

In order to examine the relationship between these categories of slope and accidents frequencies, they were correlated through statistical software package SPSS version 17.0. The test result indicated 0.977 which is greater than the significant level at 0.05, which means that there is no significant relationship between slope and RTA frequencies along the study route. Therefore, slope cannot be listed among the spatial causes of road traffic accident along Kaduna-Zaria expressway. The correlation result is presented in Table 7.

Table 7: Correlation Matrix of Slopes and Road Traffic Accidents Frequencies along Kaduna-Zaria Expressway.

	0%-0.47%0.47%°-2.34%
Accidents	Pearson Correlation 0.9770.974 Sig(2-Tailed) 0.1370.144 N 2 2

Correlation is significant at 0.05level (2-tail). (p)= NS<0.05, >0.05, <0.05 and <0.01

NOTE: Mean followed by same letters under same factors is not significant at 5% level of significant.

4.1.5. Effects of Feeder Road on Road Accident

The study identified a total of 55 feeder roads connected to Kaduna- Zaria expressway as indicated in Table 4. These feeder roads include footpath, cattle crossing, tarred roads and un-tarred roads. These feeder roads sometimes lead to RTAs along the study route. Such accidents are however, due to poor knowledge of traffic interchange and general driving skills of the motorists.

Findings revealed that statistically, there is no significant relationship between the frequency of road accidents and the number of feeder roads identified along Kaduna- Zaria expressway as can be seen in the result of correlation matrix of road condition in Table 7 and that most of the areas of intersections and connectivity with high accidents records are within the settlements of Rigachuku, Katabu, Foundation Village, Farakwai, jaji, Dutsen Abba, Zaria and other feeder roads outside the settlements leading to the farmlands.

5. Conclusion

There are several death traps, otherwise referred to as black spots along Kaduna- Zaria Expressway. These are areas where RTAs always occur. Since it has been revealed in this paper that the concentration of the menace of RTAs are not evenly distributed along the route, need to fish out these black spots where ever they may be, which is a theme of this paper is a fruitful effort with a view to checkmate them against causing very avoidable accidents . Thus, it is the submission of this paper that road infrastructure such as road signs, culverts, bridges, street light etc should be adequately maintained, and if possible, improved upon along the entire route. Above all, infrastructure that are lacking along the study route should be provided, all aiming at free accident drive!

References

CGRS (2006)''*Make Road Safe*" A New Priority for Sustainable Development. 60 Trafalgar Square London, WC2N 5DS, United Kingdom.

Chidoka O (2010) 1,800 Die In Auto Crashes In Six Months. Daily Trust News Paper 18th August pp6

E-road network-Wikipedia free encyclopedia, 2008.

Gordon L and James S (2009), *Evaluating the Level Of Safety Of The Fused Grid Road Pattern.* School of Engineering, UBC Okanagan for the Canada Mortgage and Housing Corporation (www.cmhc-schl.gc.ca)

Kaduna Environment Protection Agency (KEPA) (2006).

Mustafa, A. (2010): 1,800 Die in Auto Crashes in 6 Month .*Daily Trust News Paper.* 16th August. P6.

Parkman International in Association with Parkman Nigeria Ltd, (1997): *State Wide Water Resources Master Plan, Kaduna State. Volume II.Water Resources and Facilities. Pp 22-3*

PIARC. (2003): *Road Safety Manual* .Philip Island, Australia. Pp13-14

Sayer S. A. (1994): Accident Black Spot Investigation. *A paper presented to the International course on prevention and Control of Traffic Accidents and Injuries*. New Delhi, India, 8-16 December, 1994.

WHO (2004): Summary Report on Road Traffic Injury Prevention, World Health Organization, Geneva, Switzerland. Pp 243.