

ASSESSING THE ENVIRONMENTAL IMPACT OF POOR DRAINAGE IN BOSSO TOWN, NIGER STATE, NIGERIA

Ahmed Y¹, Ishaq, A.B², Waziri, A.M³ and Odekunle, M.O⁴

^{1,2,3,4}Department of Geography, Federal University of Technology Minna, Niger State. Nigeria

yusuf.ahmed@futminna.edu.ng

aishaq@futminna.edu.ng

a.waziri@futminna.edu.ng

odemary@futminna.edu.ng

Abstract

The research is to examine the environmental impacts of poor urban drainage system in Bosso town. Poor drainage system have become a problem which lead to soil erosion, flooding and other land degradation processes of the ground surface, gully erosion and excess surface water to the infrastructure and settlement which also lead to flooding. The research is also to locate the erosion prone areas and examine the drainage pattern within the study area, to identify and analyze the major environmental impacts of poor drainage in the study area. The data for the analyses was collected through terrain analysis on the study area with the aid of digital elevation model (DEM) from shuttle radar topographic mission (SRTM) and the drainage network of the study area was extracted through the interpolation of flow accumulation and flow direction from the SRTM data (DEM) using ArcGIS 10.3 software, the digital elevation model was further classified using image classification scheme feature in Idrisi software and an overlay of the DEM and google earth image of the study area to generate the risk map of the study area and Questionnaire was used which frequency-percentage technique was adopted as one of the techniques for the analysis. The analysis of frequency percentage is one of the first techniques used in the analysis of research data that were collected through the use of questionnaire. The frequency-percentage technique is relatively easy to analyze, present and interpret. Frequency percentage= $\frac{\text{number of observed}}{\text{total number}} \times \frac{100}{1}$. there are a lot of poor drainage system in the study area which have result to very high erosion risk zone attributed to low slope and high surface soil moisture while the very low risk zones can be attributed to factor such as high slope and low run-off respectively which the drainage should be linked to solve the problem of erosion and other land degradation processes.

Keywords: drainage, flooding, land degradation, impact, digital elevation model (DEM), shuttle radar topographic mission (SRTM)

1.0 Introduction

Drainage systems are pathways created naturally or constructed to address the increasing problems of diffuse sewage and run-off over an area. The run-off whether deliberate or accidental can be a major cause of flooding and polluted stagnant water in urban environment. Water is very essential for so many purposes such as for human consumption, plants use and other various purposes, but can also cause devastation through erosion and flooding when it's not properly controlled on the earth's surface.

Due to the development of infrastructures as a result of urbanization, the surface runoff water is drastically increasing in the urban area damaging infrastructures, displacing people from the affected area and sometimes leads to loss of lives (Udosen, 2011). The contributed runoff water therefore needs to be safely disposed or evacuated to the rivers/outlets channels so that the functional utility of the infrastructure is maintained and therefore avoid the damages. Adequate drainage is very essential in the design of an urban area since it affects the town serviceability and

usable life. If ponding on the traveled way occurs, aquaplaning becomes an important safety measure.

Drainage systems are of advantageous towards various environmental sectors such as buildings, agricultural sectors, landscape and among others. These advantages includes; water accumulation prevention, it reduces the occurrence of soil erosion, it guarantees a healthy living if properly managed, it reduces flooding and other environmental-related problems.

Drainage design involves providing facilities that collect, transport and remove storm runoff from the town or city. Flood which is another output of inadequate drainage system is also discussed as follows. Flood is the overflow of water into an environment that is normally dry thereby causing inundation and harm to plants and animals including man. Its harm can be extended to man's buildings and infrastructures (Udosen, 2011).

This study tends to describe the two kinds of drainages that are available in the entire Bosso town, their dimensions and also their effects on the environment. These kind of drainages which are available in the study area includes the artificial drainage system (constructed drainage system) and the natural drainage system (originated through occurrence of erosion or flooding). There are poor nature of urban drainages in most parts of Bosso town and which are not efficient enough to channel the stagnant water that flows on the earth surface for hours or even days after a heavy down pour. This surface flow is however what often leads to the occurrence of the natural drainages which on the other hand disorganizes and disintegrates the landscape of the area. As a result therefore, the study tends to look at all these geographical/environmental problems which are viable in Bosso town, Niger state with a view to finding a lasting solutions to these environmental problems.

Bosso is a local government area in Niger State, Bosso local government has an area of 1,592km² and a population of 147,359 at the 2006 census, the postal code of Bosso is 920 (Nipost, 2010). Bosso is a commercial urban area or more of a central place in Niger state. Bosso lies between Latitude 9° 33'N and 9° 40'N, and Longitude 6° 29'E and 6° 35'E on a geological base of undifferentiated basement complex of mainly gneiss and magnetite. At the North corridor of the town lays a continuous steep out crop of granite, which form a limitation towards physical development in that axis. In the present political zoning system, it is within the north central zone (Niger state ministry of environment, 2013).

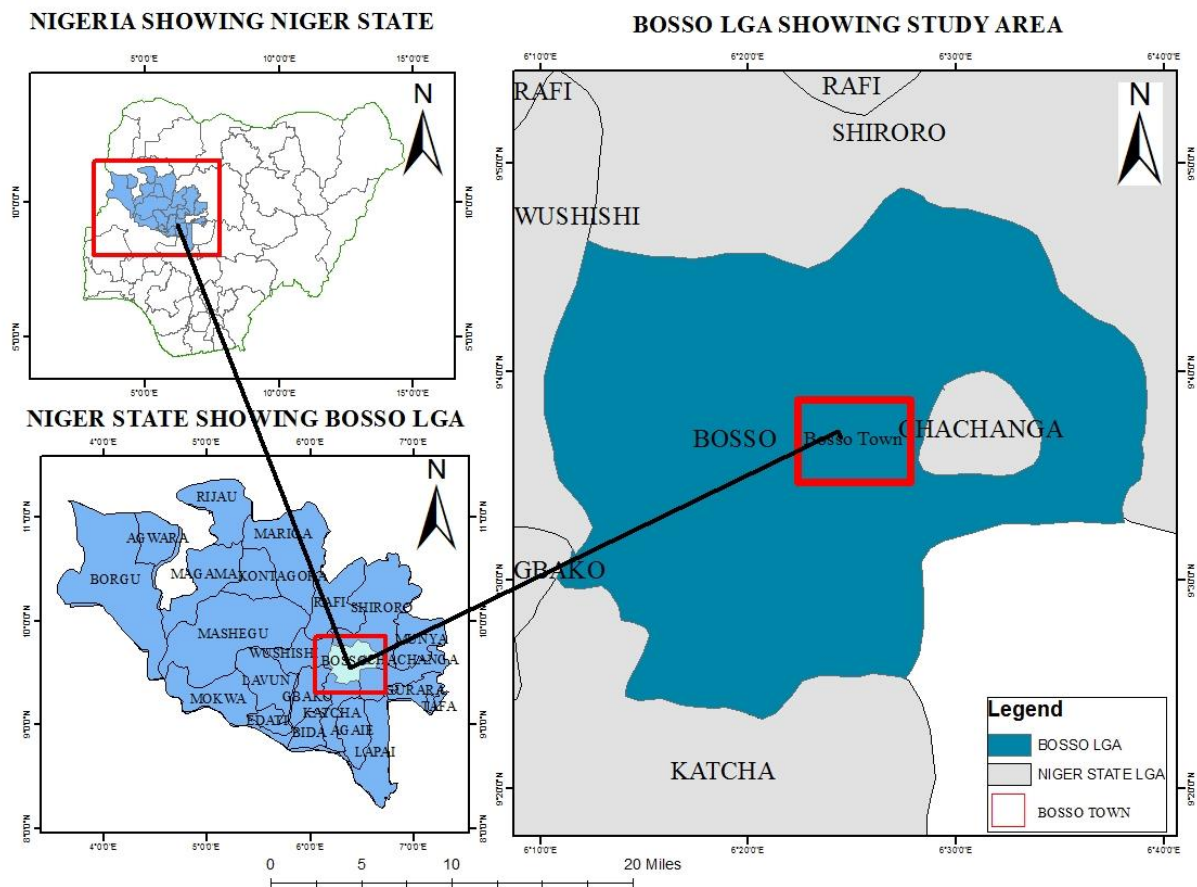


Figure 1.1: Map of the study area

Source: Author' analysis, 2018

1.0 Literature Review

A drainage has in it stream flow and channel characteristics that are in certain equilibrium in three stream regimes which are the upstream, the middle stream and the downstream. When any of the either upstream, middle stream and downstream is tempered with in any way either through human activities or natural cause, the impacts goes directly to the environment thereby causing environmental pollution, Mrokwa (2014).

Consequently, under the scenario, the drainage system upstream affects the downstream due to the induced high speed of the water from the upstream to the downstream location of the channel which has resulted in the distortion of the ecological balance. In the control of the effects, there are local efforts by the dwellers downstream of the channel to reduce the effect by using large stones and concrete reinforced materials to cover some of the areas affected by the artificial erosion activities (Blackham, 2006).

Other additional informal changes in the drainage such as soil excavation from the river bank during the dry season for use in the house construction, cause destruction of the environment with negative effect on the drainage system. On causes of the serious environmental degradation, there is a grievous effect on the drainage system that aggravates solution to erosion and flooding (Blackham, 2006).

Remote sensing and geospatial techniques can be applied in drainage studies through various means such as digital elevation model in determining the flow path/direction, processing of satellite images in the analysis of land use change, terrain analysis, delineation of watershed and among others. Solomon *et al* (2012) use Geographic Information System (GIS) and Remote Sensing Data

for extracting the river drainage pattern. The areas of basins studied using GIS and Remote Sensing Techniques in similar studies are of the range of a few hundreds to a little over thousand sq.km, whereas the study area considered here is 81,155 km². Accuracy of the morphometric properties (based on shape of the basin) depends on the accuracy in delineation of the watershed which is governed by the resolution of the satellite imagery available.

A new approach was developed by Li, Wang, & Hao (2008), in which the river system in digital maps was considered as the correct river network (CRN) while that extracted from DEM was called the digital river network (DRN). Morphometric parameters of a watershed can be studied from the digital network extracted from using GIS.

3.0 Methodology

This include various ways and stages of data collection and how each data was analyse. From primary data source to the secondary data and how it was analyzed.

3.1 Sources of Data

The sources of data for this research includes primary and secondary data sources. Primary source of data for this study include GPS coordinates of gully sites, field survey, questionnaire and oral interview, these four primary sources of data were used to achieve some of the objectives of this study. Secondary data source such as satellite images, drainage map of the study area, internet, journals, text books and related research works were also used to achieve the objectives of this research.

3.2 Data Collection

This is the extensive personal observation carried out by visiting the study area to get the first-hand details on the nature of the drainages such as their capability and efficiency of evacuating surface runoff during rainy season and also the impact of human activities on the existing drainages within the study area.

3.2.1 Oral Interview

An oral interview is an effective research technique which help the interviewer access his or her information needed to carry out his research effectively and efficiently. This method involved personal meetings with designated affected people as result human activities on the drainage channels within the study area.

3.2.2 Questionnaire

Structured questionnaire was designed to collect useful data and information from the respondents. The questionnaire contained multiple choice questions that respondents required to select the option that appealed to them. The areas covered by the questionnaire include causes of the environmental effects poor drainage in the study area, and mitigation and adaptation to cope with the environmental effects.

3.2.3 Sample Size and Technique

Random sampling size technique was adopted in this research. Using this technique, 250 structured questionnaires was distributed randomly across the study area in order to acquire the necessary field data needed to accomplish some of the objectives of this research. Out of the 250 questionnaires administered, 233 questionnaires containing the necessary information were returned while 17 were omitted due to incompleteness and uncoordinated response.

3.1.4 Satellite-Based Data

Digital elevation model (DEM) from shuttle radar topographic mission (SRTM) which has spatial resolution of 30m is acquired in respect to the study area. Digital elevation model is used in this research to delineate the drainage network and to locate the upstream and downstream areas which enables the location of areas that are more vulnerable to surface erosion and flooding. Thus DEM from SRTM data covers objective one of this thesis.

3.3 Method of Data Analysis

3.3.1 Locating the erosion prone areas and examine the drainage pattern within the study area

This objective was carried out through the terrain analysis on the study area with the aid of digital elevation model (DEM) from shuttle radar topographic mission (SRTM) and the drainage network of the study area was extracted through the interpolation of flow accumulation and flow direction from the SRTM data (DEM) using ArcGIS 10.3 software.. The digital elevation model was further classified using image classification scheme feature in Idrisi software and an overlay of the DEM and google earth image of the study area was done to generate the risk map of the study area (Bosso Town)

3.3.2 Identify and analyze the major environmental impacts of poor urban drainage within Bosso town

A frequency-percentage technique was adopted as one of the techniques for the analysis. The analysis of frequency percentage is one of the first techniques used in the analysis of research data that were collected through the use of questionnaire. The frequency-percentage technique is relatively easy to analyze, present and interpret. Frequency-percentage was used to achieve objective two, three and four of this research.

$$\text{Frequency percentage} = \frac{\text{number of observed}}{\text{total number}} \times \frac{100}{1}$$

4.0 Result/Discussion

This chapter presents the results and discussion based on the earlier stated objectives in the previous chapter. It was analysed using descriptive statistics and remote sensing techniques.

4.1 Analysis of erosion prone areas and drainage pattern within the study area

4.1.1 Digital Elevation Model (DEM)

Elevation and slope play an important role in governing the stability of a terrain. Slope has a dominant effect on the contribution of rainfall to stream flow. It controls the duration of overland flow, infiltration and subsurface flow. Combination of the slope angles basically defines the form of the slope and its relationship with the lithology, structure, type of soil, and the drainage.

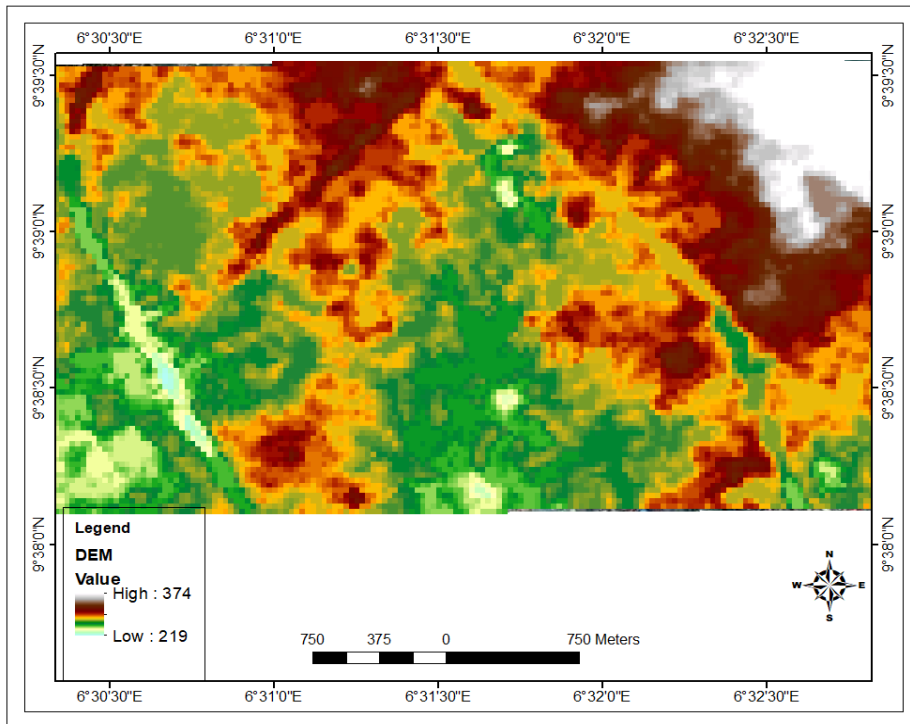


Figure 4.1: Digital Elevation Model of the Study Area

Source: Data Analysis, 2018

Digital Elevation Model (DEM) of the study area was derived from Shuttle Radar Topographic Mission (SRTM) data and the spot heights collected from field survey was used to update the elevations data. The DEM of the study area has elevation ranging from 219 m to 374 m as presented in figure 4.1.

4.1.2 Drainage Patterns of the Study Area

Figure 4.2 portrays the drainage network over the study area, as the areas with unconstructed drainages and abused constructed drainages as a result of human activities are more vulnerable to erosion, flood and other environmental problems such as pollution and landscape degradation during wet season. Areas with more channelized drainages are definitely less vulnerable to erosion and other environmental-related problems but if the constructed drainage channels are not well maintained, the area may fall into environmental danger as that of the areas with no good drainage network.

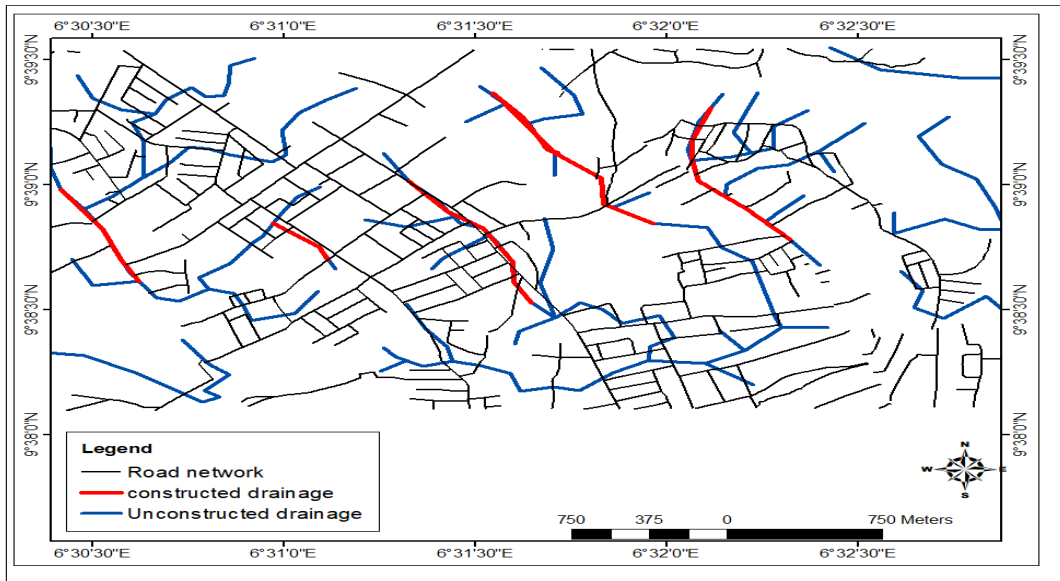


Figure 4.2: Drainage Map of the Study Area
Source: Data Analysis, 2018

4.1.3 Erosion Prone Sites

Erosion and environmental pollution are the major hazard faced by the settlement at the study area. The study showed that the study area lacks efficient drainage system and this is attributed to human activities and attitude towards the environment as buildings and other structures are indiscriminately erected very close to the drainage lines. The study shows that some of the residential buildings were built on floodable terrain as well as wastes from various homes are being dumped indiscriminately on the water ways across the study area. Water run-off during rainfall is usually through the street, this situation aggravate the settlement vulnerability and incidence of flood as shown in the figure 4.3. These communities include Hayan-gwari, tudunfulani, church villa, Behind Futminna staff quarters, okada road, Bosso estate (From Left-Right respectively).



Figure 4.3: Erosion Prone area over the Study Area
Source: Data Analysis, 2018

4.1.4 Erosion Risk Map of the Study Area

Figure 4.4 presents the erosion risk map of the study area which illustrates how various parts are susceptible to erosion risk. Generally, the erosion risk map over the study is categorized as High, Moderate and Low risk zones covering 2.18 Km² (17.59%), 6.26 Km² (50.52%), and 3.95 Km² (31.88%), of the total area respectively. The very high erosion risk zone can be attributed to low slope and high surface soil moisture while the very low risk zones can be attributed to factor such as high slope and low run-off respectively. So therefore, the drainage network between upland and low land area should be well linked and a regular maintenance should be encouraged to address drainage issues especially in the highly risk zone (low-lying areas)

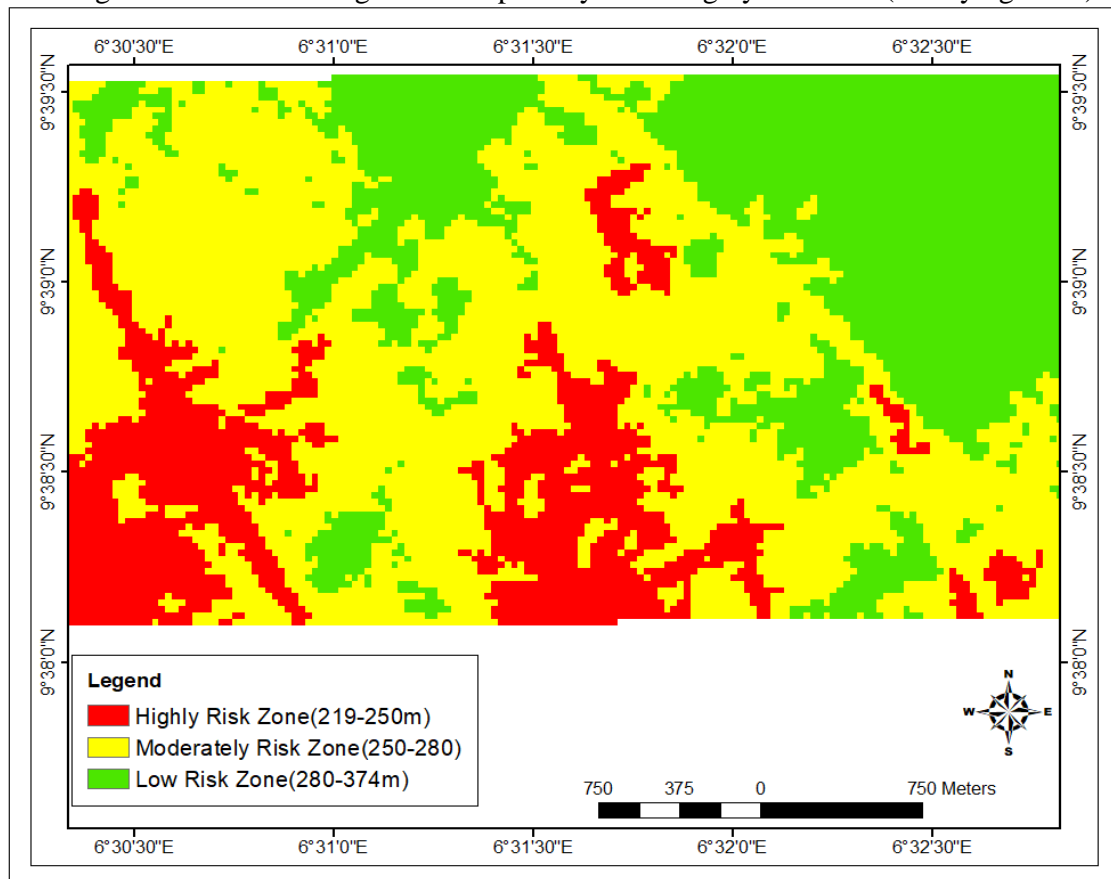


Figure 4.4: Erosion Risk Map over the Study Area
Source: Data Analysis, 2018

4.2 Analysis of the major environmental impacts of poor drainage in the study area

This section presents the major environmental impacts of poor drainages over the study area derived from the analysis of questionnaire.

4.2.1 Demographic Analysis of the Respondents

Figure 4.5, showed that about 54.08% of the respondents are male whereas 45.92% are female. The higher percentage of male respondent is an attention that men are mostly involved in activities that have bearing on the environment.

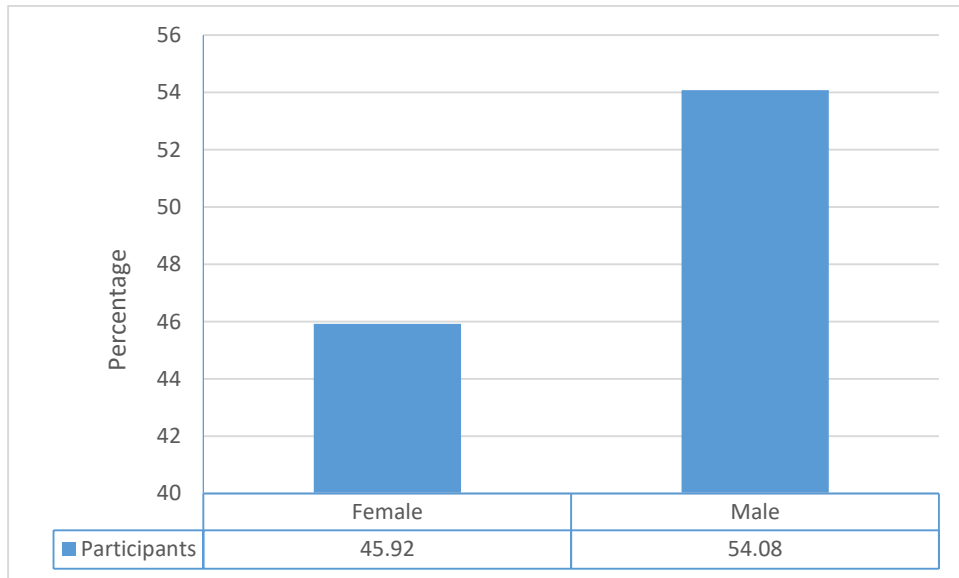


Fig 4.5: Gender Distribution of the Respondents
Source: Field Survey, 2018

Similarly, information on educational qualification of the respondents are presented in Figure 4.6. These shows that about 60.52% of the respondents had attained higher level of education while primary, secondary and no formal education representing 10.30%, 22.75% and 6.44% respectively.

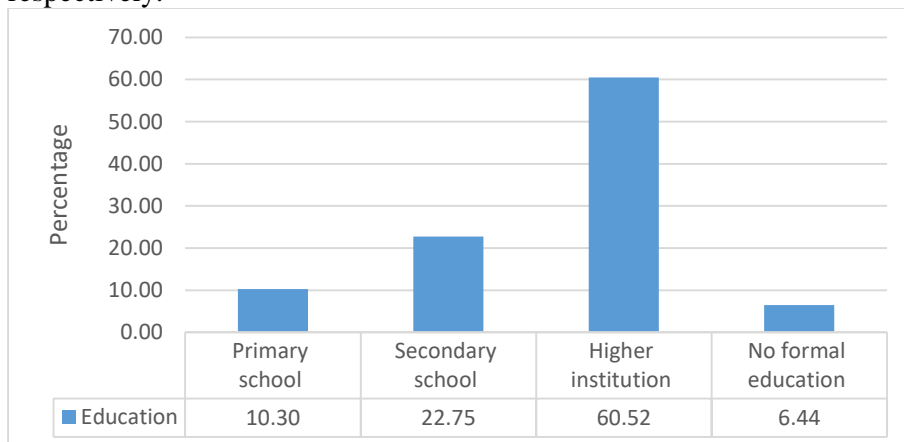


Figure 4.6: Educational Qualification of the Respondents
Source: Field Survey, 2018

Furthermore, information on the range of years by which the various respondents has settled in the study area is presented in figure 4.7. The results showed that (8.15%) has been living there for less than 5years, (17.60%) for 5-9years, (18.88%) for 10-14years, (20.60%) for 15-20years and (34.76%) for over 20years. These implies that the majority of the respondents are familiar with the study area as they have lived over 20years.

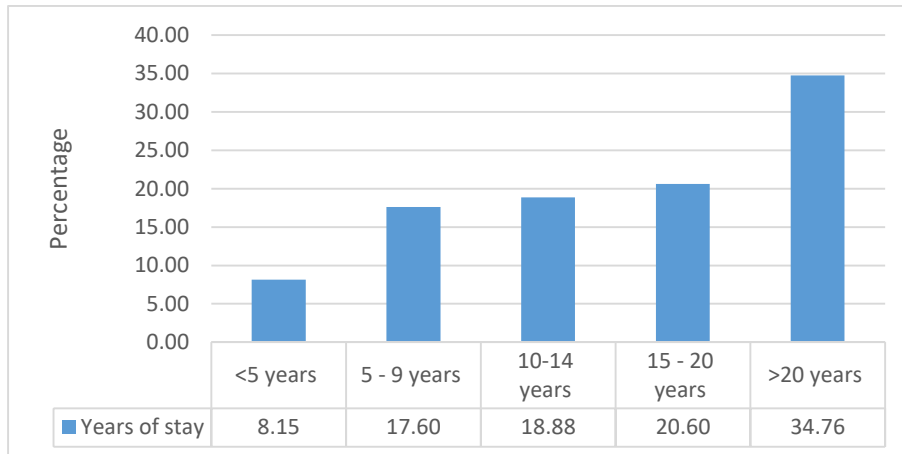


Fig 4.7: Respondents years of stay
Source: Field survey, 2018

4.2.2 Major environmental impacts of poor drainage in the study area

The major environmental impacts of poor drainage in the study area was assessed through the use of questionnaire on current environmental condition which revealed that the study area is currently degraded or seriously degraded as shown in figure 4.8 that degraded ranked the highest with (44.20%), followed by seriously degraded ranked (31.47%) and moderate ranked lowest with n=59 (25.32%). This implies that the study area is under treat of erosion as most of the area along the unconstructed channel are degrading.

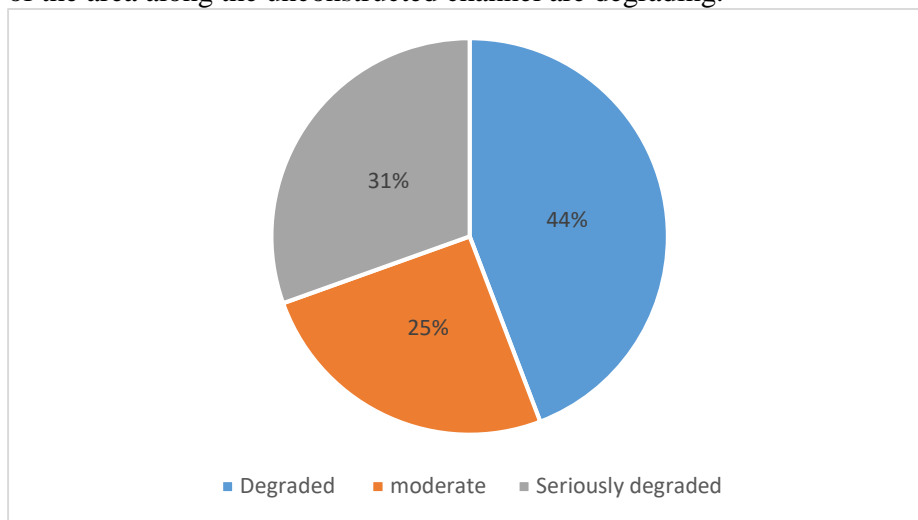


Fig 4.8: Current Environmental Condition over the Study Area
Source: field survey, 2018

5.0 Conclusion and Recommendation

Bosso and its environs are expanding rapidly both in area and population, with a corresponding increase in the urban poor population in slum settlements. The study shows that erosion, flood and environmental pollution are the major hazard faced by the settlements. This is as a result of non-functional drainage system as the little available drainage are being converted to refuse dump sites and also, indiscriminate human activities on available space especially on flood prone locations. Water run-off during rainfall is usually through the street, this situation aggravate the settlement vulnerability and incidence of flood. Most of the flood and erosion

sites identified are usually located at a low land area of the settlement, declaring that low lying areas are prone to flooding.

The following recommendations are as follows;

1. Residential buildings shouldn't be erected very close to drainage lines and other high risk zones.
2. Areas of high hazard need immediate attention, hence appropriate protection measures should be taken earlier.
3. Regular environmental sanitation should be implemented within the local government area to ensure that the existing drainages are well maintained and cleared of blockages by sediments, refuse and other solid materials.
4. Unconstructed drainages should be channelized to effectively evacuate storm run-off within the study area to a larger river outlet during wet season.
5. Embankments and other structural flood control measures should be constructed at areas of high risk.

References

- Blackham, D. (2006). The resistance of herbaceous vegetation to erosion: implications for stream form. PhD, University of Melbourne.
- Mrowka, J. P. (2014). Man's impact on stream regime quality: Manners and Mikesell (Eds), *Perspectives on Environment*, pp. 79-104.
- Udosen, C. (2011). "Flood Problems in Uyo Local Government Area" Eroflod Consulting service. Uyo.
- Solomon *et al*, (2012). Extraction of drainage pattern from ASTER and SRTM Data for river basin. *International Conference on Environment, Energy and Biotechnology*.
- Li, L., J. Wang, and Z. Hao. 2008. Appropriate contributing area threshold of a digital river network extracted from DEM for hydrological simulation. *IAHS-AISH Publication (322)*: 80-7.