Gombe Journal of Geography and Environmental Studies (GOJGES)

Vol. 2 N0.1 Jun. 2021

e-ISSN: 2714-321X

p-ISSN: 2714-3201

http://www.gojgesjournal.com

Gombe Journal of Geography and Environmental Studies (GOJGES) Vol. 2 N0.1 Jun. 2021, e-ISSN: 2714-321X; p-ISSN: 2714-3201

ASSESSMENT OF THE IMPACT OF EXCESSIVE RAINFALL ON ROAD TRANSPORT INFRASTRUCTURE IN LOKOJA METROPOLIS, NIGERIA

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Abstract

This study examines the effects of extreme rainfall characteristics on road transport infrastructure in Lokoja metropolis. In absence of mechanical method of data collection on road characteristics, the author traversed the entire city to examine the nature of road surfaces, the effects of heavy precipitation and flooding on road surface and drainage conditions. Thus, 176 vehicle owners who have stayed in the city for at least 3years and who ply different categories of roads in the city were randomly sampled to elicit information from them on the effects of extreme rainfall characteristics on maintenance of vehicles. Tables of percentages and Analysis of Variance were employed to analyse the data. Findings reveal that virtually all the sampled road networks in the city have developed potholes which impede the free movement of vehicles. The number of Road Traffic Crashes ($F=7.335$, $p<.001$), Number of People Killed ($F=6.821$, $p<.001$) and Number of Vehicles Involved ($F=6.308$, $p<.002$) in road traffic crashes varies with amount of rainfall during the various months of years in the study area. 39.2% of motorists indicated that poor channelization and inadequate maintenance of drainage facilities have accelerated the spread of water/floods to the roads leading to displacement of people, loss of property worth millions of naira. Some of the motorists interviewed indicated that they frequently take their vehicles to mechanic workshops for repairs during the rainy season. The study concludes that extreme rainfall has adverse effects on transport infrastructure in Lokoja and its environs. The study recommends the need for government to embark on annual maintenance and rehabilitation of intra-city roads adversely affected by perennial floods associated with heavy precipitation, cleaning of drainage channels to remove eroded sands and proper channelization of rivers should be encouraged in order to minimise the effects of flooding on intra-city road networks in Lokoja.

Keywords: Assessment, Impact, Rainfall, Road, Transport Infrastructure, Vehicles, Channelization and Planning

1. Introduction

Studies have shown that climate change is a global phenomenon that affects all aspects of human life such as economic activities, health, housing, transport infrastructure and productivity (Rossetti, 2002). Transport infrastructure is composed of road network , railways, terminals or bus stations as well as transport services that operation on them(Agbigbe, 2016; Yılmaz, and Çetin, 2017). In a study of vulnerability of transport infrastructure to excessive rainfall in small rural catchment in Greece, Michalis, Efthymis, Iraklis and Evangelos (2016) reported that transport infrastructure are vulnerable to extreme weather event (heavy precipitation) restricting access to

large areas, threating safety of commuters and sometimes causing damage to other environmental facilities such as electric poles, buildings and agricultural land.

In an evaluation of the impacts of high-intensity storms or precipitation on urban transportation, Mitsakis, Stamos and Diakakis (2014) affirmed that heavy precipitation increases travel time, causes change in routing and reduces the speed of vehicular movement. Many scholars have observed that in large cities where the environment is poorly planned, the capacity of land to accommodate infiltration is low and may eventually result to flooding, with serious impact on housing, transport networks and traffic delay on urban routes (Chang, Lafrenz, Won-Jung, Figliozzi, Platman and Pederson, 2010; Suarez, Anderson, Mahal, Lakshmanan, 2005; Paul and Meyer, 2001 as cited in Mitsakis, Stamos and Diakakis 2014). Maze, Agarwal and Burchett (2006) as cited in Mitsakis, Stamos and Diakakis 2014) have summarised the impacts of weather condition on traffic flows in three major ways which includes cancellation of journey, road traffic crashes and reduction in visibility and vehicle performance that may lead to increase in road traffic accidents. In an evaluation of the effects of flooding in Tennessee area in the United States of America in 2010, Janey and Abkowitz (2016) reported that there were 11 fatalities; and economic centres were shut with freight movement paralysed. It was also reported that many roads and rail lines were destroyed. Repair of transport infrastructure took several months and this diverted the mode choice of transportation and routes of travellers from their day to day transactions.

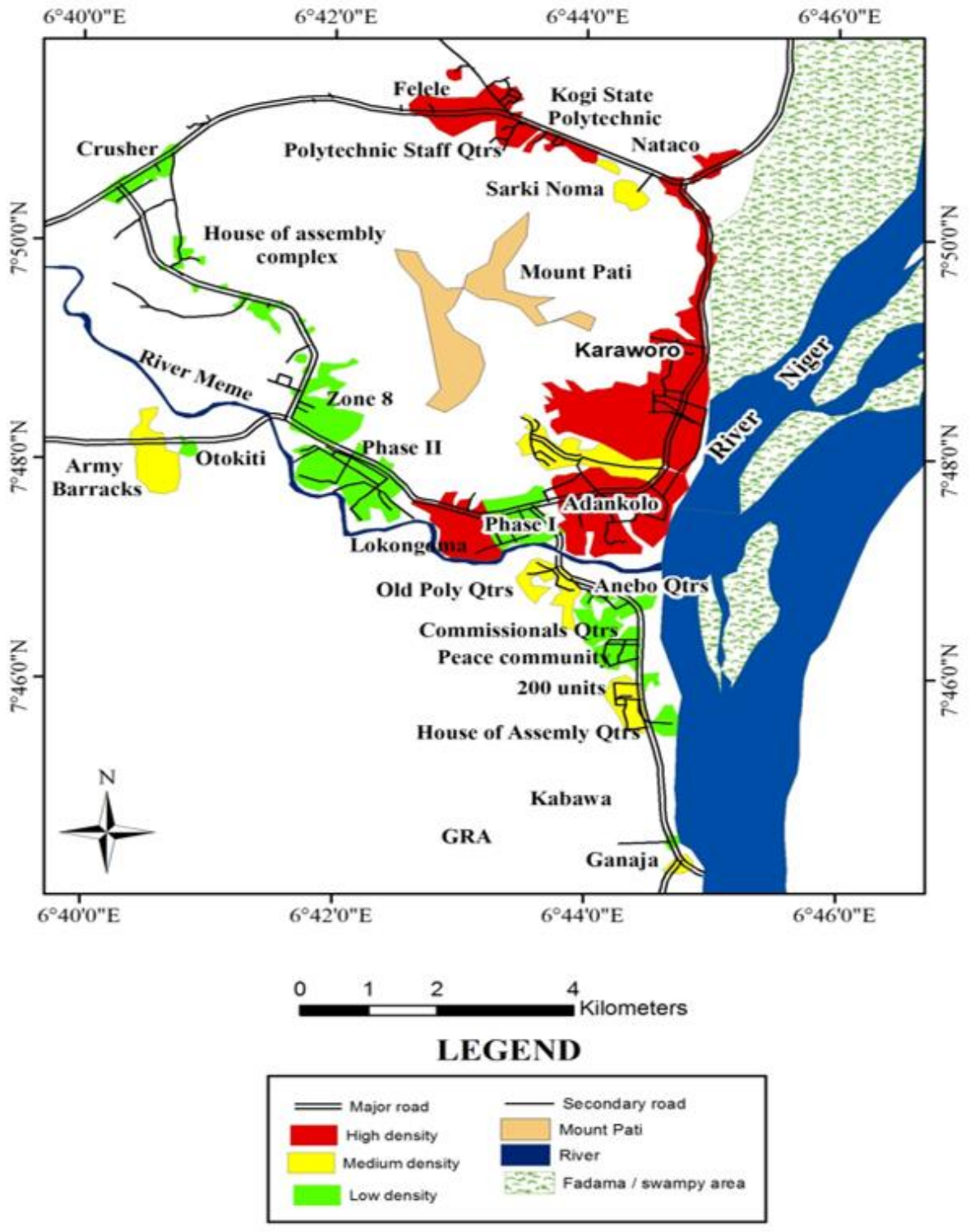
In an assessment of effects of weather elements particularly rainfall and temperature on road traffic crashes in South Western Nigeria where the rainfall is fairly distributed for more than 8 months, Olawole (2016) reported that less than 25% of road traffic accident were induced by weather elements. However, in the North Central part of Nigeria, particularly in Lokoja, where the rainy season is concentrated in less than six months with heavy torrential downpours, one would expect a significant difference in rainfall intensity that would have some impacts on transport infrastructure and other activity patterns in the city. It is against this background that this study was designed to examine the effects of extreme rainfall on transport infrastructure that affects all aspects of human life in Lokoja metropolis.

Lokoja metropolis is the study area. The distance between Lokoja and Abuja, the Federal Capital Territory of Nigeria is 138kms. The distance between Lokoja and Lagos is more than 700kms. Lokoja is located on latitude 7^0 45' 27.56" - 7^0 51' 04.34" N of the Equator and longitude $6^0$41' 55.64" - $6^0$45' 36.58" E of the Prime Meridian by the confluence of Rivers Niger and Benue (Figure 1). The city covers a total land mass of an estimated 63.82 sq. km. (Adeoye, 2012).

Lokoja is a medium-sized city, where Rivers Niger and Benue meet to form a confluence town (Nigerian Flight Deck, 2010). The built up areas of Lokoja comprises seven major localities such as Ganaja, Lokongoma, Felele, Kabawa, Zango Daji, Adankolo and Army Barracks. All these localities except Army Signal Area are located on the flood plain of Rivers Niger and Benue. These localities experience annual flooding which poses threat to life and property. Lokoja has a population of 195,261(National Population

Census, 2006). This figure was expected to increase to 264,891 in 2016(using a national population growth rate of 3.05%). The influx of people into Lokoja, when the city became the capital of Kogi State in 1991 has led to the increasing development of settlements within the flood plain (Olawepo, 2009). The resultant effects of structural development (building construction and establishment of small scale industries) have intensified the vulnerability of the inhabitants to annual flooding. Lokoja has an annual rainfall of between 1016mm and 1524mm with a mean temperature of 27 ^{0}C (Adeoye, 2012). The city onset of rainfalls is in the month of April and terminates towards the end of October of every year (Olatunde and Adejoh, 2017). The high concentration of rainfall during the few months of the year coupled with poor channelisation of Rivers Niger and Benue and inadequate damming along the rivers had intensified overflowing of large volume of water along the bank of the river, consequently resulting in floods (Adeoye, 2012; Akinbobola, Okogbue and Olajiire, 2015).

The main tributary of River Niger called Meme Stream overflows its bank and enters into many localities in Lokoja, causing serious damage to lives and property, including road transport infrastructure. During the peak period of the rainy season, the volume of water is very high along the course of Rivers Niger and Benue to the extent that it moves to the low land areas causing serious damages to the inhabitants. The intensity, seasonality, duration and frequency of rainfall characteristics that vary from one geographical location to another determine the intensity and extent of flood that may affect the life and property of residents of any region (Odekunle, 2006; Olatunde and Adejoh, 2017). In a study of rainfall intensity, duration and frequency in Lokoja, Olatunde and Adejoh (2017), reported that rainstorms with high intensity in Lokoja were relatively short in duration and their occurrences in any given year may likely trigger a flash flood in the area liable to floods. More researches have been carried out on the relationship between rainfall characteristics (duration, intensity and frequency of rainstorms) and its effects on human activities such as farming, transport infrastructure, housing, to mention but a few (Olawole, 2016; ETAC, 2007; Odekunle, 2006). It is pertinent to note that notable numbers of these studies are concentrated in south western part of Nigeria. Studies of effects of extreme rainfall characteristics on transport infrastructure (road network and transport services) in Lokoja metropolis located in the flood plain of rivers Niger and Benue is rarely found in the literature, if it exist at all. However, Areola (2004) reported that Lokoja is prone to annual flooding due to its geographical location in the flood plains of Rivers Niger and Benue. It is against this background that this study was designed to examine the effects of excessive rainfall on transport infrastructure that affects the accessibility of people to all activities located in Lokoja metropolis.



Source: Adapted from Adetunji M. A(2017)

2. Materials and Methods

2.1 Materials

Three sets of data are required for this research. The first category of data include Road Network Map of Lokoja metropolis, this was done in order to identify different types of road networks in the city. The characteristics of road networks such as condition of road surface, nature of bridges and drainage conditions were identified and observed for information and data used. The second category of data solicited and utilized was based on rainfall characteristics from January 2006 to December, 2012. Similarly data on Road Traffic Crashes between 2006 and 2009 were obtained from the archive of Federal Road Safety Corp in Lokoja metropolis. This data assisted to determine the period of the years with most traffic crashes. The third category of data collected was based on the opinion of motorists on the impacts of heavy precipitation on vehicle parts, expenditure incurred on vehicle maintenance during dry and rainy seasons. Similarly data on parts of vehicles that experience frequent default resulting in breakdown of vehicles during rainy season and strategies to adopt to reduce incidence of vehicle defaults during rainy season were solicited.

2.2 Methods

In absence of mechanical method of data collection on road characteristics, the author traversed the entire city and sampled three road segments in each of the seven localities that constitute Lokoja metropolis. The three major roads are those that connect different activity centres and therefore responsible for heavy vehicular movement in the city. Observatory survey/ technique was adopted to examine the nature of road surfaces and the effects of excessive precipitation or flooding on road surfaces. This was done with a view to determine the extent of damage caused by excessive rainfall on transport infrastructure particularly on road networks and vehicles in Lokoja and its environs. A total of 220 private car owners that constituted 1.5% of the total 14, 723 private cars that flowed in the city between Monday and Wednesday of the second and third week of January, 2014 were approached for questionnaire administration (Adetunji, 2017). Out of which 176 cars owners that were ready and willing to participate in questionnaire administration were sampled. The owners of these private cars have lived in the city for at least three years and have plied different categories of intra-city road networks in Lokoja and its environs. A structured questionnaire was administered to the motorists to elicit information from them on their perceptions of the effects of extreme rainfall characteristics on their vehicles maintenance and travel behaviour.

2.3 Statistical Analysis

Table of frequency distribution was used to present rainfall amount as well as road traffic crashes in the city and its environs. Similarly the Frequency tables and percentages were utilised to present the opinion of cars owners as it relates to the cost of expenditure on vehicle maintenance. Analysis of Variance was employed to examine the variation in the cost of vehicle maintenance during rainy and dry seasons. Also, Analysis of Variance was employed to examine whether the number of road

traffic crashes, number of people killed and number of vehicles involved in road traffic crashes varies with amount of rainfall during the various months of years in the study area.

3. Results and Discussion

Finding reveals that 1681.9mm of rainfall were recorded in Lokoja in the year 2006. It ranged from 12.4mm in the month of January to 352.8mm in the month of August, which recorded the highest precipitation in the city in 2006. Table 1 reveals that there was no rainfall in the months of November and December in 2006. A critical examination of Table 1 indicates that high precipitation is experienced in July, August and September of 2006 and these accounted for 303mm, 352.8mm and 290.6mm respectively. Heavy concentration of rainfall within these three months of the year under study may likely be responsible for the high rate of road traffic crashes experienced in these months (See Table 2a). Similarly, Table 1 further revealed that there is a decrease in rainfall amount in the year 2007. The total amount of rainfall experienced in the city and its environs was 1551mm. There was no rainfall in the months of January, February and December. The rainfall started in the month of March with a total amount of 11.6mm. However, heavy precipitation started in the month of May (277.3mm) and slightly decreases to 184.5mm, 255mm, 246mm and 240.7mm for the months of June, July, August and September respectively. These periods also coincides with the periods of high road traffic crashes leading to injury and in some cases untimely death of innocents citizens in the city (Table 2a). The result of this analysis is similar to the study carried out on the effects of rainfall and wet road condition on road crashes in India, where Mondal, Sharma, Kumar, Bhangale and Tyagi (2011) reported that 12.8% of total crashes took place on wet days and that the value of Rain-Crash-Effect (RCEi) were positive for three months, from June to August.

Table 1: Rainfall Amount in Lokoja and Environs

Yr.	M	RF (mm)	Yr.	M	RF (mm)	Yr.	M	RF (mm)	Yr.	M	RF (mm)	Yr.	M	RF (mm)	Yr.	M	RF (mm)	Yr.	M	RF (mm)
2006	Jan	12.4	**2007**	Jan	0	**2008**	Jan	0	**2009**	Jan	10.1	**2010**	Jan	0	**2011**	Jan	0	**2012**	Jan	0
	Feb	19.3		Feb	0		Feb	0		Feb	0		Feb	0		Feb	0		Feb	11.8
	Mar	40.9		Mar	11.6		Mar	21.8		Mar	5		Mar	2.2		Mar	0		Mar	0
	Apr	61.8		Apr	82.3		Apr	163.4		Apr	243.6		Apr	132.8		Apr	65.7		Apr	86.5
	May	370		May	277.3		May	161.6		May	108.4		May	114.7		May	159.9		May	233.9
	Jun	62.1		Jun	184.5		Jun	166.3		Jun	220.1		Jun	104.4		Jun	133.2		Jun	156.9
	Jul	303		Jul	231.8		Jul	213.9		Jul	212.8		Jul	136.5		Jul	128.1		Jul	283.3
	Aug	352.8		Aug	255		Aug	274.7		Aug	369.8		Aug	138.5		Aug	150.9		Aug	180.5
	Sep	290.6		Sep	246		Sep	170.2		Sep	255.8		Sep	148.2		Sep	191.1		Sep	148.4
	Oct	169		Oct	240.7		Oct	87.8		Oct	206.4		Oct	167.3		Oct	147.5		Oct	209.9
	Nov	0		Nov	22		Nov	0		Nov	0		Nov	7.4		Nov	0		Nov	2.2
	Dec	0		Dec	0		Dec	0		Dec	0		Dec	0		Dec	0		Dec	0
Total		**1,681.9 Av=140.2**			**1551.2 Av=129.23**			**259.7 Av=105.**			**1602 Av=133**			**952 Av=79.**			**976.4 Av= 81.**			**1313.4 Av= 109.5**

Source: Adapted from Daniel, 2017 **Note: Yr. = Year, M=Month, RF=Rainfall**

Table 2a: Data on Road Traffic Crashes from 2006 to 2009 in Lokoja metropolis

Year	Month	No. Of accidents	No. Of vehicles involved	No. Of people killed	Year	Month	No. Of accidents	No. Of vehicles involved	No. Of people killed	Year	Month	No. Of accidents	No. Of vehicles involved	No. Of people killed	Year	Month	No. Of accidents	No. Of vehicles involved	No. Of people killed
2006	Jan	15	21	17	**2007**	Jan	19	29	19	**2008**	Jan	12	15	7	**2009**	Jan	16	25	18
	Feb	5	7	4		Feb	10	14	8		Feb	17	26	19		Feb	20	13	16
	Mar	6	7	3		Mar	8	15	5		Mar	12	19	11		Mar	25	24	7
	Apr	13	20	16		Apr	17	24	28		Apr	11	16	10		Apr	25	0	22
	May	6	6	3		May	16	27	19		May	8	14	7		May	18	31	3
	Jun	7	13	10		Jun	15	26	17		Jun	7	15	3		Jun	14	25	9
	Jul	8	16	14		Jul	12	14	10		Jul	11	24	27		Jul	4	6	12
	Aug	17	23	6		Aug	10	18	9		Aug	10	18	10		Aug	13	22	26
	Sept	13	24	19		Sept	18	29	20		Sept	17	29	24		Sept	31	44	27
	Oct	7	10	4		Oct	17	32	8		Oct	8	12	10		Oct	9	11	1
	Nov	8	12	3		Nov	8	13	9		Nov	10	14	10		Nov	19	43	4
	Dec	13	21	18		Dec	36	53	34		Dec	24	34	17		Dec	18	31	23

Source: Federal Road Safety Corps Lokoja Archive from 2006- 2009

The number of Road Traffic Crashes (F=7.335, p<.001), Number of People Killed (F=6.821, p<. 001) and Number of Vehicles Involved (F= 6.308, p<. 002) in road traffic crashes varies with amount of rainfall during the various months of years in the study area(Table 2b) .

Table 2b: Results of Analysis of Variance on Road Traffic Crashes with Variation in Monthly Rainfall Amount in Lokoja**ANOVA**

		Sum of Squares	Df	Mean Square	F	Sig.
No of crashes	Between Groups	18780.000	37	507.568	7.335	.001
	Within Groups	692.000	10	69.200		
	Total	19472.000	47			
No of vehicles involved	Between Groups	48621.371	37	1314.091	6.821	.001
	Within Groups	1926.545	10	192.655		
	Total	50547.917	47			
No of people killed	Between Groups	21857.371	37	590.740	6.308	.002
	Within Groups	936.545	10	93.655		
	Total	22793.917	47			

Source: Author's Field Survey, 2020

Findings revealed that three types of road networks are found in Lokoja. These are Trunk A- Federal Roads (highways), Trunk B- State Roads, and Trunk C- Local Government Roads. The Trunk A Roads comprise the federal highway that connects Lokoja to other towns and states of the federation (Adetunji, 2017). The Trunk B-State Roads are the intra urban roads that link various activity centres. The study shows that some of the intra-city road networks/ intra urban roads in Lokoja metropolis have seriously been damaged by erosional activity due to heavy precipitation. Some of the roads sampled in the city have potholes with deep trenches, particularly along Ganaja Road. The situation is more complex at Adankolo New Lay-Out, most especially at Alhaji Aruna Street, Adankolo Cemetery and Government Day Secondary School areas where virtually all the roads were covered with water for weeks in 2012, 2018, 2019 and 2020. It is interesting to note that residents of these areas were relocated to other parts of the city for safety, even though properties worth millions of naira were lost. With respect to drainage facility in Lokoja, many of the city drainage facilities had been blocked by eroded sand.

This prevented water from the excessive rainfall to flow easily along the drainage, consequently resulting in flooding on intra-city road networks. The worst affected areas in Lokoja were Ipata Road at Ganaja Village and Jakara Marble area at Adankolo, where roads are covered by sand deposited by floods (Table 3). Heavy precipitation in the months of July, August, September and October every year in Kogi State and Lokoja has serious impacts on intra city movement.

Table 3: Condition of Roads during Heavy Precipitation in Lokoja

Localities	Road Characteristics	Nature of Road Network Surface	Road Surface Condition during Rainy Season	Drainage Condition	Occurrence of Potholes
LOKOJA CORE AREA					
Jakara Marble Road	Tarred	Fairly Smooth	Covered with water during excessive rainfall/ flood of 2012, 2018 and 2019	Blocked drainage with eroded debris and sand deposits. Sand covered the entire roads which impeded free movement of vehicle.	Potholes are fully developed
European Cemetery Road	Tarred	Rough surface	Some Length of roads particularly at Kewon Hotel were under water during 2012 flood	Drainage blocked with sand	Potholes were fully developed.
Karaworo-Palace Road	Tarred	Fairly smooth	Potholes have developed	Poor Drainage	Numerous Pot holes.
KABAWA AREA					
Honourable Buba Jubril Street	Not tarred	Rough surface	Poor road condition	Poor drainage blocked with sand	Numerous potholes
Hatusa street	Not tarred	Rough surface	Poor road condition	Drainage covered with sands(blocked)	Many potholes
Sardauna Street	Tarred	Rough surface	Poor road condition	Blocked drainage.	Many potholes.
ADANKOLO AREA					
Adankolo Cemetery Road	Not tarred except Agbayi road leading to Dignity Church	Rough	All roads around the cemetery area including Government Day Secondary School were under water for weeks in 2012, 2018 and 2019	Block drainage	Many potholes
Agbayi Street	Tarred	Fairly smooth	Fairly smooth	Block drainage	Few potholes
Egbon Street	Tarred	Rough	Poor condition	Block drainage	Numerous potholes
GANAJA VILLAGE AREA					

Ganaja Round About- 500 Housing Units First Gate	Tarred	Rough surface	Completely covered by water during excessive rainfall leading to floods of 2012 and 2020 in particular	Blocked drainage and flooded bridges	Numerous potholes
Ipata Road at Ganaja village	Tarred	Rough surface	Movement of people was totally restricted during 2012 and 2020 flood	Blocked drainage	Numerous potholes
Waterside Road	Tarred	Rough surface	Poor condition	Poor drainage.	Numerous potholes
LOKONGOMA AREA					
Lokongoma Primary School Road- Nostalgia	Not tarred	Rough surface	Poor Condition	No drainage	Many potholes
OluRoya Road	Not tarred	Rough surface	Poor Condition	No drainage	Many potholes
Agbaja Road	Tarred	Rough road	Poor Condition	No drainage	Many potholes
FELELE AREA					
Ndako Street	Not tarred	Rough surface	Poor Condition	No drainage	Numerous potholes
Oworo Road	Not tarred	Rough surface	Poor Condition	No drainage	Many potholes
Agbaja Road	Tarred	Rough surface. Road network was completely washed away	Poor condition	No drainage	Many potholes
ZANGO DAAJI AREA					
Al-Azhar College Road	Tarred	Fairly smooth	Poor condition	Blocked drainage	Numerous potholes
Olatunde Road	Not tarred	Rough surface	Occurrence of silt soil on the road which impede free movement of vehicles	No drainage	Numerous potholes
Market Road	Not tarred	Rough surface	Poor condition	No drainage	Numerous potholes

Source: Author's Field Survey 2020.

In study of rainfall characteristics in Lokoja, Daniel (2017) reported that there is occurrence of heavy precipitation from July to October every year in the city and this has serious implications on road transport infrastructure (Table 2). It constitutes serious havoc to roads and break down of vehicles. Table 4 reveals that 83% of motorists sampled in the city indicated that they have taken their vehicles to mechanic workshops for repairs due to frequent breakdown of their vehicles during the rainy season. Only 17% of motorists indicated that they experienced frequent breakdown of their vehicles during the dry season.

Table 4: Season of the Year with most Breakdown of Vehicles

Seasons of the Year	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Rainy	146	83.0	83.0	83.0
Dry	30	17.0	17.0	100.0
Total	176	100.0	100.0	

Source: Author's Field Survey, 2020

Different parts of vehicles experience one fault or the other during torrential downpour in Lokoja and its environs. Table 5 indicates that 38.6% of motorists claimed that the shock absorbers of their vehicles frequently got damaged during the rainy season due to numerous potholes created by heavy precipitation within the short rainy season in the area. Another 36.9% of the vehicle owners in the city indicated that they experienced frequent deflation of their tyres during the rainy season. An approximately 13.1% and 7.4% of motorists indicated that they experienced loss of bolts and rusting of their vehicle spare parts respectively.

Table 5: Fault Parts of Vehicles

Parts Fault	**Frequency**	**Percentage**	**Valid Percentage**	**Cumulative Percentage**
Brake Failure	2	1.1	1.1	1.1
Loss of Bolts and Knots	23	13.1	13.1	14.2
Frequent Deflation of Tyres	65	36.9	36.9	51.1
Shock Absorber	68	38.6	38.6	89.8
Rusting of Spare Parts	13	7.4	7.4	97.2
Wiper Defect	3	1.7	1.7	98.9
Light Accessories	2	1.1	1.1	100.0
Total	**176**	**100.0**	**100.0**	

Source: Author's Field Survey, 2020

The effects of heavy precipitation on transport infrastructure include route diversion, traffic delay, road traffic crashes, cancellation of trips and poor visibility (Pregnolato; Ford; Wilkinson, and Dawson, 2017). Table 6 revealed that 32.4% of motorists claimed that they have diverted to other routes to reach different activity patterns located in Lokoja and its environs during the

floods of 2012 and 2020, in particular, which displaced many people, claiming lives and property worth millions of dollars (Aderoju; Jantiku; Fagbemiro; Aliyu; Nwadike; Ajonye; Salman, (2014); FloodList New in Africa, 2020). It is pertinent to note that approximately 27.8% of respondents (motorists) indicated that they have lost substantial time on transit due to traffic delay emanating from slow movement of vehicles on roads occupied by flood. Slow movement of vehicles and poor visibility constitute 14.2% and 12.0% respectively of the consequences of excessive rainfall in Lokoja and its environs. Approximately 4% of motorists indicated that they experienced road traffic crashes during the heavy precipitation due to poor visibility and loss of control on roads occupied by flood. In a similar study carried out on the impacts of heavy precipitation /flood on road transport in Newcastle city, England. New Castle City Council (2013) reported that heavy precipitation that occurred on the 28th June, 2012 resulted in floods, which eventually resulted in cancellation of public transport and slow movement of vehicles. Also, the report affirmed that many drivers abandoned their vehicles, while some ran out of petrol after several hours of slow movement in heavy traffic.

Table 6: Effect of Heavy Precipitation on Intra-City Movement

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Loss of time due to traffic delay	49	27.8	27.8	27.8
	Diversion of vehicles to other available roads	57	32.4	32.4	60.2
	Road traffic crashes	7	4.0	4.0	64.2
	Slow the movement of vehicles	25	14.2	14.2	78.4
	Cancellation of trip purposes	17	9.7	9.7	88.1
	Poor visibility	21	12.0	12.0	100.0
	Total	176	100.0	100.0	

Source: Author's Field Survey, 2020

Incessant breakdown of vehicles in Lokoja and its environment during the annual floods can be attributed to a number of factors which include but are not limited to over flow of Rivers Niger and Benue, poor channelisation and inadequate maintenance of drainage facilities, defective spare parts and others. Table 7 reveals that more than 50% of the respondents claimed that heavy precipitation in the months spanning June – October forced the rivers to overflow their banks and take to roads in Lokoja and many communities located along or close to the Niger-Benue trough. Approximately 39.2% of motorists indicated that poor channelisation and maintenance of drainage facilities accelerate the spread of water/floods to roads leading to loss of properties and displacement of people. Heavy precipitation effects on vehicle parts accounts for 6.3% causes of breakdown of vehicles in Lokoja.

Table 7: Causes of Breakdown of Vehicles during Rainy Season

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Presence of potholes occupied by water/floods that move road	90	51.1	51.1	51.1
	Poor maintenance of road/ Poor Drainage system	69	39.2	39.2	90.3
	Defective spare parts	6	3.4	3.4	93.8
	Heavy rainfall on vehicle parts	11	6.3	6.3	100.0
	Total	176	100.0	100.0	

Source: Author's Field Survey, 2020

In an assessment of physical and economic impacts of urban flooding on infrastructure and surrounding communities in Hamilton County, TN area of United State of America, Neal (2014) reported that the economic costs associated with extreme flood events exceeded $110 billion in the year 2012 alone. In similar studies at Newcastle upon Tyne, United Kingdom, heavy precipitation that occurred in 2012 led to more than 1000 houses been flooded, while estimated £8million of direct damage to roads and pavements were recorded (Pregnolato; Ford; Wilkinson, and Dawson, 2017). Poor maintenance and rehabilitation of urban roads after annual flooding in many cities in Nigeria. and Lokoja in particular have serious impacts on vehicle maintenance. The cost of vehicle maintenance during the annual flood in Lokoja is more compared to the period of dry season. Table 8a reveals that in the year 2020, mean cost of vehicles maintenance varied from ₦14, 630.6818 during the dry season to ₦22, 934.6591 during rainy season, which is equivalent to 38.4121 USD and 60.2138 USD for dry season and rainy season respectively. The result of Analysis of Variance in Table 8b reveals that the Mean Cost of Vehicles maintenance varied from (F= 16.294; P<. 000 in Rainy Season to F=1.810; P<. 167), during Dry Season.

Table 8a: Mean Cost of Vehicle Maintenance in Naira (₦) during Difference Seasons of the Year

	N	Minimum	Maximum	Mean	Std. Deviation
Dry_season_maintenance_fee	176	1200.00	45000.00	14630.6818	9020.89616
Raining_season_maintenance_fee	176	1500.00	80000.00	22934.6591	14007.34472
Valid N (list-wise)	176				

1 USD = 380.887 NGN, Apr 6, 2021, 10:14 UTC (Exchange Rate Not stable)
Source: Author's Field Survey, 2020

Table 8b: Analysis of Variance of Cost of Vehicle Maintenance by Motorists during Different Seasons of Year at Lokoja and its Environs

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
Raining_season_maintenance_fee	Between Groups	5442694316.437	2	2721347158.219	16.294	.000
	Within Groups	28893304263.108	173	167013319.440		
	Total	34335998579.545	175			
Dry Season Maintenance Fee	Between Groups	291900836.840	2	145950418.420	1.810	.167
	Within Groups	13948998481.342	173	80630049.025		
	Total	14240899318.182	175			

Source: Author's Field Survey, 2020

Several suggestions were made by motorists on how to reduce the incidents and incessant breakdown of vehicles during the annual floods in Lokoja and similar other cities in Nigeria. Table 9 reveals that 47.7% of motorists were of the opinion that frequent rehabilitation of roads after periodic flooding will help to alleviate the frequent breakdown of vehicles in the city. Approximately 39.2% of motorists claimed that adequate and prompt clearing/ cleaning of drainage facilities would go a long way in reducing the problem of frequent patronage of mechanics to repair the frequent breakdown of their vehicles. According to them, good drainage facilities will allow the rain water to flow directly to river channels and reduce the incidents of flooding in the city.

Table 9: Motorists Perception on how to Reduce Occurrences of Vehicle Breakdown

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adequate and proper drainage system should be provided	69	39.2	39.2	39.2
	Use of genuine spare parts	12	6.8	6.8	46.0
	Frequent rehabilitation of roads	84	47.7	47.7	93.8
	Properly trained mechanics should be used for repairs	11	6.3	6.3	100.0
	Total	176	100.0	100.0	

Source: Author's Field Survey, 2020

4. Conclusion and Planning Implication

The study examined the impacts of heavy precipitation on road transport infrastructure in the medium-sized city of Lokoja in North Central Nigeria. At the introductory part of this paper, the effects of heavy precipitation on transport infrastructure (road networks and transport services) which include displacement of people, damage of roads, traffic delay and diversion of traffic and road traffic crashes were extensively discussed at the global level. In the methodological section, how to obtain data on the characteristics of road networks such as condition of road surface and drainage condition of the intra-city roads were discussed. Also, information relating to travel behaviour of motorists during the rainy season and the effects of heavy precipitation on vehicles parts, maintenance and patterns of movement or trips in the city were sought for. Table of percentages was employed to analyse the effects of heavy precipitation on road networks and transport services. Analysis of Variance was used to examine or determine the variation on the cost of maintenance of vehicles between rainy and dry seasons. Findings reveal that many of the intra-city road networks at Adankolo New Layout, Government Day Secondary School area, Ganaja area and Felele are usually seriously damaged, as some of the roads are covered with water for weeks. Heavy precipitation occurring in few months of every year, poor channelisation of Rivers Niger and Benue and their tributaries are the major factors accelerating the occurrence of annual flood in the city. This study concludes that annual rehabilitation of intra-city roads after floods and regular maintenance of drainage facilities should be encouraged by the three tiers of government. Also, channelisation of rivers should be carried out regularly to enhance free flow of water as this will minimise the negative impacts of heavy precipitation and floods on transport infrastructure in Lokoja and similar other cities in Nigeria.

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