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EFFECT OF URBAN DRAINAGE SYSTEM AND FLOODING OCCURRENCES IN MINNA METROPOLIS, NIGER STATE, NIGERIA

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Abstract

This study examined the drainage network and flood occurrence in Rafin Yashi, Kure market, IBB specialist, Tayi and MYPA junction in Minna metropolis. The objectives of this study include; examine the floods occurrence in the study area, examine the factors that are responsible for flooding in Minna metropolis, examine the drainage characteristics of the study area, and analyze the pattern of urban drainage system and flood occurrence of the study area. However, this study employs quantitative research method, through which both primary and secondary data were collected. The primary data were collected through the use of semi-structured questionnaires and the secondary data were obtained from the Niger state Geographic Information System (NIGIS) from 2011-2020. Descriptive statistics and Digital Elevation Model (DEM) were utilized to analyse the data. However, about 70% of the respondents were male and 30% were female. The result of the study showed that excessive rainfall is the major cause of rainfall in the study. Areas within 150-200metre were identified as areas vulnerable to flood and areas at 400metre were identified as areas with very low vulnerability to flooding. Approximately 39% of the study area were prone to flood in 2011, while it was about 48% of the area were vulnerable to flood in 2020, this can be attributed to changes in land use. There is 68% chances of flood occurrence in Rafin Yashi within 1-5year, 42% chances of flood occurrence in Kure market between 6-10years, 59% of flood in IBB specialist occurs within 1-5, 52% of flood occurrence in Tayi within 1-5years and 42% of flood in Mypa occurs within 1-5years. The Digital Elevation Model (DEM) indicated that areas like Tayi village and Rafin Yashin are located on higher elevation which makes it runoff water to drain into downstream, thus, making it rare for flood to occur in these areas. Whilst, areas like Mypa junction, IBB specialist and Kure Market were located on the downstream, which made difficult for runoff to drain into the nearby streams. Rafin Yashi and Tayi

village were identified as the watershed of the study area. However, this study concluded that excessive rainfall is the pertinent cause of flood in the study area.

Keywords: Flood occurrence, Rainfall, Urban Drainage System and Minna

Introduction

The Rio declaration and the Agenda 21 from the early 1990's introduced the concept of long-term sustainability of our environment. One important ingredient in the new approach is that technical, economic and social aspects of the development are handled carefully. There is today, a consensus that urban water systems should be approached in an integrated way. Surface water, groundwater, water quality, quantity, and ecology should be looked upon in relation to each other. Thus, practices and approaches to mitigate the negative environmental effects of storm water runoff are numerous in number that include storm water control measures (SCMs), sustainable urban drainage systems, water sensitive urban design, green infrastructure (GI), and low impact design (LID) some of the design should be implemented to control and minimize the effects of the storm water runoff (Moore *et al.,* 2018).

Presently, about 2.6 billion people are living without proper drainage system, of which Africa is not exempted (UNISDR, 2015). The need to provide proper drainage and sanitation facilities is essential to match up with the ever increasing population growth (Banerjee and Morella, 2011). The increase in the population of a settlement and the attendant growth of the needs of the residents in both quantity and variety, bring about intensive exploitation of the resources of the environment. Such exploitation might increase to a level that the resources would not be able to sustain the population, and in some cases the environment would collapse resulting in serious environmental problems (Ayedun, 2011). This is further buttressed by Belete (2011) who expressed that high urban population growth rate also results in drainage system challenges because an increase in population requires a proportionate increase in infrastructure (roads and drainage systems) of which when not properly catered for, the facilities will be imperfect. Also, inadequate integration between road and urban storm water drainage can be attributed to natural causes such as intense rainfall, flat topography and poor soil infiltration or man-made causes such as improperly laid and

graded street, poor and inefficient drainage facilities that aggravate the flooding problem (Banerjee and Morella, 2011.).

Urban environments in Nigeria are faced with myriad of issues regarding poor drainage systems (Asoegwu, 2019) and water tight structures which are the major causes of flooding (Belete, 2011). Urban flooding which is the inundation of land or property in a built environment, particularly in more crowded areas caused by rainfall overwhelming the capacity of drainage systems. Although this is sometimes caused by events such as flash flooding. Urban flooding is a condition characterized by its repetitive and systemic impacts on communities whether or not the affected communities are located within floodplains or near any body of water (Asoegwu, 2019).

Also, poor drainage systems in Minna have caused tremendous environmental challenges like flooding. These challenges are basically associated with poor maintenance of drainage system and flood which eventually leads to environmental hazards. Some places were flooded, making the roads practically impassable for motorists. In many instances, torrential rainfall literally submerged the metropolis, halting human and vehicular activities thereby forcing residents to stay indoors as a pre-emptive measure against human disaster. Therefore, this study seeks to highlight the drainage system of Minna, the causes and environmental implications of bad drainage systems in the areas that could possibly lead to flooding, highlights measures to improve health and living condition and make possible solutions and suggestions towards improving sustainable design and uses of drainages in Minna.

In Minna several works has been done in relation to flood vulnerability of the city. Among which is the work of Musa (2015) on assessment of flood vulnerability on physical development along drainage channels in Minna and revealed that human activities like construction on the flood plains, poor drainage network and relief of the area were primarily responsible for the perennial floods along the bank of River Suka. However, few studies that discussed drainage on a harbinger of flood have not taken into consideration the dimensional analysis of drainage characterization, such as the drainage volume and factors of flood events in Minna Metropolis, it is against this background that this present study seeks to fill the gap.

Study Area

Minna is the capital city of Niger state which lies within longitudes 6°33' East to longitude 6°55 East and latitude $9^0$37' North to latitude 9°61 North andMinna city

span from Tudun Fulani in the Northwest to Chanchaga in the South. It is about 135 km away from Abuja Federal Capital Territory, and about 300km away from Kaduna city to the north. Within Niger state, it is about 90 km away from Bida to the south, 100km away from Suleja to the east and about 130 km from Kontagora to the west (Oduaye, 2011).

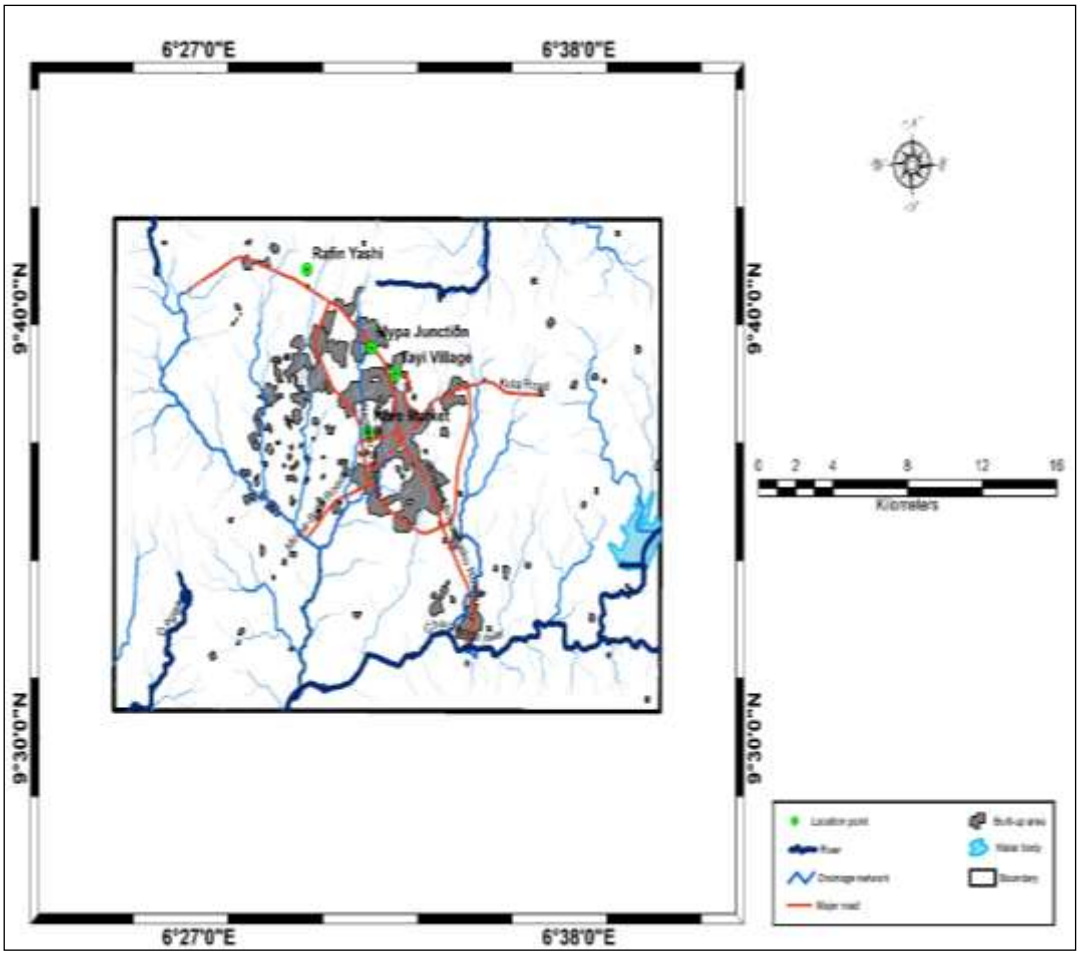

Figure 1: Minna showing the drainage network
Sources: Urban and Regional Planning Department, FUT Minna (2022)

Materials and Methods

Two types of data were sourced directly from the field which includes: (i) primary and (ii) secondary data source. Primary data: This data involved was data obtained through questionnaire administration, measurement of the attributes of interest, analysis of topographic maps, direct observation to extract the necessary information

in the field. Secondary data sources basically included, residential map, satellite images from the Niger state Geographic Information System (NIGIS).

The recurrent of flood within the study area were quantified in terms of their return periods. The information obtained from the questionnaire were analysed using the percentage to quantify the response by the respondents. Also, the bar chart was utilized for the data presentation. This gave the ratio of each response as a fraction of 100. It is usually denoted as percent (%). It is often expressed mathematically as;

$$\frac{value}{total\ value} x\ 100 \qquad 1$$

The various factors obtained were expressed as a ratio of 100. Percentage of each factors were established using the percentage. The DEM was developed utilizing 5metre contour and topographic data, bare earth DEM and built-up area DEM. These extrapolated DEMs were utilized as terrain for the spatial analysis. These generated DEMs were adopted to delineate drainage patterns and watershed of the study area. To assess the vulnerability of the study area, the watershed was obtained from the Digital Elevation Model (DEM) of the study area. Also, the major tributaries were also considered as important source of water to the drainages.

Results and Discussion

Identification of Drainage Characteristics

The major drainage characteristics were obtained, the mean of drainage width and depth were taken across all the five locations in the study area.

Table 1: Drainage Characteristics

Location	Mean width of drainage (m)	Mean depth of drainage (m)	W/D ratio
Rafinyashi	12	4.7	2.6
Kure Market	2	1.3	1.5
IBB Specialist Hospital	12	4.5	2.7
Tayi	18	6	3
Mypa	24	8.2	2.9

Source: Author's Survey (2022)

Table 1 showed the drainage characteristics of the study area. It is pertinent to note that Tayi village has the highest ratio and also Mypa. This could be said that the drainage systems in Tayiand Mypa have more adequate than that of Kure Market, Rafin yashi and IBB Specialist. Although, in spite of narrow and shallow drainage in Kure market, there is little flood event in that area. This could be attributed to little watershed and diversion of water from the Old Airport axis into Fadikpe.

The reoccurrence of flood episode in the areas were determined. In each of the areas, the percentage of each return periodsof flood were determined.

Table 2: Flood occurrence in the study area

Flood Occurrence (years) LOCATION	1-5 (%)	6-10 (%)	11-15(%)	16 & above (%)
Rafin yashi	68	21	11	-
Kure Market	12	42	17	19
IBB Specialist	59	18	15	8
Tayi	52	33	25	-
Mypa	47	35	13	5

Source: Author's Survey (2022)

Table 2 showed the occurrence of flood event in the selected areas. Flood event occur often in Rafin yashi, IBB specialist, Tayi and Mypa than it eventuates in Kure Market. It was shown that there is flood occurred in Rafin yashi, IBB specialist, Tayi and Mypa within 1-5years while it occurred in 6-10 years in Kure Market.

The causes and factors that influence flooding the study area were identified and examined. Factors such as; excess rainfall, poor drainage, building on flood plains and diversion of water course were examined.

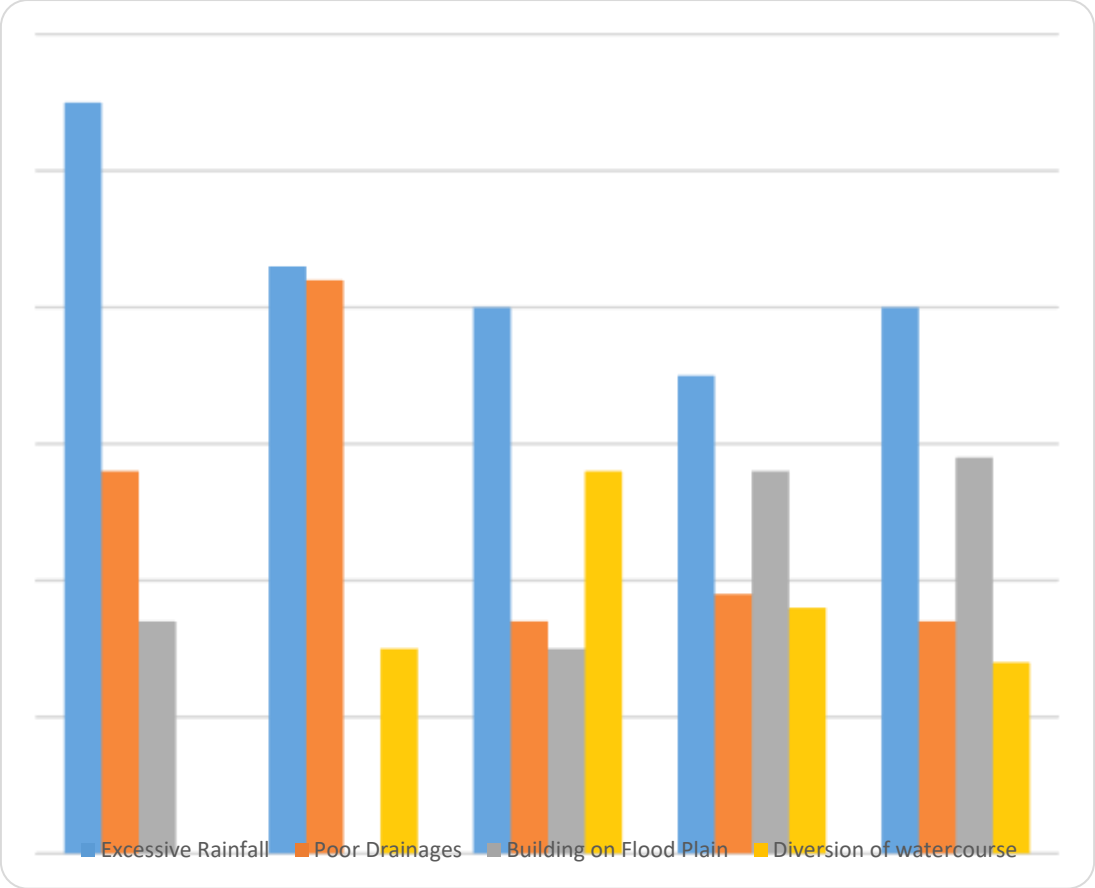

Figure 1: Factors Responsible for Flooding

Figure 2 revealed the factors responsible for flooding in the areas. The major causes of flooding in Rafin yashi and Kure Market are excess rainfall and poor drainage system. Also, in IBB Specialist the significant factors responsible for flood are excessive rainfall and diversion of watercourse, and lastly excess rainfall and building on flood plains are the significant factors that influence flooding in Tayi and Mypa.

The watershed and Digital Elevation Model (DEM) of the surroundings of Rafin yashi, Kure Market, IBB Specialist, Tayi and Map were considered in terms of flood occurrence and vulnerability.

To obtain hydrological distribution (watershed) of the study area, the major rivers and tributaries were depicted in Figure 3. Areas within the watershed (150-200m) could experience overflow or discharge from the drainages while areas with around 400m are seated on much higher ground.

Areas such as Rafin-Yashin and Tayi village are high on high elevation that quickly drain water into nearby streams which makes flooding very rare in these areas. While

areas, like Mypa, IBB specialist hospital and Kure market does slowly or moderately drain rain water into nearby streams which may result into flooding. The study revealed that watershed areas rapidly drains water after rainfall to streams and rivers close to such areas making it difficult for flood to occur.

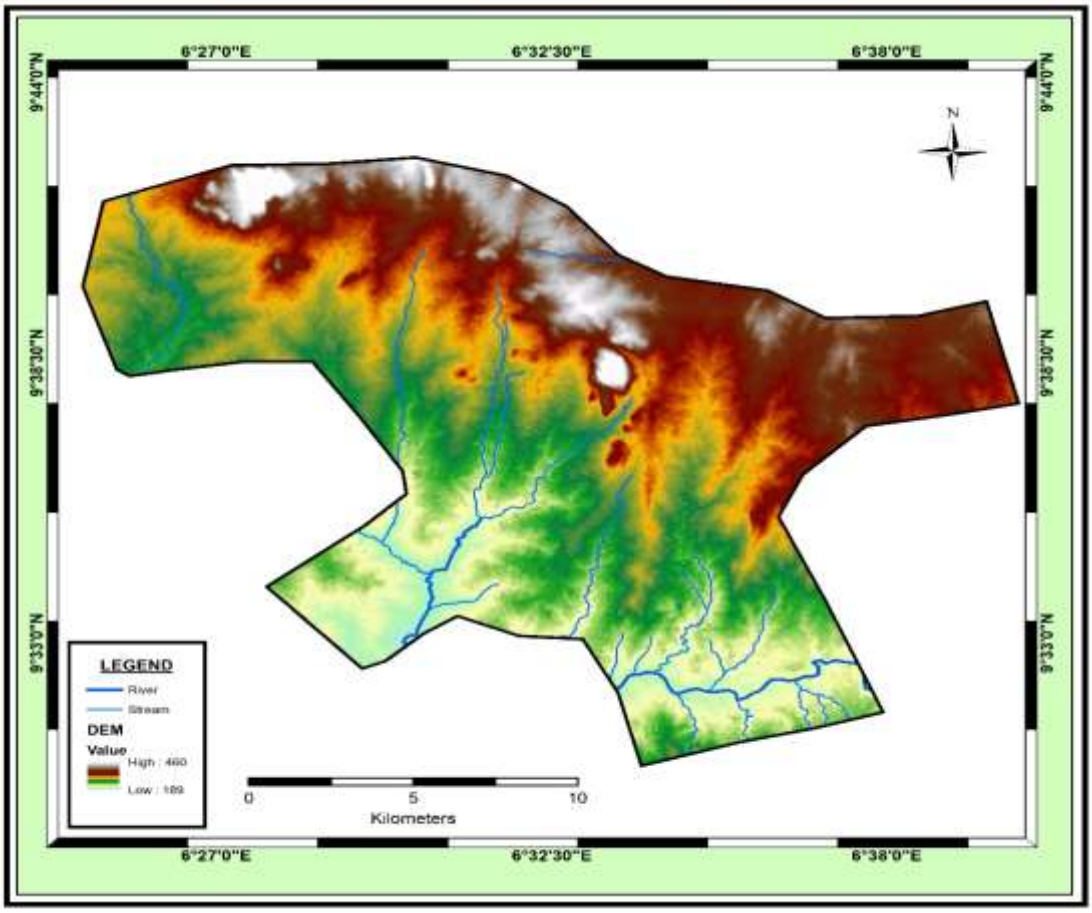

Figure 3: Watershed of the study Area

The terrain and elevation are considered in drainage characteristics and flood occurrence. Figure 4 showed the DEM of the study area. Area such as Rafin yashin is situated on high elevation which was about 460metre, Tayi village is on higher elevation, it was estimated above 400metre, Mypa is located on an average elevation of about 200metre, IBB specialist was around and Kure Market were around 190 and 180 respectively. The elevation was resampled and contour line and slope of the areas were depicted by Figure 4. The DEM revealed that flooding may eventuate on downstream locations since water would to areas where elevation is low.

Consequently, a more prominent impact of significant risk of casualties and destruction to downstream areas. This implies that areas such as Mypa, IBB specialist hospitals and Kure will experience more pronounced effect of flood.

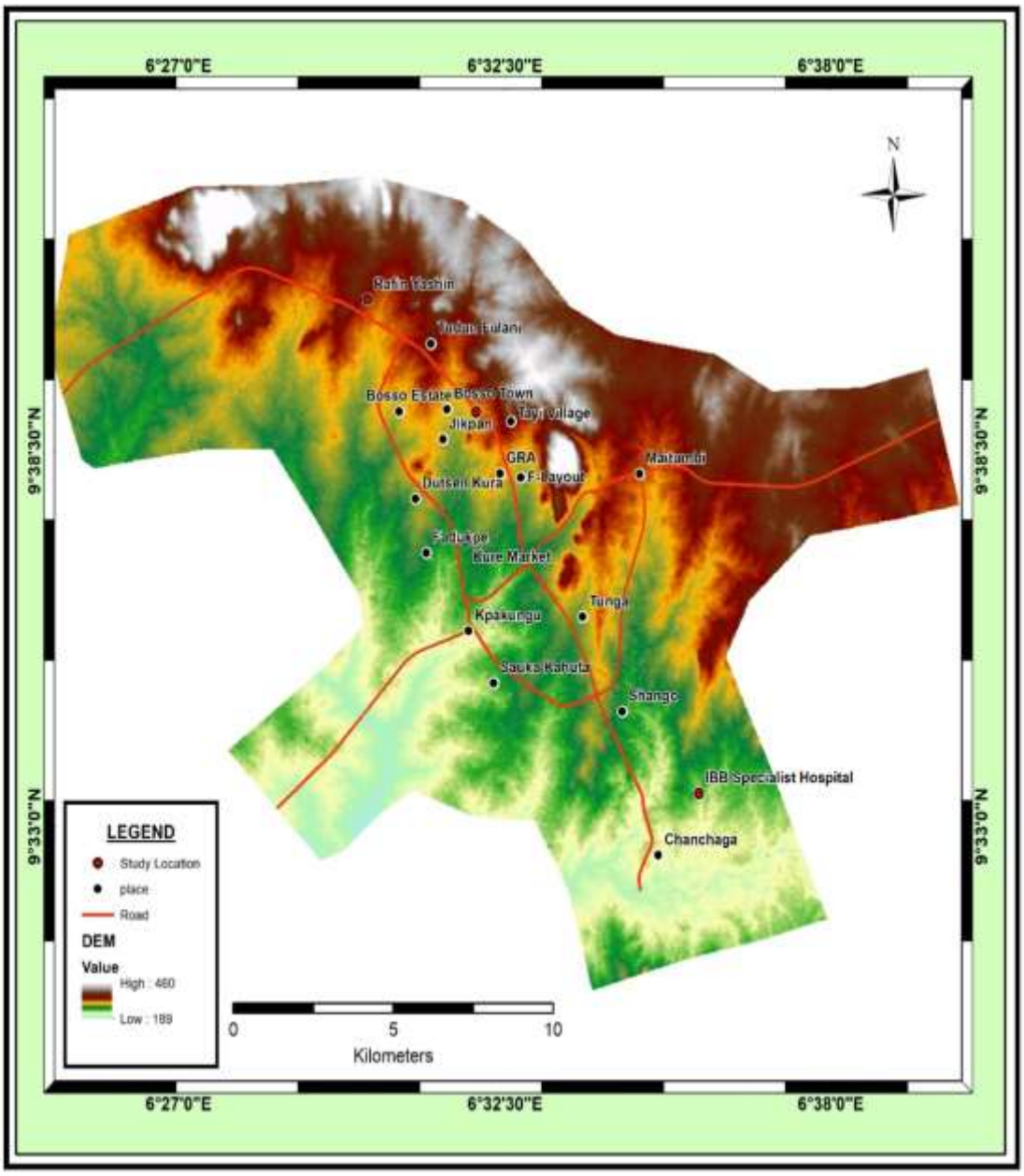

Figure 4 Digital Elevation Model of the Study Area

Figure 5 and 6 showed that most built-up areas in Kure Market and Mypa are highly vulnerable to flooding, while built-up areas in Rafinyashi, IBB specialist, and Tayi are less vulnerable. The major differences in vulnerabilities between 2011 and 2020 was

that some built-up areas in IBB specialist and some part of Rafin yashi have become prone to flooding. Although, Rafin Yashin is located within the watershed which makes it rare for flood occurrence. However, built-up and land surface modifications has altered the topography and elevations of some part of Rafin Yashi. More so, IBB specialist and Kure Market were the high vulnerable areas. While, Mypa to some part of Tayi and Rafin Yashi were moderately vulnerable and most part of Rafin Yashi and Tayi Village were low vulnerable.

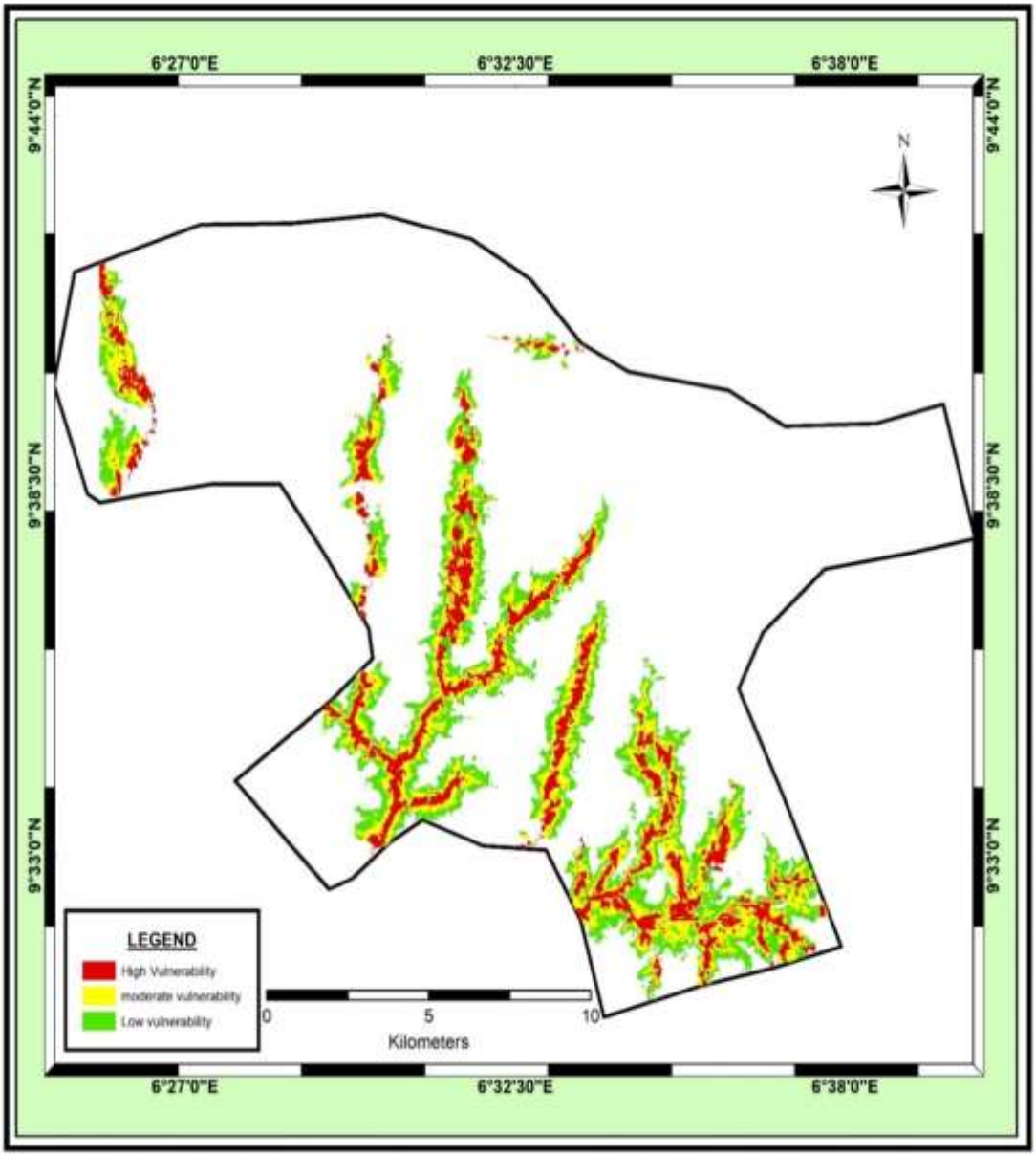

Figure 5 Flood Vulnerability of the Study Area (2011)

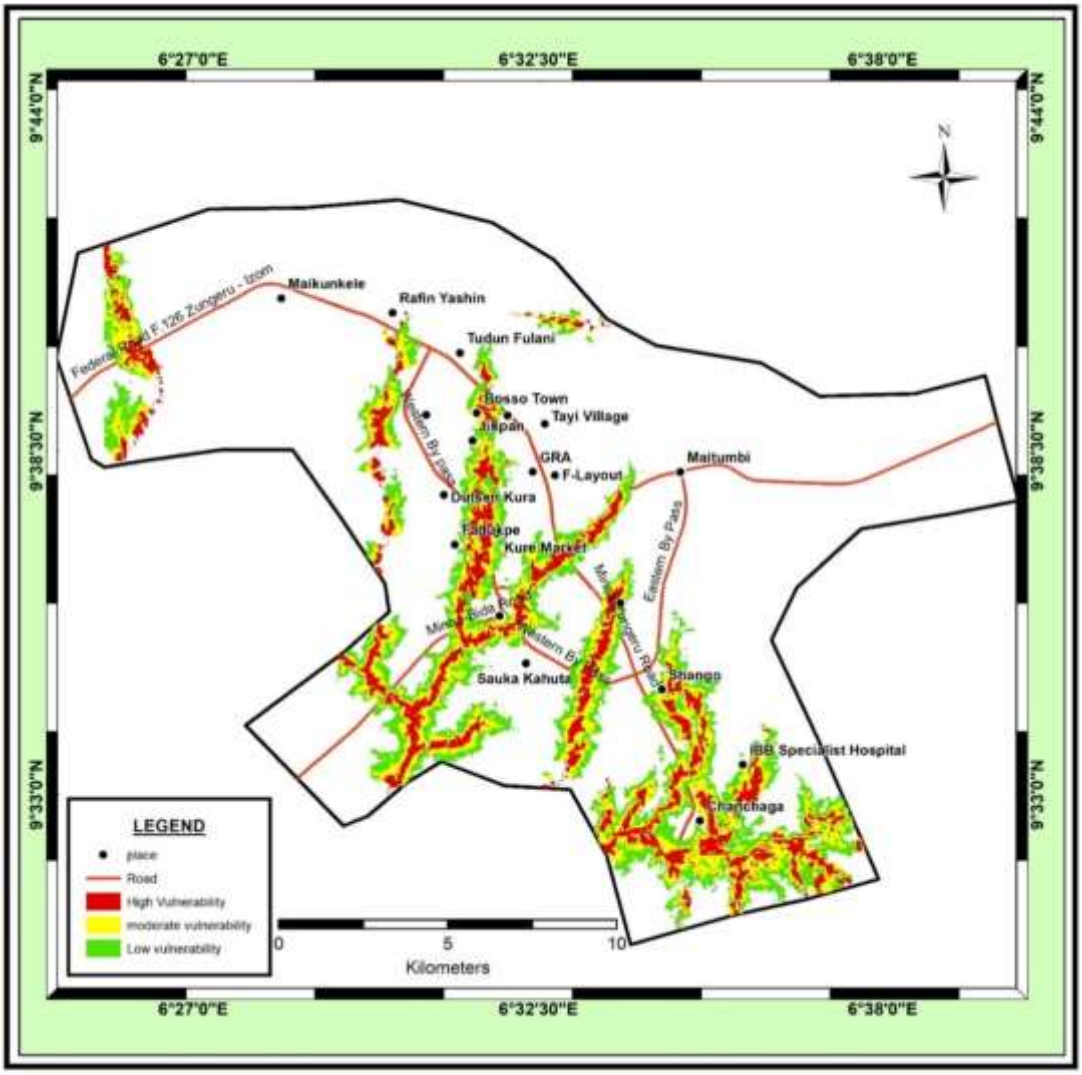

Figure 6 Flood vulnerability of the study area (2020)

Conclusion

This study examined the drainage network and flood occurrence in some selected areas in Minna metropolis, Niger state. Conclusively, the drainage characteristics of some of these areas do not adequately commensurate with the volume of water generated through surface runoff and other tributaries. Although, area such as Mypa has the best drainage characteristics among the areas under study. More so, areas with an elevation of 200metre and below are considered as areas vulnerable to flood. Excessive rainfall is considered as the main cause of flood in the area.

Geographic information system (GIS) is conceived as a sophisticated tool for monitoring and evaluating flood. However, this study called for further studies should enlarge the geographical scope of this study and employs morphometric analysis in evaluation of flood occurrence in the study area. This study recommends the following; Government should ensure that these drainages should be subjected to periodic maintenance; Inhabitants should avoid dumping of refuse and sewage into the drainages and Government agency such as Niger Management of Land and Survey and Ministry of housing should ensure that buildings and structures are not illegally constructed to block waterways.

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