Analysis of Factors Influencing Flooding and Vulnerability Asssessment of Awka and Its Environs

Chinafumnanya N. Ani, Celestine A. Ezeagu, Nkiru K. Nwaiwu and Emmanuel O. Ekenta

Department of Civil Engineering, Nnamdi Azikiwe University, Awka, Nigeria.

ABSTRACT: *Six criteria that influence flooding were selected for analysis and vulnerability to flooding was assessed in the study area. They are land use/land cover (LULC) elevation, slope, drainage density, drainage distance, rainfall and soil. GIS layers of these influencing factors were created in common geo-referencing scheme and each parameter, was converted to an integer raster map in grid format having the same pixel size (300m). The following results were obtained; spatial distribution of mean monthly rainfall ranges 53.12m – 54.89m, elevation ranges between 40m -157m with average elevation of 63m above sea level, LULC gave values as follows (Bare land (0.4231), Built-up (21.4578), Cultivated lands (12.8227), Dense vegetation (0.6310), Savannah vegetation (12.4834), Riparian (12.3681), Drainage density ranges from 0–8m^{-1}, Drainage distance ranges from 0-1000m with 0-384m(highly vulnerable), 384.1 – 579m (moderately vulnerable) 779 – 999m and above (low vulnerability) and slope ranges from 0 – 10.85 degrees with a mean slope of 4.17 degrees. These factors in order of importance were ranked and weighed. Rainfall was ranked highest with a weight of 29.6% followed by elevation with an assigned weight of 17.6%. Drainage density and slope ranked third with 15.5% each. Distance from drainage network and land use ranked 5th and 6th with 12.6% and 9.2% respectively. The weight-age was imputed into weighted overlay analysis to access level of flood vulnerability. Flood vulnerability assessment using multi-criteria evaluation approach which holistically considers the role of several factors in flood occurrence was used. And since the influence of the factors considered varies, in order to reduce subjectivity and bias in allocating weights to the factors, Analytical Hierarchy Process (AHP) approach was used to rank the weights assigned to each criteria. This was achieved by utilizing AHP calculator. The flood vulnerability potentials of Awka were analyzed and the level of vulnerability was highlighted and visualized.*

Keywords: *ASSESSMENT, FACTORS, FLOODING, GIS and VULNERABILTY.*

I.   INTRODUCTION
1.1 Background of Study

Flood is a recurrent natural phenomenon that is difficult to prevent but can be managed in order to reduce its social and economic impacts. It 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) that is usually dry land, suddenly gets submerged under water. Encarta dictionary (2009) defined flood as an overflow of water that submerges land that is usually dry. Flood occurs at irregular intervals and varies in size, duration and the affected area. Some floods can occur suddenly and recede quickly. In recent years, water-related disasters have increased considerably. Catastrophic floods endanger lives and cause human tragedy as well as heavy economic losses. Flooding may happen with only a few inches of water, or it may cover a house to the roof top. 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. It is also important to note that since water naturally flows from high areas to low lying areas. This means that people in low-lying areas are more likely to experience flood quickly before it begins to get to higher ground.

Flood risk assessment considers the impacts of flooding and how the proposed development project may affect the Awka area. In addition, the assessment includes a recommendation on how the flooding risks can

be improved after the development. On the other hand, flood risk management is an approach to dealing with flood risk based on the notion that risks cannot be taken away entirely but only partially and always at the expense of other societal goals. The aim of flood risk management is therefore, to reduce the consequences of floods, in ways that balance this aim against other considerations.

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 which 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 help 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 to analyse the factors influencing flood in the area in order to know the ways of ameliorating the problem considering the environmental built up of Awka. It has been observed that during rainfall, the generated run-off constitute 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. In addition, because of the flooding, homes of most residents within these basins eventually become a dumping ground for waste material deposited by the flood when it has subsided.

1.3. Aim of the Work

This work is aimed at analyzing the factors influencing flooding in Awka and flood vulnerability assessment of Awka and its environs.

1.4. Objectives of the Work:

By carrying out this research work these objectives are targeted; the extent to which some selected factors affect flooding in the area of study will be shown to make us proffer ways of reducing the vulnerability of Awka people and their environs to flooding. The reason for this work is justified because damages caused by floods on human health are the most adverse consequence of flooding, for example psychological problems, injuries and loss of human life. Furthermore, loss of goods and disruption of activities as well as environmental pollution have been witnessed. Therefore, this work will be useful in that it will 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 in ways that balance other socio-economic considerations.

1.5 Scope of Work

Six factors that influence flooding were selected for analysis. These are Land use/Land cover, elevation, slope, drainage density, drainage distance, rainfall and soil. Vulnerability to Flooding was assessed in the study area

1.6 The Study Area

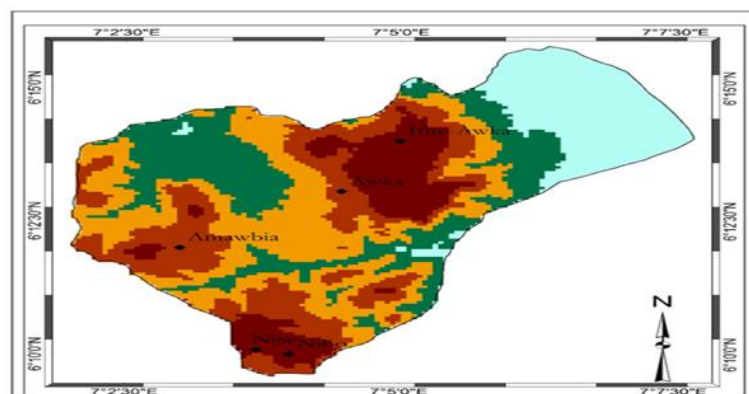The area of study is Awka and surroundings as shown in the map below:

Fig.1.1: Map of Study Area.

Awka is situated at 6.21° North latitude, 7.07° East longitude and 136 meters elevation above the sea level. Awka is a big town in Nigeria, having about 301,657 inhabitants according to 2006 census.

II. LITERATURE REVIEW

Flood is also defined as "An unusual accumulation of water above the ground caused by high tide, heavy rain, melting snow or rapid runoff from paved areas." (EEA, 2007). FEMA (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 policyholder's property) from: --overflow of inland or tidal waters; or --unusual and rapid accumulation or runoff of surface waters from any source; or –mudflow (a river of liquid and flowing mud on the surfaces of normally dry land areas, as when earth is carried by a current of water. According to Komi (2016), the causes of floods can be broadly divided into physical, such as climatologically forces, and human influences such as vegetation clearing and urban development. The most common causes of floods are climate related, most especially rainfall. Prolonged rainfall events are the most common cause of flooding worldwide. These events are usually associated with several days, weeks or months long of continuous rainfall. Human impacts on river catchments also influence flood behaviour. Land use changes in particular have a direct impact on the magnitude and behaviour of floods all over the world. Deforestation results in increased run-off and often a decrease in channel capacity due to increased sedimentation rates.

2.1 Consequences of Flood

Floods can have devastating consequences and can have effects on the economy, environment and people. Borrero et al (2006) indicated that among natural catastrophes, flooding has claimed more lives than any other single natural hazard.

(i) Economic: According to (Sale, 2014), floods are the most costly and wide reaching of all natural hazards. It usually takes years for affected communities to be re-built and business to come back to normalcy. In the decade 1986 to 1995, flooding accounted for 31% of the global economic loss from natural catastrophes and 55% of the casualties. Some impacts of floods are intangible and are hard to place a monetary figure on. Intangible losses also include increased levels of physical, emotional and psychological health problems suffered by flood affected people. Indirect and intangible consequences of flooding are probably greatest in Least Developed Countries (LDCs), especially where frequent and devastating floods create special impacts for the survivors. The damaging effects of flooding are likely to become more frequent, more prevalent and more serious in the future (Sale, 2014; Smith et al, 2007).

(ii) Environment: Additionally, flooding kills animals, and others insects are introduced to affected areas, thereby distorting the natural balance of the ecosystem.

(iii) People and animals: Water supply and electricity are disrupted and people struggle and suffer as a result. In addition to this, flooding brings a lot of diseases and infections including military fever, pneumonic plague, dermatopathia and dysentery.

But flood is not totally bad, there is also something good about floods, especially those that occur in floodplains and farm fields. Floodwaters carry lots of nutrients that are deposited in the plains. Farmers love such soils, as they are perfect for cultivating some kinds of crops.

2.2 Flood Vulnerability and People

Adeloye, et al, (2015) 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. 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 floodplains 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. Floods have been cited as being the most lethal of all natural disasters (Alexander, 1993). Therefore, in the process of flood risk analysis, loss of life (flood death or flood fatality) is always an important type of consequence of flood incidents (Jonkman, 2007). The extent of a flood has a direct relationship with the recovery times of crops, pastures and the social and economic dislocation impact to populations of a country. Flood fatality, also called "loss of life in floods", "flood mortality" and "killed by flooding" refers to a fatality that would not have

occurred without a specific flood event (Jonkman and Kelman, 2005). Flood death toll is the most commonly reported figure for flood fatality. Flood tolls are often carried out during or soon after a flood event and show the number of deaths due to the flood event. The flood fatalities counted in the flood toll are caused by the physical aspects of the flood water such as drowning. But Bennet (1970) observed a higher mortality rate in the flooded area compared with the non-flooded area after investigating the longer-term effects of floods on mortality after the 1968 floods in Bristol, United Kingdom. Strong evidence shows the correlation between psychological health effects and mortality in flood disasters.

2.3 Factors Contributing to Flooding
Urban flooding on the other hand 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 (Ali, 2005).

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.

Swamps and natural ponds or lakes have the capacity to store floodwater and release it slowly. Artificial structures such as dams or detention basins (small reservoirs) can also store water for a period of time, and reduce the peak of downstream flows while extending the duration of an event. All such structures have a finite capacity and there is a limit to the volume of catchment flow that can be stored. Apart from these there also some human activities contribute to flooding in an area:

- Land-use activities such as urbanization increase run-off volume and rate,
- Occupation of the flood plain obstructing flows,
- Structural flood control measures such as embankments in the upstream,
- Decrease in conveyance of the river channels owing to build up of river debris, restriction of waterways, dumping of mineral, wastes and rubbish, and
- Mining and other industries altering water regimes.

Ebuzoeme, (2015), said that Ebisemiju (1993), is of the opinion that the most significant impact of flooding arises from urbanization. Again, flood control/risk analysis is more complex in urban areas than in rural areas due to their closely packed buildings, different kind of land uses large number of flood control works and drainage systems. (Chaochao et al, 2016)

This so because urbanization goes along with constructions that lead to deforestation, land-use changes, temperature modification of soil physical properties and structures and the exposure of bare soil surfaces especially of construction sites all of which bring about changes in the morphological and hydrological state of water. Kofo, (2012) also in a research work titled "Global Warming and Challenges of Floods in Lagos Metropolis, Nigeria found out that global warming and extreme weather events have caused havoc to lives and property in recent years.

2.5 Effects of Flooding in Awka
Flood has many effects on environment. In Awka according to Ebuzoeme, (2015), concluded that major effects of flooding in Awka include: road congestion, accident, damage of buildings, destruction of properties, health problems, reduction of aesthetic beauty of the environment, increase in poverty level and death. Floods can also disrupt drainage and sewage systems, presenting a serious health hazard resulting from

pollution and water borne-disease. Poor communities are at higher risk due to the vulnerability of their livelihoods, especially in the rural areas where access to services and infrastructure are limited. Increasing income generation can reduce flood risk (Kossi et al, 2016). Flood has serious effect on the health of the people. An article titled: Vulnerability to Flood-induced Public Health Risks in Sudan by Haintham and Jayant (2014) analyzed flood vulnerability via-visa flood induced health risk to understand the relationship between them and suggested measures to reduce health risks in Sudan. Flood and health consequences in two communities were compared. It was discovered that flood and health vulnerabilities are positively correlated factors like urbanization poverty and education directly affect the vulnerability of communities. Sometimes, some places have already been known to be flooded from often yet inhabitants of such areas remain there for many reasons. In a paper titled: An Assessment of the Impact of Flood Events in Makurdi, Nigeria by Hula and Udoh (2015). Historical findings, showed that flood disaster is a re-occurring problem in Makurdi such that it has become an awaited or expected evil. The flood in the area is such that is takes between 2-3 days to subside in some cases. The flooding occurs mostly between the months of September and October with great damage of both personal properties and public infrastructure. Despites these, the residents of these flood prone areas have remained on the basis of having no alternative, cultural ethnic affinity, family home where parents were buried and cheaper houses to rent. They further identified that some flooding mitigation measures have already been carried out such as dredging of river, use of high foundations for building and building on levees and embankment.

2.7 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 analysed the factors influencing flooding and vulnerability assessment of Awka and its environs to establish a relationship among these factors. Therefore, this work tried to fill this gap considering the deplorable extent to which Awka has been messed up by flood.

III. RESEARCH METHODOLOGY

　　Geographic Information System (GIS) were used for the delineation of flood factors in Awka. Initially, GIS maps are created for each factor in common geo-referencing scheme. Rainfall and soil maps are prepared using data collected from Inter-governmental Panel for Climate Change (IPCC) and Food Agriculture Organization (FAO) portals respectively. Drainage network and slope maps are generated from Digital Elevation Model (DEM) produced using SRTM data. Drainage density (Dd) is measured, where Dd= L/Ad, the total length of all channels (L) divided by the area of the drainage catchment. Covering the study area was used for land use and land cover classification. Land use layer and land cover was also produced using Landsat satellite imagery acquired for year 2018 compared with recent imagery available on Google earth to enhance classification accuracy. After producing GIS layers of each parameter, all layers are converted to an integer raster maps in grid format having the same pixel size (30m). Thematic layers were created for the following factors: (i) Rainfall (ii) Soil. (iii) Drainage density. (iv) Distance to drainage. (v) Elevation. (vi) Slope. (vii) Land use land cover.

Table 3.1. Data Sources for Factors that Influence Flooding Occurrences.

Data Type	Source	Acquisition Date	Relevance
Precipitation	Inter-govermental Panel for Climate Change (IPCC)	2000-2018	Mean annual Precipitation; Interpolation and as criteria for erosion susceptibility analysis.
Landsat Imagery	Earthexplorer http://earthexplorer.usgs.gov/	2018	Land use/Land cover Classification; Criterion for erosion susceptibility.
Shuttle radar topographic mission(SRTM)	Earthexplorer http://earthexplorer.usgs.gov/	-	Elevation, watershed delineation, drainage density and slope analysis.
Soil Map	Food and agriculture Organization (FAO)	2018	Soil type delineation and feature class creation.
Administrative map of Nigeria	Office of the surveyor general(OSGOF)	-	Study area delineation

　　Analytical hierarchy process (AHP) method will be employed to compute weights for the different indicators considered. The AHP method, which was developed by Saaty (1990), is a multi-criteria, mathematically based method which uses a set of pairwise comparison matrices to estimate the relative importance of different criteria and alternatives, among which the best decision is made. Saaty's AHP model has attracted the interest of many researchers (Danumah et al, 2016; Bathrellos et al, 2013; Omkarprasad, and Sushil, 2006 and Marinoni, 2004) because it has the advantage of incorporating a test for checking the consistency of a choice, thus reducing the uncertainty in the evaluation process. In order to compute the weights for each indicator, the AHP starts creating a pairwise comparison matrix.

IV. RESULTS AND DISCUSSIONS

4.1 Analysis of Factors Affecting Flood Occurrence in the Study Area
(i) Rainfall (ii) Soil. (iii) Drainage density. (iv) Distance to drainage. (v) Elevation. (vi) Slope. (vii) Land use land cover.

4.1.1 Rainfall: The rainfall map shown in figure 4.1 indicates the spatial distribution of mean monthly rainfall in the study area.
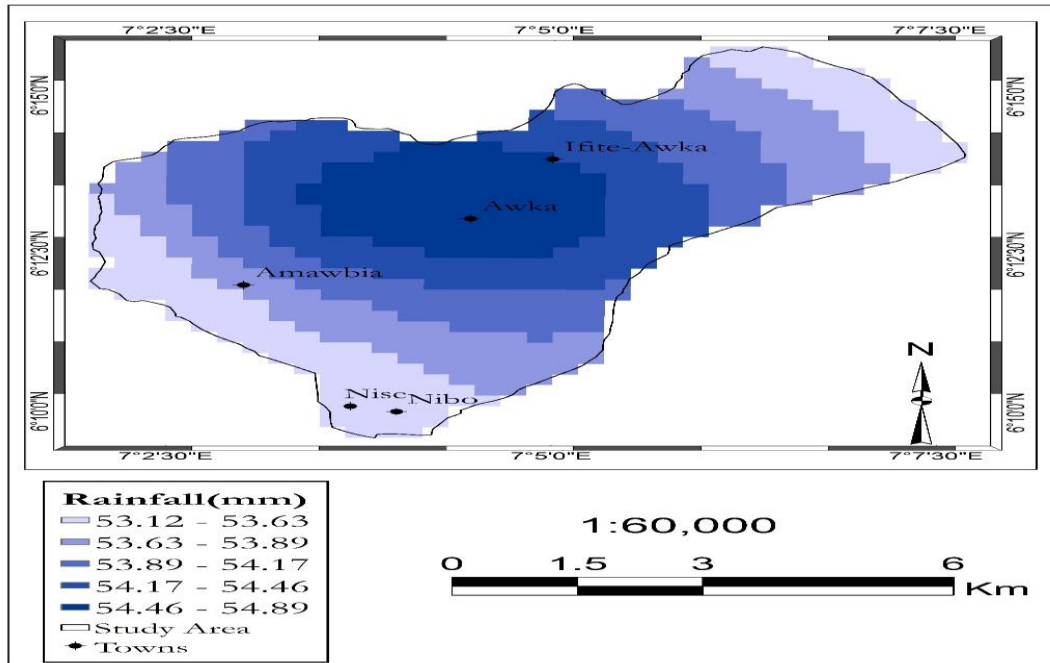
Fig. 4.1: Rainfall distribution of Awka and its environs.

4.1.2 Elevation: Elevation plays an important role in flood occurrence. If fluvial flooding is the main concern, elevation difference of the various DEM cells from the river could be considered, whereas for pluvial flooding, local depressions i.e. DEM cells with lower elevation than the surrounding ones, would be more important. The elevation values in the study area range between 40 meters and 157 meters above sea level with a mean elevation of 63meters above sea level.
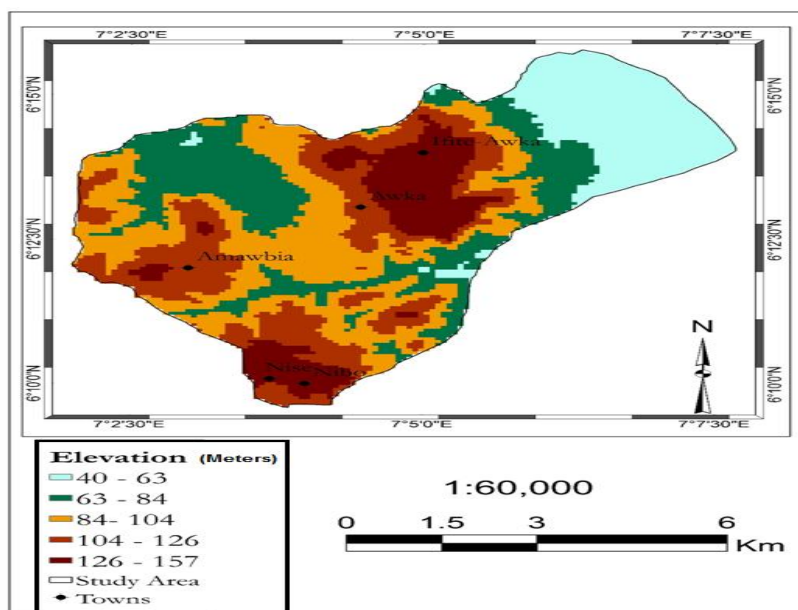
Fig 4.2. Elevation of Awka and its environs.

4.1.3 Land Use and Land Cover (LULC) : Land use practices and land cover has been seen to play a critical role in levels of exposure to soil erosion. Figure 4.4 and figure 4.5 shows land use and land cover map of the area and the reclassified LULC map respectively. Fig 4.5 shows the order of influence across the various land uses and cover classes.
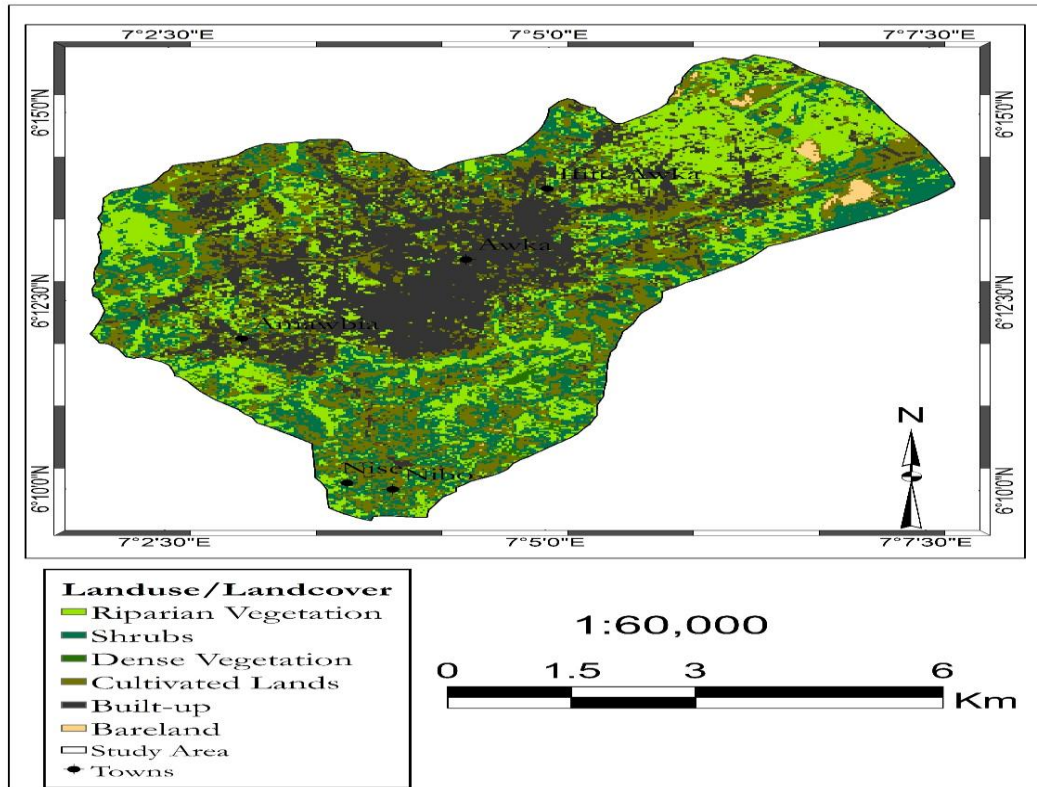

Fig 4.3. Landuse/ Landcover of Awka and its Environs.

Table 4.2: Land use and Land cover classification @ landsat imagery

LULC (Sq/Km)	2018
Bareland	0.4231
Built-up	21.4578
Cultivated Lands	12.8227
Dense Vegetation	0.6310
Savanna Vegetation	12.4834
Riparian Vegetation	12.3681

4.1.4 Drainage Density

The drainage of the study area is represented as density map for easy characterization of runoff and infiltration of rainwater. Drainage density is a measure of the total length of the stream segment of all stream orders per unit area. It is the closeness of spacing of stream channels and an inverse function of permeability. The less permeable a rock is, the less the infiltration of rainfall, which conversely tends to be concentrated in surface runoff.
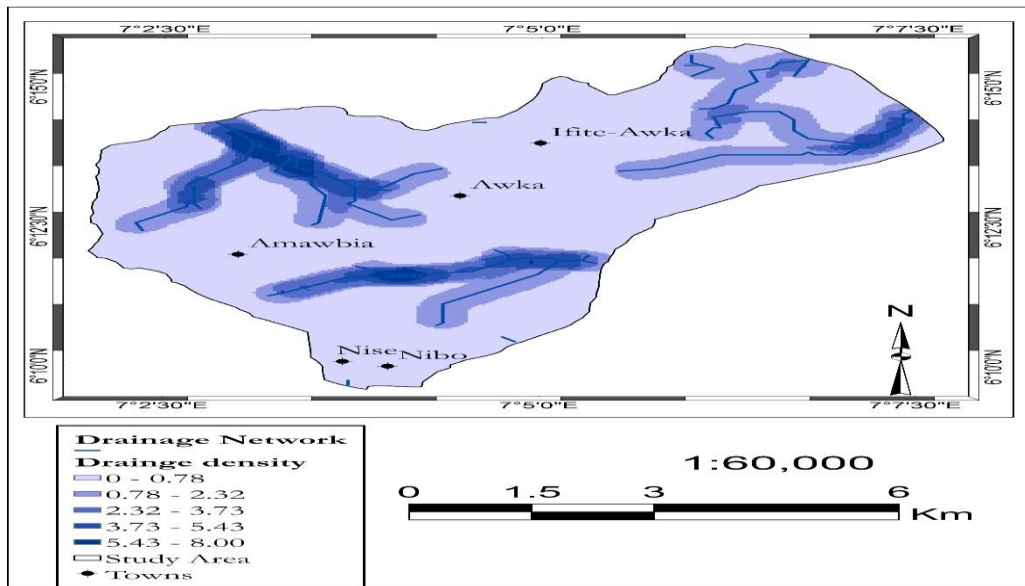
Fig 4.4. Drainage density of Awka and its environs.

4.1.5 Distance from Drainage: The proximity of an area from the stream or drainage network can influence the flooding vulnerability potentials of the area due to surface and ground water table changes. Natural Water ways are highly vulnerable to flooding and this can impinge on areas within the range of the occurrence. In this view, the Euclidean distance from drainage networks was taken into consideration. The distance ranged from 0- 1000 meters within the area of study. With respect to flood vulnerability levels, the areas within the range of 0-384m were considered highly vulnerable. This was followed by 384.1-579m, while 779-999m and above and which were considered moderate and low vulnerability zones respectively.
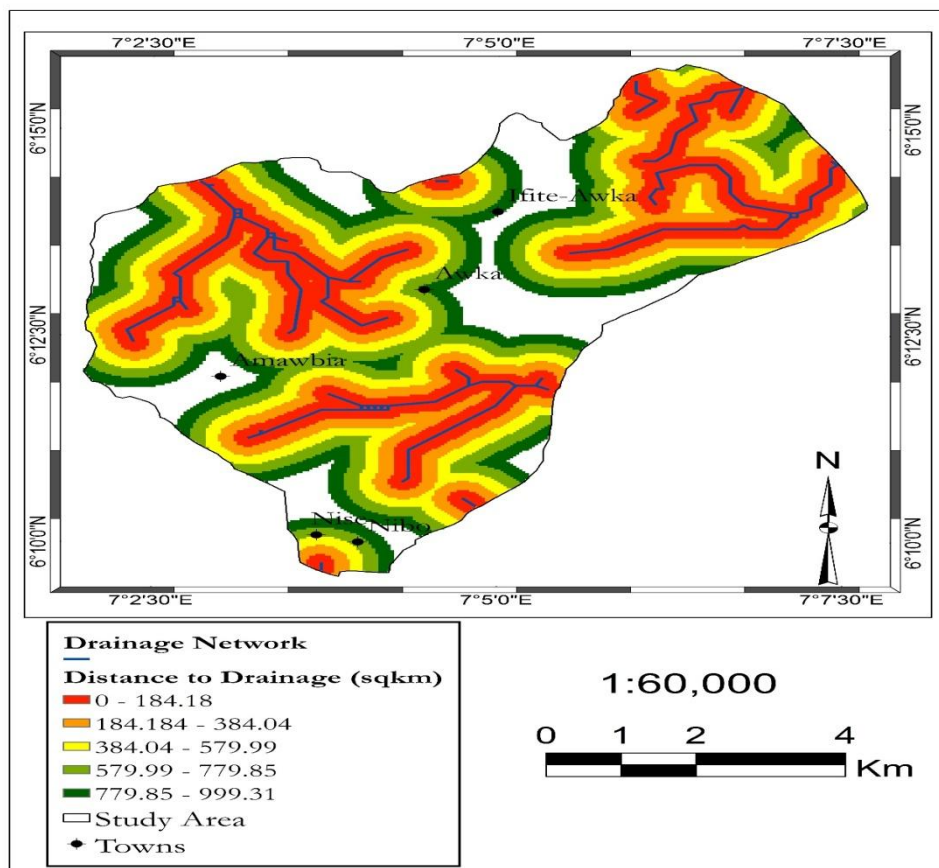

Fig 4.5. Distance of drainage for Awka and its Environs.

4.1.6 Slope: The slope influences the direction and amount of surface runoff or subsurface drainage reaching a site. Slope has a dominant effect on the contribution of rainfall to stream flow. It controls the duration of overland flow, infiltration and subsurface flow. Steeper slopes are susceptible to surface runoff. Flat terrains on the other hand are susceptible to water logging.

Low gradient slopes are more vulnerable to flood occurrences compared to high gradient slopes. Rainfall or excessive water from the river always gathers in an area where the slope gradient is low or gentle. Areas with high slope gradient do not permit water to accumulate and are therefore less susceptible to flood. The slope was derived from SRTM data covering the study area. The slope ranges between 0 and 10.85 degrees with a mean slope of 4.17 degrees.
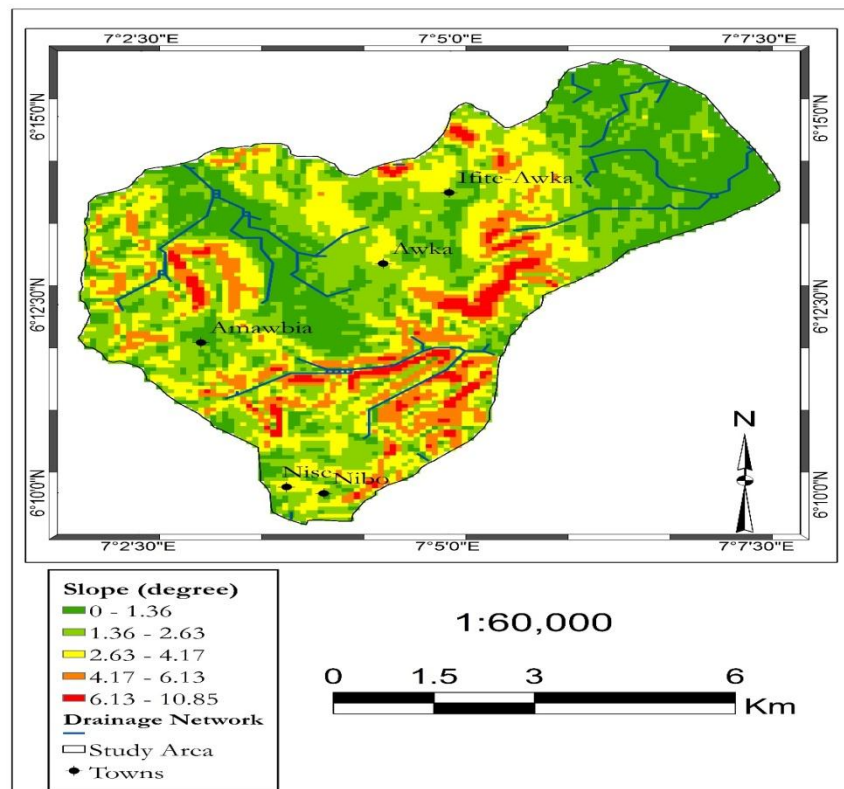

Fig 4.6. Drainage slope of Awka and its Environs.

4.1.7. Flood Vulnerability of Awka : Flood vulnerability assessment using multi-criteria evaluation approach holistically considers the role of several factors in flood occurrence. The influence of the factors considered varies. Weights were assigned to these factors based on their relative importance. In order to reduce subjectivity and bias in allocating weights to the factors considered, Analytical Hierarchy Process approach was used to rank the weights assigned to each criteria. This was achieved by utilizing AHP calculator. The rank for each criteria and the decision matrix is shown in figure 4.7.

Table 4.3: Criteria Weights based on Pair-wise Comparisons

As revealed in table 4.3, 15 pair-wise comparisons were made which gave an acceptable consistency ratio of 1.3% (<10%). In order of importance, rainfall was ranked highest with a weight of 29.6% followed by elevation with an assigned weight of 17.6%. Drainage density and slope ranked third with 15.5% each. Distance from drainage network and land use ranked 5th and 6th with 12.6% and 9.2% respectively. This weight-age was inputted into weighted overlay analysis to assess the levels of flood vulnerability in the area as will be shown in subsequent sections. Each criterion considered was evaluated to accommodate their individual influences to flood vulnerability in the study area are shown in table below.

Table 4.4: Evaluation of Criteria

Criteria	Value	Reclassified Values	Rank	Weight (%)
Land use/Land Cover	Vegetation	1	6	9.2
	Bare soil/River sand.	2		
	Built-up/ Water body	5		
Distance from Drainage	0- 184m	5	5	12.6
	384-579m	4		
	579-779m	3		
	779-999m	1		
Slope	0-2.6	5	3	15.5
	2.61-4.17	4		
	4.18-6.12	2		
	6.1-10.85	1		
Drainage Density	0-02.3	1	3	15.5
	2.31-3.7	2		
	3.71-5.4	3		
	>5.5	5		
Elevation	40 – 63m	1	2	17.6
	63 – 84m	2		
	84 – 104m	3		
	104 – 126m	4		
	126 – 157m	5		
Rainfall	53.12- 54.17mm	5	-	29.6
	54.17 - 54.46mm	2		
	54.46 - 54.89mm	1		
VULNERABILITY LEVELS:1= least; 2= Low; 3= Moderate; 4=High; 5=Extreme				

4.2 Flood Vulnerability Assessment of Study area.
The weighted overlay analysis was used incorporating the weights assigned for each criterion. The flood vulnerability potentials of Awka were analyzed and the level of vulnerability was highlighted and visualized.
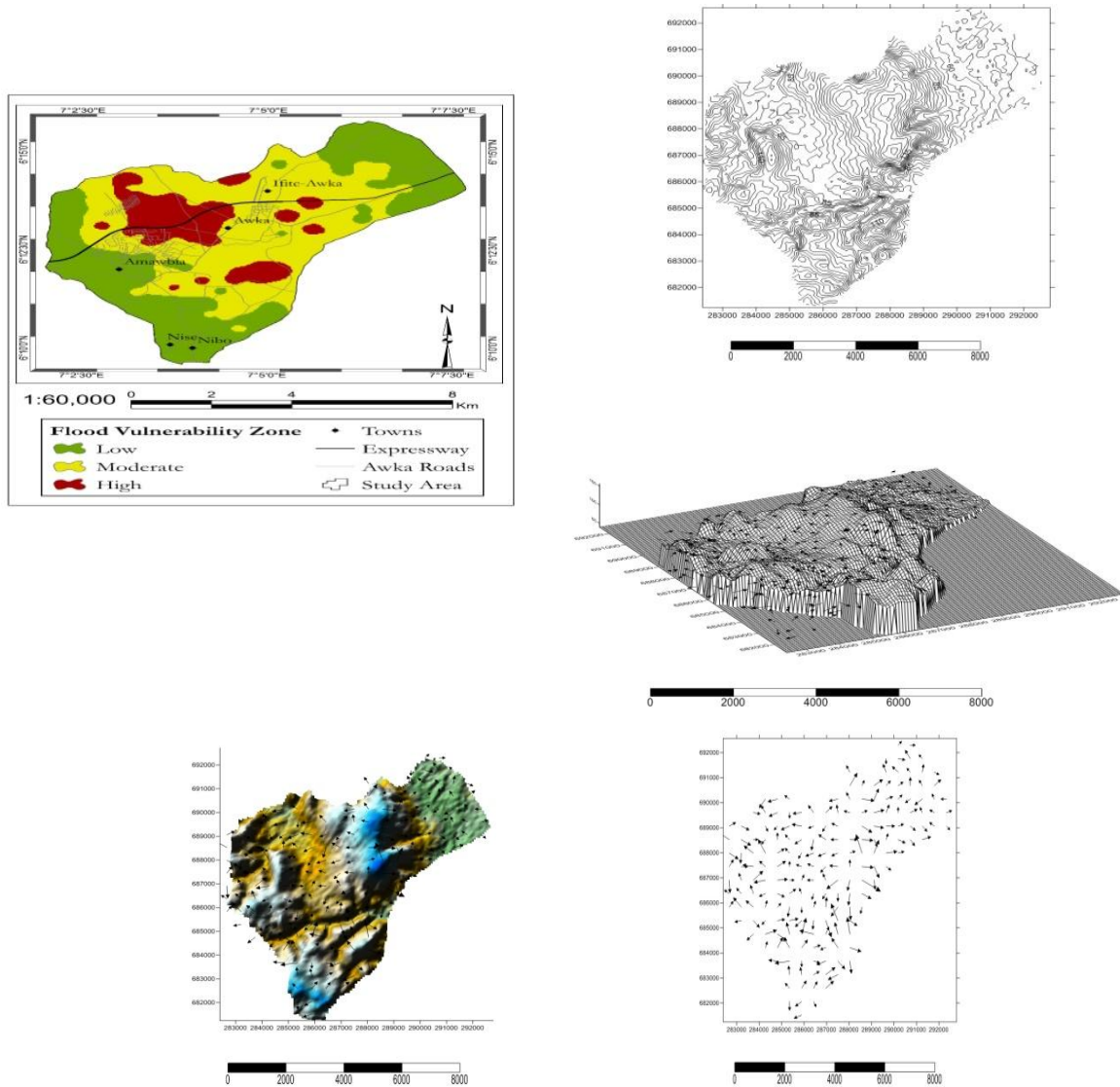
Fig 4.7a,4.7b, 4.7c, 4.7d. 4.7e. Flood Vulnerability Potential for Awka and Its Environs.

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, this study revealed that the factors affecting the occurrence of flooding in the study area as ranked in the order of importance are rainfall ranked highest with a weight of 29.6% followed by elevation with a weight of 17.6%. Drainage density and slope ranked third with 15.5% each. Distance from drainage network and land use ranked 5th and 6th with 12.6% and 9.2% respectively. It is clear that first and the second are natural and therefore cannot be altered by man while the third, fifth and sixth human factors. Hence, these human factors can be worked on in order to reduce the occurrence of flooding in the area.

Furthermore, the vulnerability assessment study also showed that greater part of Awka metropolis fall under high vulnerability zone while its environs like Amawbia and Nibo have fall under low and moderate vulnerability zones. Therefore, investment made in places like Nibo, Amawbia and Nise have less threat of been flooded than in the heart beat of Awka the capital of Anambra State. This is due to its elevation since rainfall is almost the same.

5.2 Recommendation
It is therefore, recommended that
1. Further study on how to handle flooding in the centre of excluding these environs can be further carried out.
2. Government should come up with stronger policies to stop inhabitants of Awka from blocking the existing drains with refuge dumps.
3. Periodic maintenance of the drainage facilities is highly clamored for.

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