Assessment of the Risk of Rainstorm and Flood Hazards in Minna, Niger State

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Abstract

Disaster occurrence in human settlement are engendered and driven by several underlying hazards and risk factors which are preventable. The identification and assessment of hazard risks require empirical studies driven by research skills. This study examined and assessed both rainstorm and flood hazards in 23 neighborhoods of Minna. The main objective was to determine the potential risks of the existing hazards and to proffer measures for disaster risk reduction in the area. The data for the study were collected through direct field survey, using selected criteria for hazard recognition and documentation. Hazard risk assessment was done using the simple probability (likelihood) and severity rating\scoring method. A five point scale (5 to 1, indicating high to low) was adopted for both hazard probability and severity scoring based on the level of risk and potential impact. The cross tabulation function of the Statistical Package for Social Scientists (SPPSS) was used to capture the variations in the level of hazard risk across the neighbourhoods studied. Hazard mapping was done using ILWIS and ArcGIS 9.3 software. Raster data from the street guide map and the Quick bird (3.0 m resolution) image of Minna were used as inputs and map processing was done using the Geographic Information System (GIS). Amongst others, the research outcome shows that the neighbourhoods in Minna are exposed to the risks of rainstorm and flood hazards. The probability and severity of rainstorm occurrence was moderate in 70% (16 out of 23) of the neighbourhoods. However, high and extreme cases of flood hazards were recorded along the river banks and flood plain areas with an estimate of 1, 657 buildings under the risk of flooding. Generally, the probability and severity of the two major hazards varied across the 23 neighbourhoods studied and the variation observed (X^2 = 49.7328) is statistically significant at 0.460 alpha level and 49 degree of freedom. Based on the findings of the study, it was recommended that Niger State Government should formulate an action plan for disaster risk reduction. Some of the strategies recommended include massive construction and rehabilitation of drainages; removal of housing structures from the river banks and flood plains; massive trees planting and retrofitting of weak roofs in the study areas.

Keywords: Flood, Hazards, Risks Assessment, Rainstorm,

1. Introduction

Large and medium sized cities across the world, particularly in the developing countries, are exposed to various forms of disaster risks. More than ever before in human history, flooding, tsunamis, hurricanes, earthquakes and volcanic eruptions are increasingly devastating human settlements and their economies. These are in addition to several other human-induced calamities such as road traffic accidents, building collapse, civil and communal strives, epidemics, acts of terrorism and wars. According to Jinadu (2007), global statistics on the debilitating nature of natural disasters are quite intimidating. At the global level, the UNISDR (2013) estimated that between 2000 and 2012, disasters had damaged property and critical resources worth over 1.7 trillion dollars, affected over 2.9 billion people and killed over 1.2 million people.

In Nigeria and many other developing

countries, the trend, magnitude and losses from disaster occurrence are on the increase. In 2012 alone, flooding disaster ravaged 28 out of the 36 States in the Country, displaced 3,871,053 residents of several communities and killed 363 people (Federal Government of Nigeria, 2013). The scale of disruptions and economic dislocations associated with various forms of disasters are of major concern to governments at various levels, researchers, communities and other critical stakeholders in the disaster risk management domain.

Several researches have revealed that cities in the developing countries are highly vulnerable to disasters due to high incidence of hazards which have led to the accumulation of urban risks. Many settlements in Latin America, Asia and Africa are characterized by conditions of hazards such as poor physical development, uncollected garbage, poor hygiene, pollution, occupation of dangerous zones (flood plain, steep slopes, etc.) and environmental degradation which put the people and their assets at the risk of disasters. The existing hazard condition is reinforced by poverty, poor infrastructure, low hazard awareness and low capacity to cope with the hazards. This situation increases the vulnerability of urban areas and their population to the impact of disasters.

Hazard identification, assessment and mapping are important exercises in the realm of disaster management. They are the basic aspects of disaster preparedness and mitigation measures which are implemented by countries to reduce the risk of disaster and build community resilience. In view of the increasing negative impact of disasters in Nigeria, there is the need for empirical information on the existing hazards and the risk of disasters in order to institute programmes and measures for effective management of disasters. This study, therefore, examined and assessed both rainstorm and flood hazards in Minna, Nigeria with a view to determining their potential risks and proffering measures for managing the risk emanating from the hazards.

2. The Research Setting

The study area is Minna, the capital city of Niger State, Nigeria. Niger State is located within the North-Central geo-political zone in the middle belt region of Nigeria (Figure 1). It consists of 25 Local Government Areas (LGAs) among which are Bosso and Chanchaga LGAs. Minna settlement is spread into parts of Bosso and Chanchaga Local Government Areas (LGAs) with land area of 1636.331 and 74.384 square kilometers respectively. According to the 2006 National Population Census, Bosso LGA had a population figure of 148, 136, while Chanchaga LGA had a population figure of 202, 151. Thus, the study area had a total population figure of 350, 287 as at year 2006.

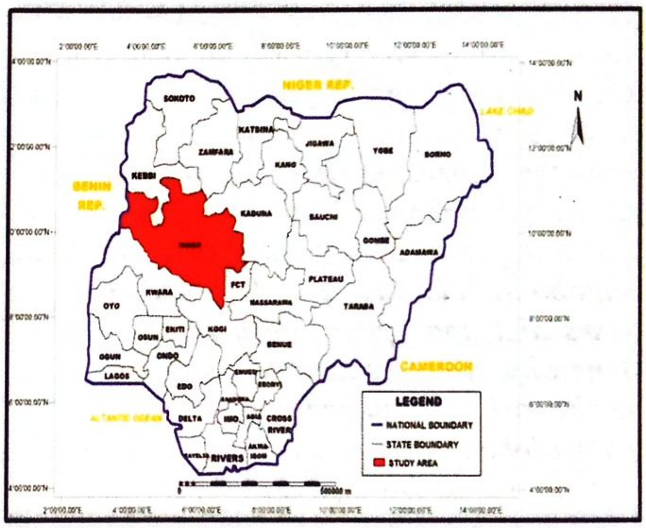


Figure 1: Location of Niger State in Nigeria

Source: Department of Urban and Regional Planning, FUT Minna, 2013

Minna is a medium sized settlement located between Latitudes 9°33' and 9°37' North of the Equator and Longitudes 6°32' and '6°39' East of the Greenwich Meridian (Figure 2). The city is built on a geographical base of undifferentiated basement complex rock of mainly granite and magnetite rock situated at the base of prominent hills in an undulating plain. The soils of Minna are mainly loamy- clay. The entire settlement area is drained by River Suka and River Chanchaga which are seasonal in nature. The city enjoys intercontinental tropical climate which is characterized by wet (April – September) and dry (November- March) seasons. The mean annual rainfall is about 1334mm (52 inches) with September recording the highest and March the lowest at 300mm (11.7 inches). The mean monthly temperature is highest in March 30.50°C (85°f) and the lowest in August is 22.03°C (72°f).

attitudes of the residents. The poor management of land uses and physical development activities in the city have combined with other natural factors to create hazard conditions which make Minna vulnerable to the risk of disasters.

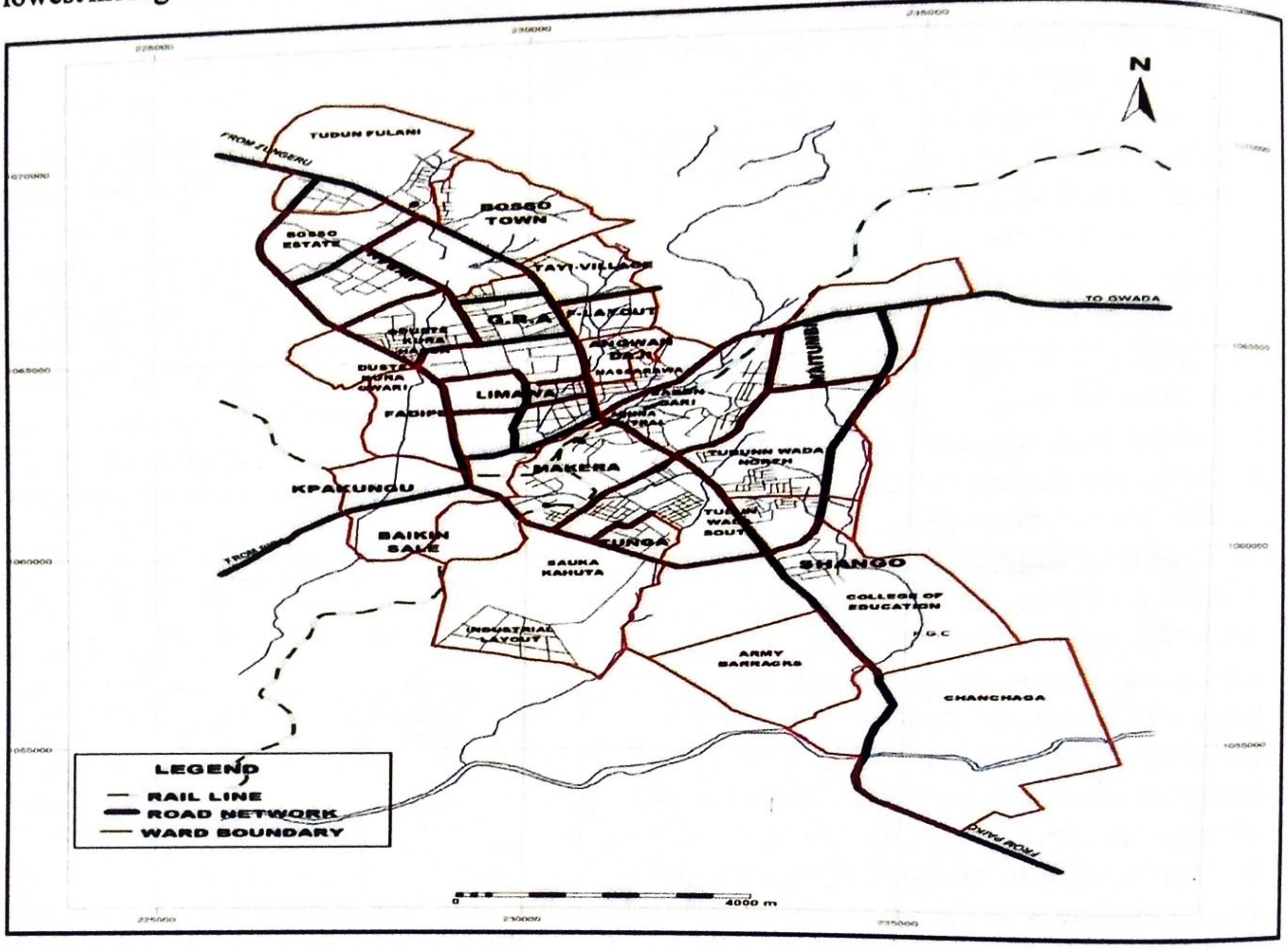


Figure 2: Residential Neighbourhoods in Minna

Source: Department of Urban and Regional Planning, FUT Minna, 2013

The residents of Minna are spread across the existing 24 residential neighbourhoods (Figure 2) which are of varying densities and environmental quality. Over the years, the neighbourhoods have witnessed tremendous population growth and physical development. Research findings have shown that apart from the GRA, F-layout and Tunga Low Cost, most other neighbourhoods are of poor environmental quality (See Baba and Jinadu, 2008; and Sanusi, 2008) arising from poor, physical development, inadequate Urban Basic Services (UBS) and some environmentally unfriendly socio-economic activities and

3. Research Methodology

The research utilized data from both primary and secondary sources. The primary data collected include information on hazard types, nature (characteristics), physical dimension and the geographic coordinates of hazard location. The secondary data collected and used include maps of Nigeria, Niger State and the neighborhoods of Minna as well as the Quick Bird panchromatic satellite image of Minna taken in 2011 with 3.0 meters resolution.

The practical fieldwork covered 23 out of the 24 neighborhoods in Minna. The Army Barrack was not covered due to restriction of access.

Complete coverage was achieved in all the neighborhoods surveyed and the inventory of all hazards were taken and documented. The Ground Positioning System (GPS) model 76 CSX was used to pick and record the geographic parameters of hazards and field measurements of the area coverage, height and depth of hazard phenomena as well as distances between the hazard sources and the elements at risk were taken. Oral interview was used to collect additional data on hazard likelihood and severity in the study area and Sony digital camera (Cyber-shot DSC-W550) was used to take photographs of identified hazards.

Hazard risk assessment was done using the simple probability (likelihood) and severity rating\scoring method. Hazard likelihood is the probability that harm will occur while severity is the seriousness of the harm that could result from contact with a hazard. A five point scale was adopted for both hazard probability and severity scoring based on the level of risk and potential impact. The likelihood of occurrence and severity rating scales (Table 1) range from 5 to 1, indicating high to low probability and severity of hazard risks in the study area. The scoring was done through expert judgment using the field data collected.

Table 1: Hazard Probability\Severity Rating and Description

S/No.	Probability	Severity	Score	Descriptions
1	Certain	Catastrophic	5	Hazard will be experienced. Over 90% chance of occurrence annually. Hazard is likely to result in death and severe property destruction.
2	Almost certain	Critical	4	Hazard most likely to occur. Between 50% - 90% chance of occurrence annually. Hazard has potential for substantial injury/damage and property loss.
3	Possible	Moderate	3	Some manifestations of the hazard are likely to occur. Between 25% - 50% chance of occurrence annually. Hazard has potential for moderate injury and property damage.
4	Unlikely	Minor	2	Manifestations of the hazard are possible, but unlike ly. Between 5% - 25% chance of occurrence annually. Hazard has potential for minor /localized injury and property loss.
5	Rare	Negligible	1	Manifestations of the hazard are very unlikely. Less than 5 % chance of occurrence annually. Unimportant hazard with no significant risk of injury or property damage.

Source: Adapted from Lozier, 2011

The hazard probability and severity scores were multiplied along the column and rows of the matrix to derive the total scores. The level of risk acceptability was determined by constructing the scale of risk scores to categorize the risks into different levels as shown in Table 2. The hazard severity and priority ranking was done using the total scores to determine the ranking of the hazards in each of the neighbourhoods and the priority for action.

Table 2: Risk Categories and Required Treatment Action

S/No.	Assessment score	Risk Code	Treatment Action
1	1 – 4	Low	Generally acceptable level of risk, but required monitoring
2	5 – 11	Moderate	Tolerable risk level, tre atment required as soon as possible
3	12 – 16	High	Intolerable risk level, immediate action is required
4	17 – 25	Extreme	Highly unacceptable risk level, urgent action is required

Source: Authors, 2013

The total score of hazard likelihood and severity was used to analyze the spatial variation of disaster risk in the study area. The cross tabulation function of the Statistical Package for Social Scientists (SPPSS) was used to capture the variations in the level of hazard risk across the neighbourhoods and Chi Square result was used to test the level of statistical significance of the variations observed.

The Geographic Information System (GIS) was used for map and satellite image processing. Hazard mapping was done using ILWIS and ArcGIS 9.3 software. First, the street guide map of Minna was scanned into a Raster format (TIF). The raster map was later scanned and imported to ILWIS environment. The map was geo-referenced on ILWIS and the map features (neighbourhoods boundaries, roads and rivers) were digitized and exported to ArcGIS interface for further processing.

The coordinate points of hazards features recorded on the field were transformed from latitude and longitude into Universal Transverse Mercator (UTM) in other to create a point map and was exported to the ArcGIS interface for composition. Thereafter, the Quick bird (3.0 m resolution) image of Minna was also imported to ArcGIS environment. Shape files were later created on the ArcGIS interface for all the hazard features recorded. The shape files (polygons, lines and points) were used to represent features such as roads, rivers, buildings and other hazard features.

In order to determine the number of buildings vulnerable to flooding on the image, a buffer of 15 meters, as standard development setback, was created along the rivers in Minna using the Arc toolbox window on the ArcGIS interface. Buildings within the buffer zones were considered as vulnerable to flooding and were digitized for map composition and subsequent enumeration.

4. Data Analysis and Findings

A survey of rainstorm and flood hazards in Minna metropolis revealed that the hazards are found in all the neighborhoods surveyed in varying degrees. A brief description of each of the hazards and pictorial illustrations are as given below.

4.1 The Nature of Rainstorm Hazards in Minna

Rainstorm hazards are found in the old and slummy areas of Minna which are characterized by weak and deteriorating roof structures. In most of the neighbourhoods with rainstorm hazards, the roofs are generally corroded and weak thereby making the buildings in the areas susceptible to rainstorm disasters. General lack or inadequacy of trees as wind breakers were observed in the areas prone to rainstorm hazards in the city. The neighbourhoods with high risk of rainstorm include Bosso, Barkin- Saleh, Limawa, Sabon-Gari, Kpakungu, Shango, Dutsen- Kura, Makera, Sauka-Kahuta, Nassarawa and Tayi Village. Plates Ia – Id show building structures that are prone to rainstorm in some of the neighbourhoods in Minna.

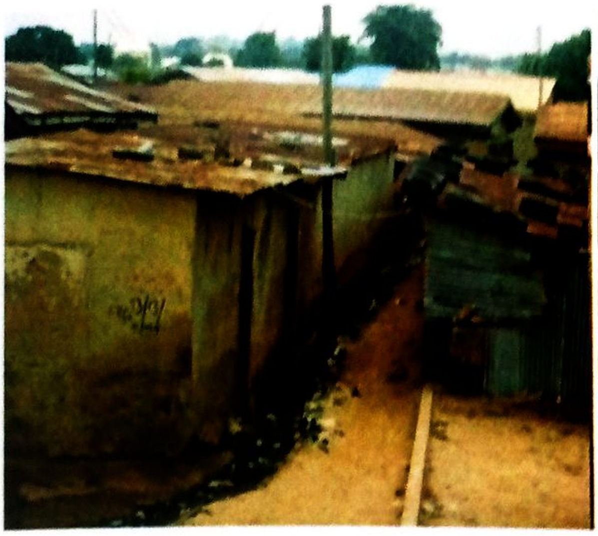


Plate Ia: Rainstorm hazard in Soje, Barkin –Saleh
Source: Fieldwork, 2013

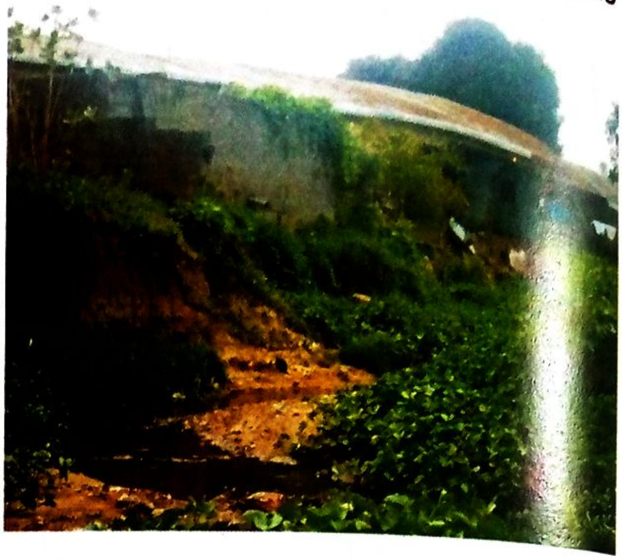
Plate 1b: Rainstorm hazard in Chanchaga
Source: Fieldwork, 2013

Plate Ic: Rainstorm hazard in Dutsen Kura
Source: Fieldwork, 2013

Plate Id: Rainstorm hazard in Tunga Kura
Source: Fieldwork, 2013

4.2 The Nature of Flood Hazards in Minna

Flood hazards are found in all neighbourhoods in Minna and they manifest in form of complete absence of drainage channels, broken or silted\blocked drainages as well as river bank and\or flood plain development. Flooding hazards are more prominent in areas adjoining the major rivers where physical development has encroached on the river banks and the flood plains. Survey findings show many residential buildings within 0.6 – 5.5 meters set back to



4.3 Rainstorm Hazard Probability and Severity Analysis

Hazard probability and severity assessment (appendix I) conducted across the 23 neighbourhoods

revealed that the two hazards pose different levels of risks in the study area. With respect to rainstorm hazard, the distribution pattern across the neighbourhoods shows that the probability and severity of occurrence is moderate in 70% (16 out of the 23) of the neighbourhoods, including GRA, Tunga, F-Layout, Bosso Estate, Kpakungu, Chanchaga and Fadikpe amongst others (Table 3). The risk of rainstorm is, however, high in Dutsen Kura, Shango, Barkin Saleh, Limawa, and Angwan Daji while the situation is worse in Nassarawa and Sabon Gari areas where the risk of rainstorm is extreme. The pattern of rainstorm hazard risk is displayed in Figure 3.

Table 3: Hazard Probability and

Table 3: Hazard Probability and Severity Scores in Minna

S\No.	Neighbourhoods	Hazard Probability and Severity Scores	
		Rainstorm	Flood
1	Bosso Town	6	16
2	Dutsen Kura	16	12
3	Fadikpe	6	12
4	Kpakungu	6	12
5	Tayi Village	8	20
6	Nassarawa	20	16
7	Maitumbi	6	25
8	Shango	15	12
9	Chanchaga	8	20
10	Barkin Saleh	12	12
11	Sauka Kahuta	6	16
12	Bosso Estate	9	6
13	Limawa	12	12
14	Makera	10	1
15	Sabon Gari	20	20
16	F-Layout	8	1
17	Agwan Daji	12	9
18	Minna Central	6	9
19	Tudun Wada South	8	12
20	Tunga	6	1
21	Tudun Wada North	9	15
22	Tudun Fulani	6	12
23	GRA	6	1
	Average Scores	**9.6**	**11.8**

sources: Authors' Analysis, 2013

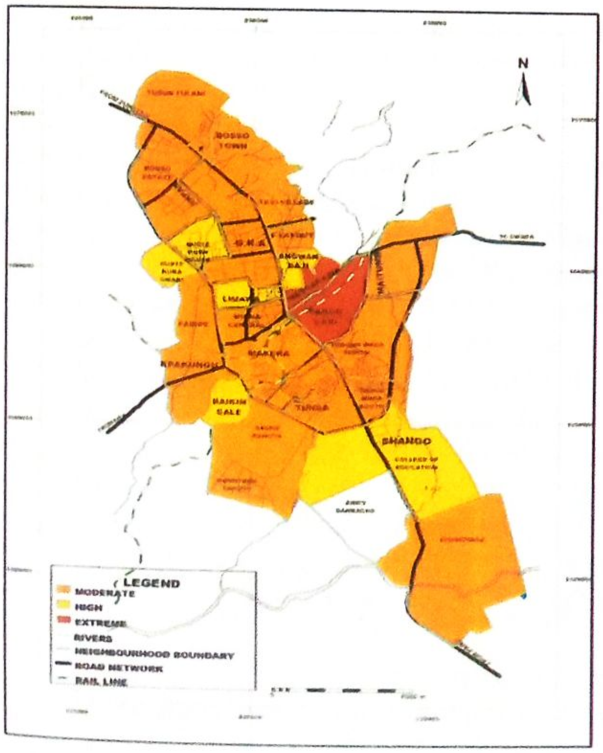


Figure 3: Rainstorm Hazard Probability and Risk Levels in Minna

Source: Authors' Analysis, 2013.

4.4 Flood Hazard Probability and Severity

With respect to flood hazards, the probability and severity scores in Table 3 indicate low risk of flooding in Makera, F-Layout, Tunga and GRA areas while Bosso Estate, Angwan Daji and Minna Central neighbourhoods face moderate level of risk. However, high flood risk occurs in Bosso Town, Dutsen Kura, Fadikpe, Kpakungu, Nassarawa, Shango, Barkin Saleh, Sauka Kahuta, Tudun Wada North and South, Limawa and Tudun Fulani areas of Minna. The situation in Tayi Village, Maitumbi, Chanchaga and Sabon Gari is worse as these neighbourhoods' record extreme levels, of flood risk (Figure 4).

The high and extreme cases of flood hazards are recorded along the river banks and flood plain areas (the 15meters river setback or buffer zone) of the neighbourhoods. The research findings show that 1, 657 buildings of various uses are in the river bank\flood plain areas and are at the risk of flooding disaster in Minna (Figure 5).

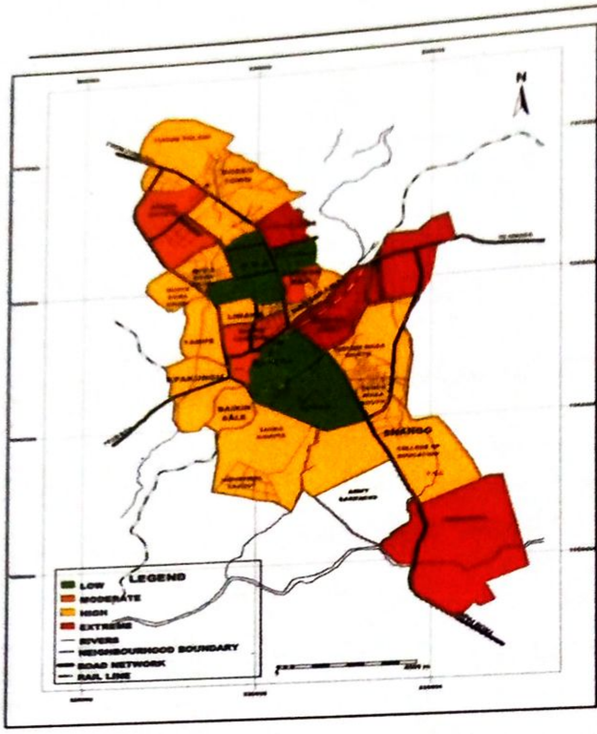


Figure 4: Flood Hazard Probability and Risk Levels in Minna
Source: Authors' Analysis, 2013.

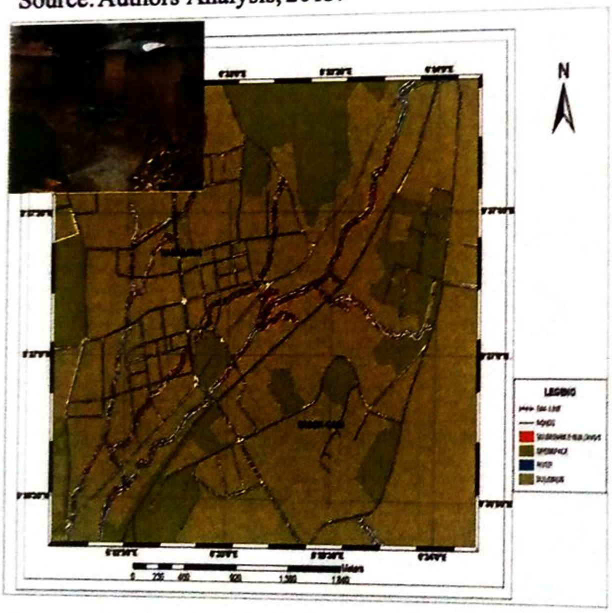


Figure 5: Vulnerable Buildings along River Bank\Flood Risk Areas in Minna.
Source: Authors' Analysis, 2013.

The mean probability scores in Table 3 indicate the relative level of severity of the rainstorm and flood hazards in the study area. The findings show that the problem of flood hazard (11.8 mean score) is more severe than rainstorm (9.6 mean score) in Minna. The treatment of flood hazards should, therefore, be given priority in Minna.

5. Summary of Findings and Recommendations

5.1 Summary of Findings

The research outcome shows that the neighbourhoods in Minna are exposed to the risks of rainstorm and flood. Neighbourhoods with rainstorm hazards show evidence of corroded and weak roofs, general lack or inadequacy of trees (wind breakers) with stones placed on roof tops as coping strategy for rainstorm hazards. The probability and severity of rainstorm occurrence is moderate in 70% (16 out of the 23) of the neighbourhoods, including GRA, Tunga, F-Layout, Bosso Estate, Kpakungu, Chanchaga and Fadikpe while it is high in Dutsen Kura, Shango, Barkin Saleh, Limawa, Angwan Daji, Nassarawa and Sabon Gari areas of the city.

Flood hazards manifest in form of complete absence of drainage channels, broken or silted\blocked drainages as well as river bank and\or flood plain development. The high and extreme cases of flood hazards are recorded along the river banks and flood plain areas and the research findings show that 1, 657 buildings of various uses occupy the river bank\flood plain areas and are at the risk of flooding disaster in Minna.

Generally, the probability and severity of the two major hazards considered vary across the 23 neighbourhoods studied. The variation observed ($X^2 = 49.328$) is statistically significant at 0.460 alpha level and 49 degrees of freedom. The results indicated that one hazard is more serious than the other within a given neighbourhood. For instance, flood hazard is found to be the most severe in Chanchaga (30.3%), Maitumbi (36.2%) and Tayi village (31.2%) while rainstorm hazard is the most severe in Nassarawa (30.8%) and Sabon Gari (26.3%) areas of Minna.

5.2. Recommendations

The primary objective of hazard identification and assessment is to provide information on existing hazards, their probability, severity\risk level and possible impact to be able to formulate strategies and programmes for disaster risk reduction. Based on the findings of this study, the following recommendations are made in order to mitigate the risks emanating from the existing hazards in Minna.

I. Niger State Government should evolve an action plan and strategies for reducing the risk of disasters in Minna based on the outcome of this study.

ii. Massive construction of new drainages and rehabilitation\clearing of existing damaged or blocked ones should be embarked upon in high risk neighbourhoods like Kpakungu, Shango, Fadipe, Tudun Wada and Tayi Village to reduce the risk of flood and erosion hazards in the study area.

iii. The State Government should acquire and remove all housing structures on river banks and flood plains within the metropolis to prevent flooding disaster. The population at risk should be relocated to safe environment.

iv. There should be massive planting of trees in all neighbourhoods to serve as wind breaks and protect houses from rainstorm hazards. Retrofitting of weak roofs in old and poor neighbourhoods is also required to reduce the risk of rainstorm disaster in Minna.

6. Conclusion

Human occupation of space and the subsequent man-environment interaction bring about the existence of both natural and technological hazards which have become common features of all human settlements worldwide. The study on hazard identification and risk assessment in Minna, Niger State, Nigeria provides additional empirical evidence of the nature of hazards and the risk of disasters in urban settlements in many parts of the world. As evidenced from the study, the neighbourhoods in Minna are faced with varying degrees of rainstorm and flood hazards which expose the city to the risk of disasters. Any disaster that may be caused by the existing hazard risk portends serious social, economic and environmental impact on the city and its residents. There is the need to take proactive actions to reduce the risk posed by the existing hazards and to forestall all kinds of disasters in the city. In order to ensure this, the Niger State Government, through the relevant agencies, should formulate and commence immediate implementation of disaster preparedness action plan based on the findings and recommendations of this study.

References

Baba, J.M and Jinadu, A. M (2008). Analysis of Spatial Variations in the Occurrence of Housing Environment-Related Diseases in Minna, Nigeria.

ENVIRON, Journal of Environmental Studies, Ahmadu Bellow University, Zaria; Vol., 2. No. 9, 1 – 12.

Federal Government of Nigeria (2013). *Nigeria Post Disaster Needs Assessment (PDNA)*; A Report of the Federal Government of Nigeria with Technical Support from the European Union, United Nations, World Bank and other Partners, May 2013; pages xix – xxi.

Jinadu, A.M (2007). Mainstreaming Disaster Risk reduction into Human Settlement Development in Nigeria. *Mainstreaming Disaster Risk Reduction into Sustainable Development in Nigeria; Vol. 1. National Emergency Management Agency, supported by UN/ISDR, December 2007. Pp* 23 - 42

Lozier, Tim (2011). Risk Assessment: Creating a Risk Matrix. Retrieved from http://blog.etq.com/bid/57768/Risk-Assessment-Creating-a-Risk-Matrix on 22nd July, 2013

Sanusi, Y. A. (2008). Application of human development index to measurement of deprivations among urban households in Minna, Nigeria. *Habitat International*, vol. 32 No 3, 384-398.

UNISDR, (2013). *Disaster Statistics: Latest Infographics*; United Nation Office for Disaster Risk Reduction. Retrieved from: http://www.flickr.com/photos/isdr/sets/7215/, on the 22nd July, 2013

Appendix I: Assessment of Neighbourhood Hazards

a.Assessment of Rainstorm Hazards

S/NO.	Neighbourhoods	Hazard Probability (1)	Hazard Severity (2)	Score (1 x 2)
1	Bosso Town	2	3	6
2	Dutsen Kura	4	4	16
3	Fadikpe	3	2	6
4	Kpakungu	2	3	6
5	Tayi Villa ge	2	4	8
6	Nassarawa	4	5	20
7	Maitumbi	2	3	6
8	Shango	3	5	15
9	Chanchaga	2	4	8
10	Barkin Saleh	3	4	12
11	Sauka Kahuta	2	3	6
12	Bosso Estate	3	3	9
13	Limawa	3	4	12
14	Makera	2	5	10
15	Sabon Gari	4	5	20
16	F-Layout	2	4	8
17	Agwan Daji	3	4	12
18	Minna Central	2	3	6
19	Tudun Wada South	2	4	8
20	Tunga	2	3	6
21	Tudun Wada North	3	3	9
22	Tudun Fulani	2	3	6
23	GRA	2	3	6

B. Assessment of Flood Hazards

S/NO.	Neighbourhoods	Hazard Probability (1)	Hazard Severity (2)	Score (1 x 2)
1	Bosso Town	4	4	16
2	Dutsen Kura	3	4	12
3	Fadikpe	3	4	12
4	Kpakungu	3	4	12
5	Tayi Village	4	5	20
6	Nassarawa	4	4	16
7	Maitumbi	5	5	25
8	Shango	3	4	12
9	Chanchaga	5	4	20
10	Barkin Saleh	3	4	12
11	Sauka Kahuta	4	4	16
12	Bosso Estate	2	3	6
13	Limawa	4	3	12
14	Makera	1	1	1
15	Sabon Gari	4	5	20
16	F-Layout	1	1	1
17	Agwan Daji	3	3	9
18	Minna Central	3	3	9
19	Tudun Wada South	3	4	12
20	Tunga	1	1	1
21	Tudun Wada North	5	3	15
22	Tudun Fulani	3	4	12
23	GRA	1	1	1

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