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ASSESSMENT OF FLASH FLOOD HAZARD RATING OF SOME SELECTED FLOODED ROADS IN AWKA.

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ABSTRACT

Flood has been a major problem in the study area. Four (4) major flood prone areas were chosen for this study. They are Court Road (R_1) on Lat. 6.210 - 6.213 & Lon. 7.066 - 7.060, Obunagu Road (R_2) on Lat. 6.213 - 6.215 & Lon. 7.060 -7.058, Eke Awka (R_3) on Lat. 6.206 - 6.208 & Lon. 7.064-7.059 and Igweze Street (R_4) on Lat. 6.207-6.213 & Lon. 7.069 - 7.072. R_1 measured a total length of 714 metres, R_2= 550 metres, R_3= 600m and R_4= 600metres. Each of the roads was visited first for observation and subsequently for measurements. The capacity of the existing drainage was measured and observed. These parameters- flood height (H), and flood velocity, (V) were measured at various sections of the roads at 50 metres interval. The required values were used to calculate the hazard rating (HR) of the roads during floods at various points. The HR ranged from (1.25-2.99) for R_1, (1.60-2.58) for R_2, (1.39-2.17) for R_3 and (1.81-2.31) for R_4 which indicates high risk. A total of 56 points were taken. More than 70% of the points showed high risks for all while 28% of them were risky for some as a result of inadequate drainage capacity.

KEYWORDS: Assessment, Awka, Flash Flood, Hazard Rating and Road

I. INTRODUCTION

1.1 Background of Study

Flooding is a recurring disaster that threatens people's lives and homes, leading to damage of properties (Directive, 2007). It can further be explained to be a natural event or occurrence where a piece of land (or area) t0hat is usually dry land, suddenly gets submerged under water. Flash floods are considered among the most severe disasters in terms of fatalities and economic loss (Abdel-Fattah, Kantoush and Sumi, 2021). Flooding may happen with only a few inches of water, or it may cover a house to the rooftop. There are many possible causes of floods including heavy rain or snowmelt, coastal storms and storm surge, waterway overflow from being blocked with debris or ice to overflow of levees, dams, or waste water systems. Flooding can occur slowly over many days or happen very quickly with little or no warning, this is called flash floods. Floods, though destructive, can be controlled or ameliorated by employing the right measures to reduce or limit their impacts. Recently, flood occurrence possibilities have been increased globally due to two main reasons namely, lands urbanization and climate changes (Qin, Xu, Liu, Du, Xiao and Liu, 2020). This paper will focus on flash urban flood caused by heavy rain-falls. Flood risk management does of course involve the development of flood warning systems or of insurance schemes that are essential for flood event management, as these should operate all the time and not just during flood events, (Hamilton, Peden, Keech and Hagger, 2019). It is important also to know that flood hazard rating is not a one-off activity, such as building an embankment or a dam. It is a continuous process, characterized by repeated activities: analysis of the flood risk, consideration of measures and policy instruments to reduce the risk, making policy decisions, implementing measures and instruments.

1.2 Statement of Problem

In Awka capital city, flood is the one of the disasters that affects both lives and property. Flooding has been a threat in the study area, Awka the capital of Anambra state. She has been experiencing flood disasters as a result of so many factors like lack of spaces for drainage system, blockage of the drainage system, unplanned building and businesses, poor environmental awareness, inadequate management of wastes, poor construction of drainage system, attitude of the residence towards wastes disposal etc. All these helps to aggravate flooding during rainy seasons in Awka. Flooding has equally caused a lot of damage to infrastructure and human resources. Hence, there is need for assessment of the flash flood hazard rating of some these flooded roads in Awka. It has been observed that during rainfall, the generated run-off constitutes the major movement problem witnessed in Awka metropolis, movement is held to a stand-still and major activities halted until the rain and generated run-off or flood subsides. Consequently, vehicular movement is seriously obstructed and in some cases no passage at all along the roads. More worrisome is that goods and valuables of inhabitants along these roads are seriously threatened by the generated flood and washed away most times. The residents are therefore, fully on red alert during the events of these floods.

1.3. Aim of the Work

This work is aimed at assessing the flash flood hazard rating of some selected flooded roads in Awka.

1.4. Objectives of the Work

This research work targeted these objectives; the extent to which some selected roads are hazardously affected by flood in the area of study thereby reducing the vulnerability of Awka people and other users. Therefore, this work will be useful in that it will provide useful information that can formulate a new guideline for the government, donor agencies and private developers. It will also enhance safety during rainfall and ensure easy passage during rainy seasons and it will reduce the consequences floods by creation of awareness.

1.5 Scope of Work

Four flood prone basins were selected, those flooded axes are: (1) Court Road: Ogbalimngba to Akwata. (2) Obunagu Road: Works Road Junction to Sammy Sparkle Plaza. (3) Old Enugu-Onitsha Express Road (Zik's Avenue): Eke Awka Junction to Igwebuike Grammar School Junction and (4) Igweze Street. They are the problematic basins that need immediate attention. It has been observed that during rainfall, the generated run-off within these axes constitutes the major bulk of flood in Awka metropolis.

1.6 The Study Area

The study area is Awka city, the capital city of Anambra state. It was declared capital on 21 August, 1991, after the creation of Anambra. It has an estimated population of 470,069 in 2026 according to city population official attribution.

Geography: Awka is situated at 6.21° North latitude, 7.07° East longitude. Awka lies below 300 metres above sea in a valley on the plains of the Mamu River.

Geology of Awka: Awka town and its environs are mainly underlain by the Imo shale formation. This consists of thick clayey shale, fine-textured, dark-grey to bluish-grey with occasional admixture of clay ironstones and thin sandstone bands.

Four major flood routes in Awka are used as a case study as indicated in figure 1.1 below.

Fig 1.1 Map of Study Area.

2 Literature Review

Flash flood is a sudden and extreme volume of water, which flows rapidly. It usually results from large amounts of rain falling in a brief period. They occur with little or no warning and can become quite powerful within a few minutes. FEMA (NIG) (2001) defined flood as a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least 1 of which is the policy holder's property).

2.1 Flood risk and vulnerability

Schanze (2006) identifies flood risk as the convolution of flood hazard and flood vulnerability which refers to the characteristics of the elements exposed to the flood hazard. The vulnerability can be social vulnerability such as loss of life, health, injuries or economic vulnerability such as direct and indirect financial losses. Although Schanze's definition of flood vulnerability is conventional, the measure of flood vulnerability is confused with flood risk measures that are widely used (Penning-Rowsell, Johnson, Tunstall, Tapsell, Morris, Chatterton and Green, 2010). Adelekan, (2011) quoting Kron, said that it is more acceptable that flood risk is defined as a product of hazard, exposure and vulnerability (Kron, 2003). Kachroo, *et al*. (2000) observed that some groups are more vulnerable to floods than others are, especially in the developing countries. Vulnerability is not increased for poverty, but also the poor tend to be the most vulnerable due to their lack of choices. Primarily losses of any disaster like flood can be high in rural areas where most of the damage is sustained by crops, livestock and the agriculture infrastructure, such as irrigation system, levees, walls and fences. In other words, primary losses relate mainly to the disruption of economic and social activities, especially in urban areas, immediately after a flood. Even when poor people come to cities, with large increase in population and increasing urbanization they live more in the informal settlements, which are often on flood plains as this is the only underdeveloped land available near cities. The people living in these settlements are those who are most at risk, not only due to their geographical location in the flood plain but also because they do not have the financial resources to recover from the damage caused by flooding. The influences of both poverty and development process on people's vulnerability to disaster are now well established. Class, ethnicity, gender, disability and age are some of the factors increase the affecting people's vulnerability. It is estimated that, poverty does not equal vulnerability but being poor makes people more vulnerable to disasters because poor people have lack of resources (physical, social and knowledge based) to prepare them for and respond to such threats and shocks as natural hazards. Poor people often get locked in a cycle of vulnerability. As they are vulnerable; they are at great risk in the face of a natural hazard, leading to disaster. Close analysis of disaster impact shows that the vulnerability of men and women to disaster, their capacities, and the options available to them differ in character and scale to their gender which may have a close link with the level or severity of disaster event (Kachroo, *et al*. 2000). He further suggested that, although women are often more vulnerable to disasters than men, they are not just helpless victims as often represented. The impact of disasters is usually measured in quantifiable ways, such as adding up the number of the dead and injured, and estimating the physical damage to housing, land, livestock, agriculture, stores and infrastructure. However, attention is not necessarily paid to how disasters impact on different categories of people, men, women, children, aged people, etc in socially and economically. Disasters affect men and women differently because of the different roles they occupy and the different responsibilities given to them in life and because of differences in their capacities, needs and vulnerabilities (Kachroo, et al. 2000). In a similar study Rashid (2000), also agreed that women and children are the most vulnerable during the disasters.In the risk analysis theory, one of the most important concepts is the quantification of risks, and the kind of measurement used to evaluate the risks is the foundation of this flood risk analysis approach (Miao, 2015). He suggested that the potential harmful consequences considered in assessing risk include:

(a) Human health (b) The social and economic welfare of individuals and communities (c) Building and infrastructures (d) The environment (including cultural heritage)

With the development of flood risk analysis, some practical risk measurements have been widely used such as flood damage or mortality. According to the observed practical flood death data, many mortality functions were deduced for different types of floods in different locations in the world (Boyd, 2005; IPET, 2006; Jonkman, 2007), and these models attempt to determine the relationships between the flood mortality and water depth. Besides, the variations in flood warning, evacuation and shelters for different flood events at different locations are not taken into account.

2.2 Flood hazard describes the flood conditions in which people are likely to be swept over in a flood with the possibility of drowning, and is a combination of flood depth, velocity and the presence of debris. In England for instance, a method of assessing the flood risk to people was developed by Flood Hazard Research Centre (FHRC) (Adelekan, 2011). The method of calculating risk to people is expressed by Equation (2.1):

$$\boldsymbol{E} = \boldsymbol{f}(\boldsymbol{F}, \boldsymbol{L}, \boldsymbol{P}) \qquad \mathbf{2.1}$$

Where:

E = Nature/extent of effects (on those exposed)

F = Flood hazard characteristics (depth, velocity, etc.)

L = Location characteristics/area vulnerability (inside/outside, nature of housing)

P = Population characteristics/people vulnerability (age, health, etc.)

Abt et al. (1989) derived an equation to estimate the critical product at which a human subject becomes unstable as a function of the subject's height and mass. Based on the test of a person's height and mass (Karvonen *et al.*, 2000), it was found that the critical depth velocity products are between 0.64 m^2/s and 1.29 m^2/s. Siegrist, and Gutscher, (2006) reports that these results indicate that people will experience difficulties in walking through water when the depth–velocity product exceeds 0.5 m^2/s.

Through laboratory experiments, it has been proved that the often-used depth-velocity (hv) product has a physical relationship with moment instability (Jonkman and Penning- Rowsell, 2008). Penning-Rowsell et al. (2005) proposed an equation to relate the flood hazard to people to the depth and velocity of the water as well as the number of debris that is in the water. The flood hazard rating is calculated using Equation (2.2):

$$\boldsymbol{HR = d \times (v + 0.5) + DF} \qquad \textbf{2.2}$$

Where, HR = (Flood) hazard rating;

d = Depth of flooding (m); v = Velocity of floodwaters (m/sec); DF = Debris factor

The flood hazard can be estimated and then categorized as 'low,' 'moderate,' 'significant' or 'extreme' as compared with societal risk analysis (Shah, Mustaffa, Matínez-Gomariz, Yusof and Al-Qadami, 2019).

2.3 Factors Contributing to Flooding

Urban flooding occurs in towns, on flat or low-lying terrains especially where little or no provision has been made for surface drainage or where existing drainage has been blocked with municipal waste, refuses and eroded soil sediments Hula, and Udoh, (2015).

Rainfall is the most important factor in creating a flood, but there are many other contributing factors. When rain falls on a catchment, the amount of rainwater that reaches the waterways depends on the characteristics of the catchment particularly its size, shape and land use. Some rainfall is 'captured' by soil and vegetation, and the remainder enters waterways as flow. Floods occur when the amount of water flowing from a catchment exceeds the capacity of its drains, creeks and rivers. This process begins with rainfall, but is affected by many other factors. Generally, the more rain that falls in a particular area in a given period of time, the lower the proportion that can seep into the ground or be stored on the surface, also the greater the rainfall intensity, the greater the potential for runoff. How long it rains, and the area covered by the rain, are also important.

The more vegetation there is in an area, the greater the amount of rainfall that is captured and the less water there is available to flow over the surface. Natural and artificial storages like farm dams and rainwater tanks have a similar effect in reducing runoff.

The soil types in a catchment, land use and weather conditions prior to a rainfall event are also important as they control the amount of rainfall that can infiltrate into the soil, and hence the amount of rainfall which becomes flow. If a large storm is preceded by a period of wet weather, then the ground has little capacity to absorb further rainfall, and a higher proportion of the rainfall will flow across the land surface and into waterways. The construction of areas that cannot absorb water, such as roofs and roads, will also result in reduced infiltration and more rainfall being turned into runoff. Floods are also affected by the roughness of the terrain being passed over. Dense vegetation and artificial obstacles such as fences and houses will slow down water flow, often leading to lower flood levels downstream.

2.4 Gaps in Literature

Amongst other areas not covered by the literature reviewed above, it is evident to the best of available knowledge that none of the studies has assessed the flash flood hazard rating of those flooded roads in Awka. Therefore, this work tried to fill this gap considering the deplorable extent to which Awka has been messed up by flood.

3.0. MATERIALS AND METHODS

3.1 Materials: The following materials were employed in this work. They include:

(i) **Walk / wheel meter -** to measure road length.
(ii) **Steel tape -** for measuring shorter distances.
(iii) **Iron peg -** for establishment of chain-ages.
(iv) **Stop watch** - for time measurement.
(v) **Hammer** - used to drive iron pegs into the ground.
(vi) **Shovel** - for earth shifting where need arises**.**
(vii) **Matchet** - for bush clearing where necessary.
(viii) **Digger** - for excavation where needed.
(ix) **GPS** - for location and area identification.
(x) **Camera** - for taking photographs.

3.2 Field study: The fieldwork involved site visits and observations as well as measurement of parameters of flood activities such as flood height, flood velocity, flood volume, Field work was carried out firstly when it was not raining to survey the areas and make observations. During this survey, the pegs were driven into the earth at 50 meters intervals. These **chain-ages** were established before rainfall to aid measurement during flood.

3.3. Real-time value taking; this was now done during flash flood along the selected routes using the marks already made on the iron pegs in the field to measure the flood height. Floating material was used to measure flood velocity by calculating the distance covered from one peg to another divided by the average time taken to do so. Flood volume was also calculated by multiplying an average depth by a unit square of a flooded area.

3.4 Procedural method for measuring flood height and volume

(i) Calibration of the iron pegs at 0.2m intervals with red and white colours.
(ii) Driving the pegs into the ground before the commencement of rain
(iii) Monitouring and taking the reading of the flood height during rainfall
(iv) Calculation of volume by the multiplication of the area covered by flood with the flood height.

3.5 Procedural method for measuring flood velocity

(i) Installation of pegs at 50m intervals along the drainage length
(ii) Use of flow meter to measure speed of the flood
(iii) Monitouring and taking reading of time taken by the object to move from one peg to the other using stop watch
(iv) Calculating the flood velocity by dividing the distance covered by the time taken.

3.6 Case study selection: The selected roads were chosen from public out-cry and observation of the extent these roads were flooded. They are also major roads with great economic importance in Awka.

3.7 Challenges in the study: Many difficulties were encountered during the field work. Some of them include:

(i) Difficulty of working under the rain sometimes when it is absolutely compulsory.
(ii) Risk of being carried by flood.
(iii) Fund scarcity.

3.0 Results and Discussion

3.1 Results: The results of flood activities along the roads selected for case study are presented in this section. The results of flood activities along Court Road: Ogbalingba to Akwata is presented in Table 1. The total Length of the Road is 714m and it is divided into distances of 50m.

Table 1 Results of flood activities along Court Road: Ogbalingba to Akwata

Distance (m)	Velocity, V (m/s)	Debris factor DF	Flood Height, H (m)	Hazard Rating H.R (m^2s)
00	0.38	1	1.30	2.14
50	0.38	1	1.30	2.14
100	0.38	1	1.30	2.14
150	0.40	1	1.40	2.26
200	0.42	1	1.40	2.29
250	0.42	1	1.42	2.31
300	0.50	1	1.42	2.42
350	0.60	1	1.51	2.67
400	0.67	1	1.85	2.16
450	0.67	1	1.70	2.99
500	0.60	1	1.70	2.87
550	0.45	1	1.58	2.50
600	0.38	1	0.45	1.40
650	0.38	1	0.40	1.35
714	0.32	1	0.30	1.25

Below are the results of flood activities along Obunagu Road: Works Road Junction to Sammy Sparkle Plaza as presented in Table 2. The total Length of the Road is 600m and it is divided into distances of 50m.

Table 2 Results of flood activities along Obunagu Road: Works Road Junction to Sammy Sparkle plaza.

Distance (m)	Velocity, V (m/s)	Debris factor, DF	Flood Height, H (m)	Hazard Rating HR (m^2s)
00	0.32	1	0.48	1.39
50	0.32	1	0.58	1.48
100	0.32	1	0.63	1.52
150	0.32	1	0.60	1.49
200	0.42	1	0.80	1.74
250	0.42	1	0.80	1.74
300	0.45	1	1.05	2.00
350	0.52	1	1.00	2.02
400	0.67	1	1.00	2.17
450	0.83	1	0.70	1.93
500	0.83	1	0.87	1.72
550	0.48	1	1.05	2.03
600	0.40	1	1.05	1.96

The results of flood activities along Zik's Avenue: Eke Awka to I.G.S. Junction is presented in Table 3. The length of the Road is 750m and it is divided into distances of 50m.

Table 3 Results of flood activities along Zik's Avenue: Eke Awka to I.G.S. Junction

Distance (m)	Velocity, V (m/s)	Debris factor, DF	Flood Height, H (m)	Hazard Rating, HR (m^2s)
00	0.67	1	0.73	1.85
100	0.67	1	0.78	1.91
150	0.67	1	0.78	1.91
200	0.68	1	0.73	1.86
250	0.60	1	0.74	1.81
300	0.65	1	0.74	1.85
350	0.68	1	0.89	2.05
400	0.70	1	0.91	2.09
450	0.70	1	0.78	1.94
500	0.70	1	0.76	1.91
550	0.72	1	0.87	2.06
600	0.83	1	0.85	2.13
620	0.83	1	0.85	2.13
650	0.85	1	0.97	2.31
700	0.85	1	0.85	2.11
750	0.87	1	0.85	2.16

The result of flood activities along Igweze Street is presented in Table 4. The length of the Road is 550m and it is divided into distances of 50m.

Table 4 Result of flood activities along Igweze Street.

Distance (m)	Velocity, V (m/s)	Debris factor, D F	Flood Height, H (m)	Hazard Rating, HR (m^2s)
00	0.45	1	0.63	1.60
50	0.45	1	0.63	1.60
100	0.65	1	0.65	1.75
150	0.68	1	0.70	1.83
200	0.61	1	0.76	1.84
250	0.87	1	0.76	2.04
300	0.87	1	0.73	2.00
350	0.85	1	0.83	2.12
400	0.82	1	1.20	2.58
450	0.82	1	1.15	2.51
500	0.50	1	0.90	1.90
550	0.48	1	0.80	1.78

3.2 Discussion; The velocity was moderate. Floods usually sweep light and non-stable objects through their ways. According to Zahiraniza, Ebrahim, Syed and Khamaruzaman, (2020), vehicles are among the objects which can be swept away at certain flow velocity and depth. Flood height is considerably high, therefore, having high volume of overflow of flood per meter. The consequence of this is that, the hazard rating for this road is high. Hence, the high traffic congestion experienced along this road during heavy rain. It is therefore, not advisable to ply this road during heavy rains.

Table 2 contain the results of flood activities along Obunagu Road. The total Length of the Road is 600m and it is divided into distances of 50m.This is another flooded road in Awka. Looking at the velocity of flood here, it is also moderate. It can be observed, that the depth of drain was increased at some point thereby reducing the depth of overflow at that portion of the road. Also, observation revealed greater part of the drain is blocked by debris thereby reducing the serviceability of the drain. The consequence of this is that the road surface now becomes the flood path exposing road users to much risk Zahiraniza, *et al.* (2020). Enormous studies aimed on evaluating the blockage effects of buildings, where the existence of buildings alters the initial overland flow paths determined by gravity. According to Leandro, *et al.* (2016), to estimate the blockage effects of buildings, various methods in the past have been adopted. And these when tested showed the effects of building blockage in urban inundation simulation and demonstrated the necessity of considering building characteristics in each grid unit when a coarse model is adopted. Lee, *et al*. (2016) further emphasized the importance of involving building configuration, and then noted that building blockage effects can alter the shape of hydrographs and the distribution of the urban inundation. Many houses were built along flood way. Abdel-Fattah *et al.*, (2017) recognized that rapid increase of population, urbanization and economic developments have pushed people to construct in high disaster risk zones such as on the natural flood paths. Residents' home along this road are flooded from time to time to the point that some houses are abandoned. Volume of flood per meter cube is very high while the hazard rating is reduced because of reduced depth. The capacity of the drain needs to be increased to accommodate the discharge from these areas. This road has a lot of tributaries. The major ones are three points hence the sudden rises.

The results of flood activities along Zik's Avenue: Eke Awka to I.G.S. Junction was presented in Table 3. The length of the Road is 750m and it is divided into distances of 50m. The road measured 714m from Eke Awka to I.G.S. along Zik's Avenue. High velocity of flood was witnessed even at less sloped portioned. This can be accredited to energy accumulated from the sloppy parts of the road. The volume of flood per meter is worrisome because considering the building line there may be no enough space for a redesigned drain that will accommodate the volume of flood generated. One of the major problems of urbanization is land scarcity. Therefore, continuous urban expansion and increasing rainfall extremes give rise to frequent flooding (Zhang et al. 2018 Zhang et al. 2020). With developing science and technology, the death toll due to flooding-induced disasters has been effectively curbed, whereas economic loss geometrically rises because of increasing property exposure to floods (Komolafe, Adegboyega, and Akinluyi, (2015); Kramer, Terheiden and Wieprecht (2016). The hazard rating is moderate to high. This road experiences traffic jam during heavy rains because of the reduced movement attributed to high overflow. Observations showed that sometimes during rain one part of this dual carriage road is completely submerged that motorists cannot pass anymore talk more of pedestrians. At such times vehicles manage to pass through just one lane thereby causing a serious traffic lock that takes hours in some cases to unlock. During this time even packed vehicles are partially submerged leading to untold economic loss to the masses. It is unfortunate that this road was among the newly reconstructed roads in Awka town, yet with a failed drainage system. This means, either the drain was not designed or the design was not followed. It is very important to consider the economic value of this road promptly. There is only one tributary on this route.

Finaly, the result of flood activities along Igweze Street was presented in Table 4. The length of the Road is 550m and it was also divided into distances of 50m. Igweze Street to Akwata express also showed low to moderate velocity. About 50% of the drain capacity has been lost to sand and other solid matter. However, this agreed with Dinis, Huvi, Cabral and Pinto Carvalho, (2021) that socio-economic conditions are most likely the main reasons of flood damage. Namely, rapid population growth with poor planning and making use of low-quality construction materials, the high waste yields that are not properly managed and the absence of flood risk awareness. Most affected areas are determined by local conditions that compromise drainage at the time of the rainfall event, being very difficult to predict. Thus, road surface now becomes flood path. Volume of flood per meter is high with also considerably high flood height that can partially submerge cars. Hazard rating (HR.) is moderate to high. The consequence is that people using these roads during heavy rains are exposed to risk. There is need to redesign and reconstruct the drainage system to ease-off the low passage or even no passage at all experienced on its path whenever there is heavy rain. Due to the economic value of this road there is urgent need for attention. Some traders along this road had had their shops flooded even in the night when everyone is asleep causing unbearable financial loss to its inhabitants.

5.1 Conclusion

The hazard rating, HR for the roads considered during flood ranged from (1.25-2.99) for R_1, (1.60-2.58) for R_2, (1.39-2.17) for R_3 and (1.81-2.31) for R_4. The implication for this is that it is very risky to use these roads after heavy rain-falls. The way to reduce the risk is to increase the capacity of the drains along these roads. It is important to note that availability of land in some places for the construction of good and sizeable drainage is a big problem. This is because of the attachment of Awka indigenes to lands may be due to its scarcity. Another challenge is availability of fund for the two- time period of the maintenance; this is March/April and August/August break.

5.2 Recommendation

The following recommendations were at the end of the study:

(1) Designing drain to have a uniform section over a long road portion is uneconomical. Therefore, it can be done in such a way that it increases down the stream as the tributaries increases.
(2) It is also recommended that drains be maintained regularly and appropriately.
(3) Desilting should be carried out two times in the year. First at the beginning of the rainy season (March/April) after the first rains. Second one should be in August break in preparation of heavy rains of September and October.
(4) Strong government policy is needed to help stop completely, the dumping of refuse into the drainage ways. For example, the areas chosen as case study are residential areas; the government can make it compulsory that each Landlord will take care of their own portion of the drainage.
(5) Generally our environment is very important to us; therefore school curriculum could be designed in such a way that the importance of taking care of it can be included at various levels of education.

6.0 Contribution to Knowledge

Hazard rating for different points along these routes is now established such that engineers have real time hydraulic data to carry out a re-design.

Declaration of Generative AI and AI-assisted technologies in the writing process
During the preparation of this work the authors used Goggle map in order to generate the map of Awka. After using the goggle map, coral draw was used by the authors to review and edit in order to indicate points of sample collection as needed and take full responsibility for the content of the publication.

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