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An assessment of flood vulnerability on physical development along drainage channels in Minna, Niger State, Nigeria

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The occurrence of floods and its effects on human existence as well as the general environment has unfortunately been on the increase owing to human-induced climate change. Consequently, the vulnerability of the poor and the downtrodden has also increased; therefore the need to embark on sustainable human settlement development as well as awareness creation on the effects of flooding. As a result of this, this paper set out to analyze the causes of flooding in parts of Minna, with a view to providing solutions to forestall its impacts along the channels of River Suka. In order to achieve this, secondary as well as primary sources of data collection such as questionnaire administration and reconnaissance survey were undertaken. The data obtained from the questionnaires were analysed using the descriptive statistical method while the topographic and land use maps of Minna were digitized using the ArcView GIS package, which enabled the mapping of the Flood Risk Vulnerable Areas in Minna, Niger State. The result shows that human activities like construction on the flood plains, poor drainage network and relief of the area are primarily responsible for the perennial floods along the bank of River Suka. To this end, it was recommended that sensitization campaigns should be embarked upon by the government and stakeholders in order to create public awareness to the likely effects of flooding. The paper also recommended the monitoring by authorities, of water levels during the raining season, thereby allowing for the transmission of warning signals to the residents of the flood plains.

Key words: Drainage channel, flood, risk assessment, vulnerability.

INTRODUCTION

Natural disasters have been a regular occurrence globally right from time immemorial; but its frequency and intensity have, in the recent past, increased due to human activities. It is therefore the developmental choices (actions or

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inactions) made by individuals, communities and nations that pave way for disasters, which are unequally distribute (Ladan, 1998). The negative effects of which are debilitating and multifaceted, ranging from the destruction of the ecosystem, agricultural activities, infrastructural facilities and amenities, injury, illness, death, inhibition of access to education, health services, comfortable housing, drinking water and sanitation, aggravation of poverty and hunger, among others. One of such natural disasters is flooding, and it is usually associated with some social, economic, and environmental consequences (Queensland Government, 2014) that critically threaten the ecosystem and human existence. As a result of this, meeting some of the Millennium Development Goals (MDGs) has extremely been challenged in many communities, especially those of the less developed countries.

Flooding, according to *Geoscience Australia* (2013) can simply be described as “water where it is not wanted”. It can also be conceptualised as a situation that results when a part of the earth surface that is usually dry is inundated and covered with water due to high amount of rainfall or the overflowing of a water body. Furthermore, flooding was expounded by *pagasa.dost* (2013) as a “natural hydrological phenomenon and its occurrence is usually the aftermath of metrological events such as seismic activities, astronomically influenced phenomena (high tides coinciding with occurrence of high rainfall), construction of temporary dams, as well as the failure of hydraulic and other control structures.” The effects of floods are always debilitating, though their intensity and scope vary depending on terrain, intensity of human activities, quantum of water and the level of prepared-ness by the stakeholders.

Flooding, especially River flooding are among the most devastating natural disasters in the world, claiming more lives and causing more property damage than any other natural phenomenon (Abubakar, 1993). Though not the leading cause of death in Nigeria, but it affects and displaces more people than any other natural disaster (Usman, 2012). Therefore, there is the need to understand, prevent, prepare for, and mitigate its effects by authorities concerned, especially in developing countries. This has now particularly become rife due to the rapid urbanisation and population growth experienced in developing countries, which often results in increased population concentration in unplanned environment. Consequently, Ishaya et al. (2009) opined that identifying areas that are vulnerable to flooding as well as collecting and analysing information on the “elevation, slope orientation, proximity of built-up areas to drainages, network of drains, presence of buffers, extent of inundation, cultural practices as well as attitudes and perceptions” are the most effective means of ensuring flood preparedness and risk reduction.

Owing to this therefore, there is always the need for the production of maps of flood risk zones with a broad range of functions capable of manipulating both spatial and attribute data (Abah, 2013). Daffi et al. (2014) stated that although “conventional traditional methods can be used for flood hazard assessment, the use of remote sensing and geographic information system techniques have been suggested to provide quick, efficient and effective results as investigated and documented by Balanova and Vassilev (2010), Damayanti (2011), Kafle et al. (2006), Salimi et al. (2008), Ahmed et al. (2010) and others.” In view of the foregoing therefore, this paper sets out, with the aid of Geographic Information System (GIS), to map flood prone areas of Minna, as well as analyze the causes of flooding in parts of Minna.

The aim of this study was to analyze the causes of flooding in parts of Minna with a view to providing solutions to developmental challenges along the channels of River Suka. This has been achieved through the following objectives: i) Analyze the causes of flooding along the River channel;ii) Identify the areas at risk in the study area and; and iii) Map the flood prone areas using the GIS technique.

The study area

Minna is located between latitude 9° 36'22''N and longitude 6° 33'l 5''E; and it is situated on a geographical base of undifferentiated basement complex of much gneiss and magnetic. The town is drained by many drainage channels, with the main course of River Chanchaga taking its source from the north central highlands and thereafter, flowing towards the western lowlands before meeting River Kaduna at a point south west of Minna. Its main tributaries include Rivers Wana, Shaho, Godina, and Dunalape, which are flowing from their respective highlands and isolated compounds such as Gwam, Kpewi, Zuru, and Tsauran Nabi hills.

The study area is located in a tropical climate region which is characterized by two seasons in a year, the wet seasons and dry seasons. The annual rainfall received within the region is less than 1000 mm in the wet season and it lasts between May and October with a maximum downpour between the months of July and September. The dry season lasts between the month of October and March. Temperature varies within the region annually, with the dry season having low temperatures because the sun is at the southern hemisphere. Thus minimum temperatures of below 30°C are recorded during the harmattan period, which is late December and January in the following year, and its maximum temperature often do not exceed 42°C. During the wet season, the sun moves northwards from the equator to the tropics of cancer. This results in high temperatures because the sun overheads at noon.

METHODOLOGY

The data used for the study which included the research design and techniques were obtained through both the primary and secondary sources.

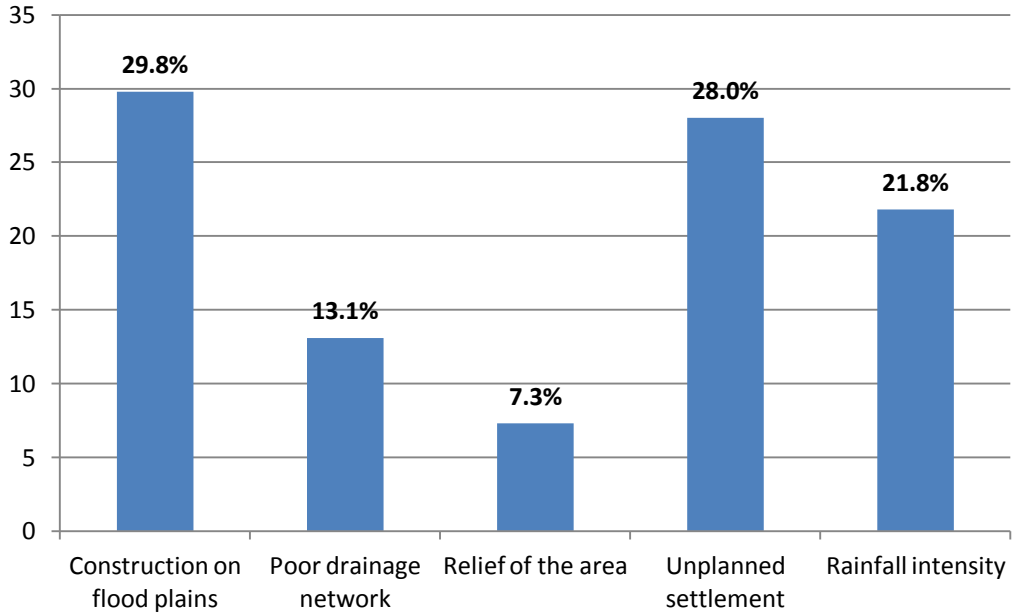

Figure 1. Causes of flooding along River Suka.

Primary and secondary data collection

The primary data used for the study were obtained through questionnaire administration and reconnaissance survey, where the Global Positioning System (GPS) and digital camera were robustly used. The questionnaires sought to feel the pulse of the respondents on the causes of flooding as well as the flood control measures adopted by the residents of the study area, while the reconnaissance survey allowed for the independent assessment of the effects of flooding in the study area, taking snapshots of objects of interest to the study using the digital camera and the delineation of flood plains with the aid of the GPS which aided the production of the flood risk vulnerable areas map of Minna, Niger State whereas the secondary data used were basically obtained from internet materials and journals, as well as the topographic and land use maps of Minna obtained from the Niger State Ministry of Lands and Housing, Minna.

Sampling technique

For the purpose of this study, a total of 350 households were randomly selected (using the random number table) within the areas declared as flood-prone by the Niger State Emergency Management Agency (NSEMA). This meant that all surveyed households were at risk, but due to local topographic effects and construction of drainage channels, not all households had been flooded. Responses from 275 households were filled and returned appropriately, giving an overall response rate of 78.6%.

Data analysis

The data collected from the field was coded and analyzed using the Statistical Package for Social Sciences (SPSS), and presented with the aid of descriptive statistics. Also, in order to create a map of flood risk vulnerable areas of Minna, the ArcView GIS package was used to digitize the topographic and land use maps of Minna. GIS Thereafter, the maps were spatially superimposed with the aid of to create a Flood Risk Vulnerable Areas in Minna, Niger State.

RESULTS AND DISCUSSION

Floods usually occur along the bank of River Suka when Minna records an unprecedented amount of precipitation or when the river is inundated by high amount of water from upstream. But its effects can be mitigated or eliminated through drainage construction, which unfortunately does not cover the entire length of the study area (Figure 2); thus areas without constructed drainages are more prone to flooding and erosion, and they as well, do not have well laid setbacks (Plate 1 and 2) when compared to those with constructed drainages (Plate 3 and 4). Therefore, flooding along parts of the bank of the river is inevitable, and this has been compounded by the reduction in the depth and width of parts of the River course due to sediments deposition resulting from the myriads of human activities taking place along the course of the River. But in order to feel the pulse of the household members residing on the floodable areas of Minna, they were asked to state the single most likely cause of flooding being experienced in their area. As shown in Figure 1, 29.8% of the respondents stated that construction on flood plains are the causes of flooding in Minna, 28.0% adduced it to the problem of unplanned settlements, whereas 7.3% of the respondents stated that relief was responsible for flooding. The usually varying opinions as regards causes of flooding was expounded in Kofo (2012), but the study conversely asked the residents of Lagos metropolis to state as many causes of flooding as possible in their neighbourhoods. The result showed that “torrential rains (94.10%), filled/silted/dirty drainage channels (87.15%), blocked canals (97.55%), inadequate drainage channels (94.30%), non-compliance with Environmental Laws(81.45%), and nature of the physical

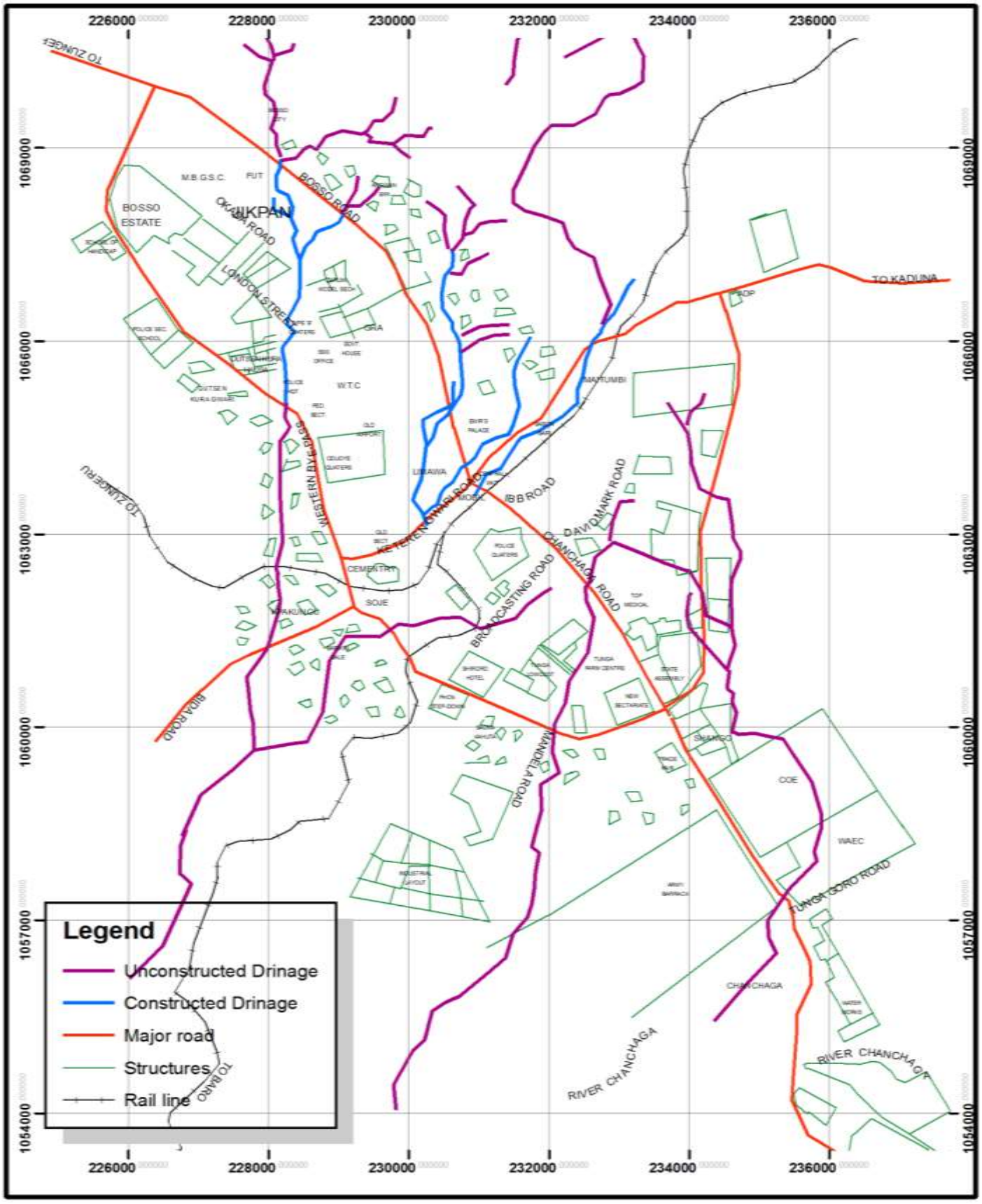

Figure 2. Constructed and unconstructed drainage channels in Minna.

Plate 1. The drainage channel that passes through Kpakungu area of Minna.

Plate 2. Human activities along the drainage channel in Soje area of Minna.

Plate 3. The drainage channel along Sabon Gari area of Minna.

Plate 4. The drainage channel along Kateren Gwari area of Minna.

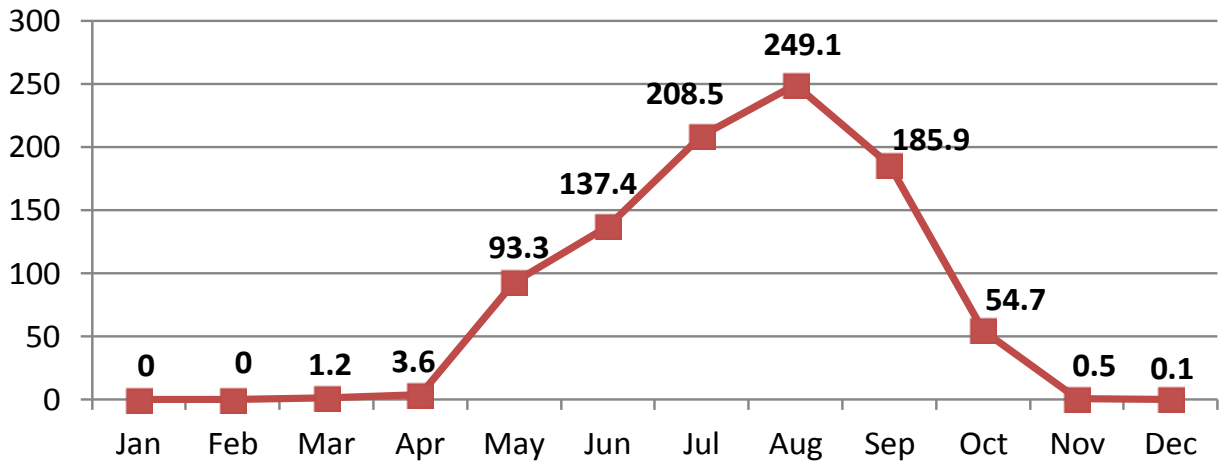

Figure 3. Rainfall pattern in the study area (in mm). Source: Nigerian Metrological Agency.

terrain (90.55%), planlessness (88.95%) and encroachment on drainage channels (90.90%)" were adduced as the causes of flooding in Lagos. Also, the residents of Minna residing along the bank of River Suka also confirmed that there are usually some negative environmental, economic and social problems that results from flooding in the study area. This apprehensive state of affairs was elaborated in Ajayi et al. (2012) which cited different sourcing as stating that over the years, flooding in the watersheds of Ogunpa and Kudeti streams in Ibadan, South West Nigeria has resulted in the loss of hundreds of lives and properties worth millions of Naira.

Rainfall variability of the study area (2002-2011)

The mean monthly discharge of a 10-year period ofMinna was obtained from the Nigerian Metrological Agency in order to analyse the monthly variability of the rainfall pattern. The result of the analysis shows that the study area experiences about 933 mm of rainfall per annum, with about half of that occurring between the months of July and August every year. Consequently, the residents of the flood-prone areas confirmed that the chances of flood occurring are usually higher between the months of July to October, as presented in Figure 3. This is in tandem with that of Makurdi, Benue State, Nigeria as expounded by Ologunorisa and Tersoo (2006); the study pointed that the outcome of seasonal variability of rainfall between 1979 and 2004 shows that the month of August recorded the highest amount of rainfall with 36.43% of the total, June (21.39%), September (20.43%) and July (19.67%).

Identifying flood prone areas using GIS

As earlier mentioned, the GIS technique was adopted in identifying the flood prone areas in Minna. Parts of Soje towards Makera, down to Kpakungu were identified as risk areas, as well as parts of Bosso due to lack of proper drainage channels. Downstream of Keteren Gwari towards River Suka was also identified as risk area due to un-constructed drainage channel and human activities along the River channel. Settlements around new extension of Farm Centre, down to some areas around Mandela road were also identified as risk areas, including parts of Shango and Chanchaga, as presented in Figure 4. Also in a study by Ikusemoran, Anthony and Maryah (2013) which aimed at assessing flood risk and vulnerability of communities in the Benue Floodplains, Adamawa State, Nigeria using the GIS method, the flood vulnerability map was developed through the use of Geo-information techniques which involved the use GPS to capture the studied communities which were consequently linked to a generated digital map of River Benue valley using ArcGIS software to assess each of the communities for flood vulnerability.

Flood control methods adopted by the residents

In the course of the research work, the following were discovered to be the local flood control methods adopted by the residents of the flood-prone areas of Minna: Opening up of new water channels and the construction of drainages; Evacuation of debris from existing drainages and; the use of sand bags to block excess water from reaching residential areas.

Conclusion

The challenges of reducing the risk of floods in the rapidly increasing global urban population in the face of vagaries of the weather due to climate change and dwindling economic fortunes has attracted enormous attention from

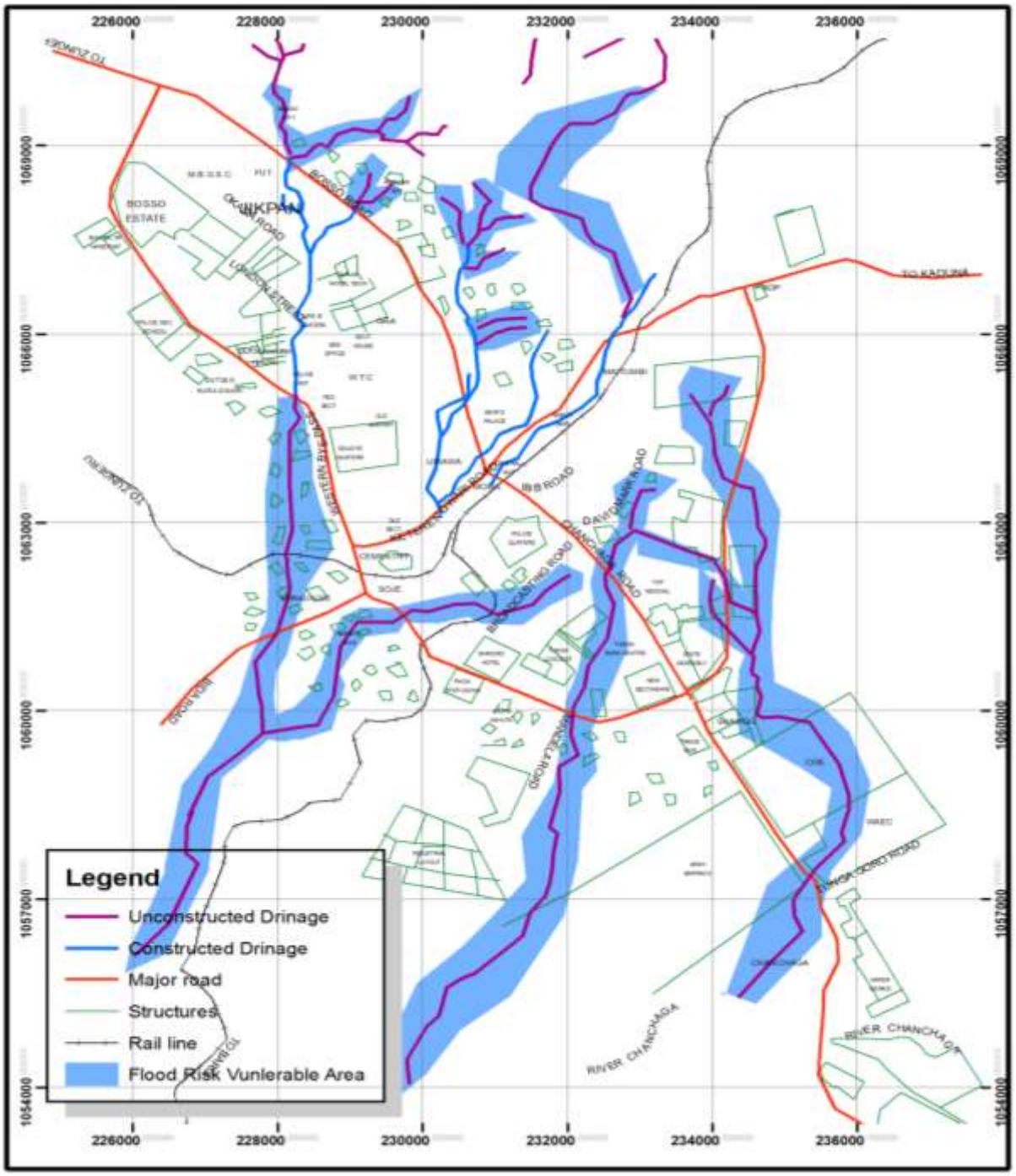

Figure 4. Flood Risk Vulnerable Areas in Minna, Niger State.

the international community, especially as regards achieving the sustainable human settlement development and the MDGs. Therefore, the need to assiduously tackle the problem of flooding through systematic physical planning approach and enlightenment campaigns, as well as the convocation of regular stakeholders' meeting for the purpose of stock taking. This, is believed, would enhance the capacity of communities in preparing for and tackling the likely occurrences of flooding.

Recommendations

In order to effectively ensure that the effects of flooding are less felt in the flood-prone parts of Minna, the following recommendations have been advanced:

1) Embarkment on sensitization campaigns in order to create public awareness on the need to understand, prevent, prepare for, and mitigate the likely effects of flooding;
2) The monitoring by authorities, of water levels during the raining season, thereby allowing for the transmission of flood signals to the residents of the flood plains and;
3) The restriction of human activities along the floodable areas of Minna by the Physical Planning Agency.

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