Delineation of Built-up Areas Liable to Flood in Yola, Adamawa State, Nigeria Using Remote Sensing and Geographic Information System Technologies

[1]Isa, Muhammad Zumo and [2]Musa A. A.

[1] Dept of Surveying & Geoinformatics, Federal Polytechnic Damaturu, Yobe State, Nigeria
[2] Dept of Surveying & Geoinformatics, Modibbo Adama University of Tech Yola Adamawa St. Nigeria
[1]GSM: 08066011217 [2]*GSM:08036127598*

Abstract
This study used the techniques of Remote Sensing and Geographic Information System (GIS) to identify the built up areas within Jimeta/Yola town that are liable to flood. Ikonos image and a topographic map covering the study area were used. Built up area was extracted from the image while an elevation model was created from the topographical map. The built up area was overlaid on the elevation model. Those within the flood plain are liable to flood while those outside the floodplain are not liable to flood. The result shows that Jambutu area in Jimeta has the highest risk of flooding; the flooded area covers 12.296 hectares. In Yola, most portion of Damare area is a flood vulnerable area. It covers an area of 1.759 hectares. The total area likely to get flooded in Jimeta/Yola town is 15.636 hectares.
Keywords: Built-up area, Flood, Floodplain, Georeference, River Benue, Yola-Jimeta

1.0 Introduction

Flooding is one of the numerous natural disasters that affect lives and properties. Over the past decades, the pattern of floods across all continents has been changing, becoming more frequent, intense and unpredictable for local communities, particularly as issues of development and poverty have led more people to live in areas vulnerable to flooding (Dabara, 2012). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change IPCC (2007) predicts that 'heavy precipitation events, which are very likely to increase in frequency, will augment flood risk'. Observation has shown that, with an increasingly urbanizing world flood disasters are reportedly increasing in urban areas, and particularly negatively impacting on poor people and urban development in general (Alam *et al*., 2008). The lives and livelihoods of many poor people are hardest hit by floods. In the past, flood had not only left several people homeless but had destroyed properties and disrupted business activities. Floods ravaging communities also threaten to expose residents to cholera, diarrhea, malaria, skin infections and other water-borne diseases causing epidemic (Etuonovbe, 2011).

The magnitude of flood disaster is not determined by water alone but also by the pattern of vulnerability in which people live. Dabara (2012); Henderson (2004) and Temi (2009); asserted that the level of risk and vulnerability in urban areas of developing countries is attributable to socio-economic stress, aging and inadequate physical infrastructure. Nigerian urban areas are typical examples of this high level of risk and vulnerability (Olorunfemi, 2008). Many risk problems sit at the interface of the natural and social environment, such as flooding, which occurs as the result of the inadequate provision and maintenance of drainage systems, the location of people on marginal sites, and the physical characteristics of an area Olorunfemi (2008); Cliff *et al.* (2009), Hualou (2011); Bariweni *et al.,* (2012).

Urbanization exacerbates the damages cause by flooding by restricting where flood or storm waters can go. Large parts of the ground with roofs, roads and pavements are covered, obstructing sections of natural channels and building drains that ensure that water moves to rivers faster than it did under natural conditions. In an urbanizing environment, the infiltration capacity is reduced by the replacement of ground cover with impervious urban surfaces (Odemerho, 1988; Ojigi *et al*., 2013).

The floodplains of the River Benue in Yola and Jimeta and adjoining areas of Dasin-Hausa, Fufore, Ngwalam and Numan where the flood-plains have been abused due to haphazard physical developments, illegal erection of buildings and other structures and the unhealthy habit of dumping refuse and other solid wastes in the usually open drainage channel systems, are some of the highly vulnerable areas to flood waters in Adamawa State. While, flood hazard is natural, human influence in the urban modification and alteration in the urban space can exacerbate the problem. The disastrous consequences are dependent on the degree of human activities and occupancy in vulnerable areas (Musa, 2010; Oludare *et al*., 2012). Jimeta-Yola is a typical example of such settlements experiencing floods. The incidence of flooding in this city has been closely linked to its close proximity to River Benue. Given the high spatial concentration of people and values within the floodplains in cities, even small scale floods may lead to considerable damages. Recent statistics clearly indicate that economic damages caused by urban floods are rising (Ojigi *et al.,* 2013).

Information on flood event, flood wave characteristics are desirous since and floodplain topography is dynamic as well historic flood may not be representative for present conditions Panayotis (2008). Assessing the impacts of and vulnerability to climate change and flood and subsequently working out adaptation needs requires good quality information. This information includes climate data, such as temperature, rainfall and the frequency of extreme events, and non-climatic data, such as the current situation on the ground for different sectors including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity, (Kolawole *et al*, 2011). In many instance, the patterns of urban form and buildings in Nigeria do not take current and future hazards into account, resulting in increased scales and levels of risk from floods.

The use of Remote Sensing and GIS techniques for identifying flood prone areas is now becoming the norm rather than the exception. (Eric, 1999; Kulapramote, 2011) developed an interactive process that takes advantage of Arc's GRID, ARCEDIT and ARCPLOT modules, integrated with watershed and river modeling software, to develop flood –prone area maps. Lear, stressed that, wide spread availability of digital elevation data and GIS software permit the automation of the time-consuming tasks associated with flood-prone area delineation using approximate methods. This paper therefore focuses on mapping the built-up areas within Jimeta/Yola town that are liable to as well as vulnerable to flooding. Such maps, it is believed would show the total land area liable to flooding so as to provide baseline information for mitigation measures and land use planning and activities to be considered.

2.0 Materials and Methods

2.1 Equipment/Materials Used

i. Pentium III computer (1.79GHz, 512MB of RAM)
ii. Ashtech 12XL (Handheld) Global Positioning System receiver (GPS).
iii. HP A3 scanner.
iv. HP A3 plotter
v. Yashica Digital camera.
vi. ArcGIS 9.2 Software ArcView license
vii. IKONOS image of 6m resolution downloaded on 15th September, 2012.

2.2 Data

The data used can be grouped into two types - primary data and secondary data. The primary data includes Ground Control Points (GCPs) and Social surveys i.e. interviews of some of the inhabitants within the floodplain. The secondary data on the other hand includes remotely sensed images of part of Jimeta/Yola town and topographical map sheets No. 196 N.E. showing Numan NE, 196 S.E showing Numan NS, 198N.W showing Girei NW and 198 SW showing Girei SW.

2.3 Data Quality

To ensure data quality in this study, the spatial data acquired from the field was compared with the data obtained from the georeferenced image. Rectangular coordinates of these points were acquired from the GPS. The coordinates acquired using the GPS was compared with the coordinates of the same points in the Image. It was found that there was no significance difference between the two.

2.4 Data Preparation

2.4.1 Map Registration or Georeferencing: Registration of both the topographical map and the image was performed before digitizing. Rectangular coordinates of the acquired GPS points were used. The software used, required the registration of a minimum of five points on each image. Table 4.1 shows the controls points used for the georeferencing.

2.4.2 Creation of Relevant Feature Data Classes

Two types of data were created for this project. Graphics inform of maps/plans and their related attributes in form of tables. Both data were created in Arc GIS environment. Creation of feature classes was done using Arc catalog software. New Personal Geodatabase was created and given a name flood. From Personal Geodatabase, two datasets were created with names built up area and topo. Projected coordinate system was selected as UTM WGW1984 Zone 33N. Vertical controls system was Africa, Lagos 1955.

From the feature datasets, feature data classes were created. Topographical dataset has river and elevation model as their data class. Built up area has buildings and structures as their data classes.

2.5 Identifying the Built up Areas within Jimeta/Yola and Environs

The already georeferenced image was displayed in the ArcGIS environment. From the georeferenced image, built up areas were identified through their tone, texture, location, pattern, size and various shapes. The data classes from datasets were overlaid on the image. River and main roads that was already digitized from the topographical map was added on the image to see if they fall exactly on the river and main road within the image. This serves as a positioning check See figure 3.7A below.

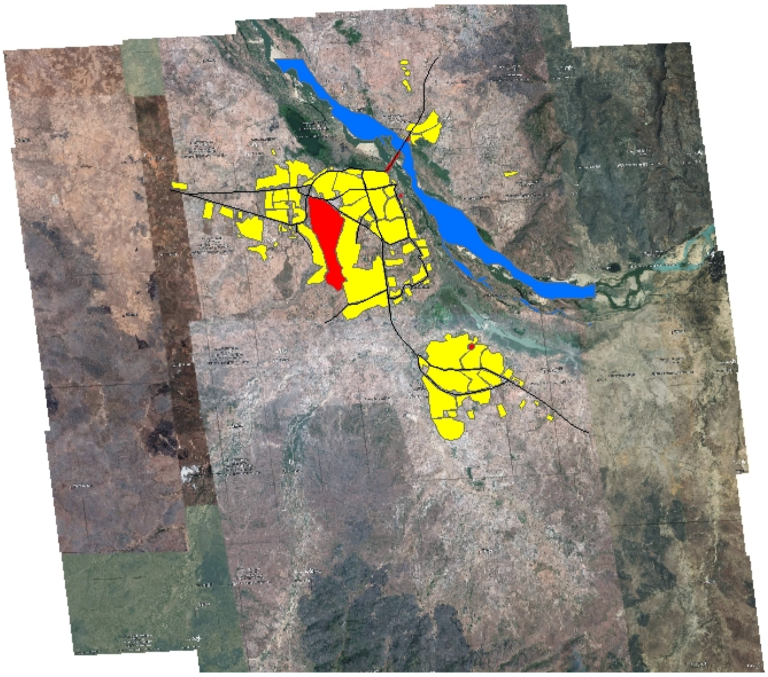
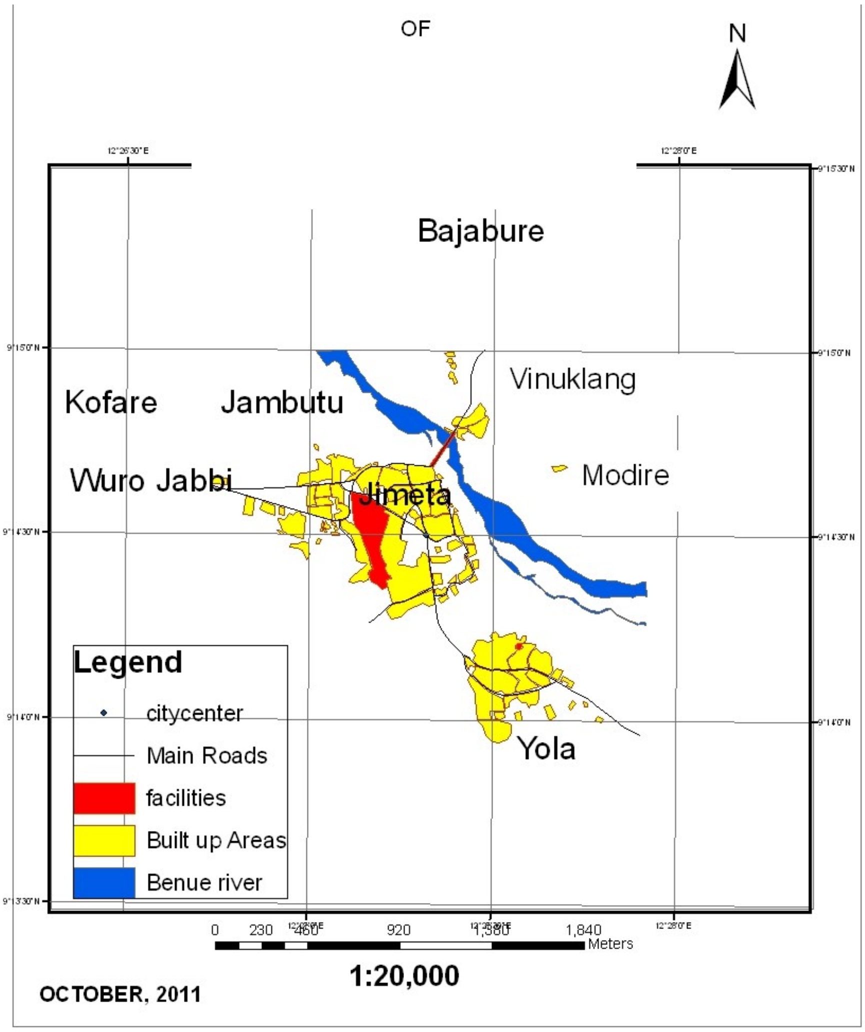


Figure 3.7A: digitized georeference downloaded Ikonos image of the study area

Yellow are built up areas, red are structures and blue is the river Benue.

The areas identified and digitized from the image were overlaid to form a map known as detail map of the study area. See figure 4.1



Fi[illegible] .il map of the study area (Ikonos image downloaded on 15th September, 2012)

2.6 Identifying Those Areas That Are Vulnerable To Flood

Flood vulnerable areas were obtained by first creating an elevation model of the area and then overlaying it with the built up area already obtained.

2.6.1 Creation of an Elevation Model:

The elevation model of the study area was created from contour lines in the topographical map. The contour lines were digitized, interpolated and classified into polygons. See figure 4.2.

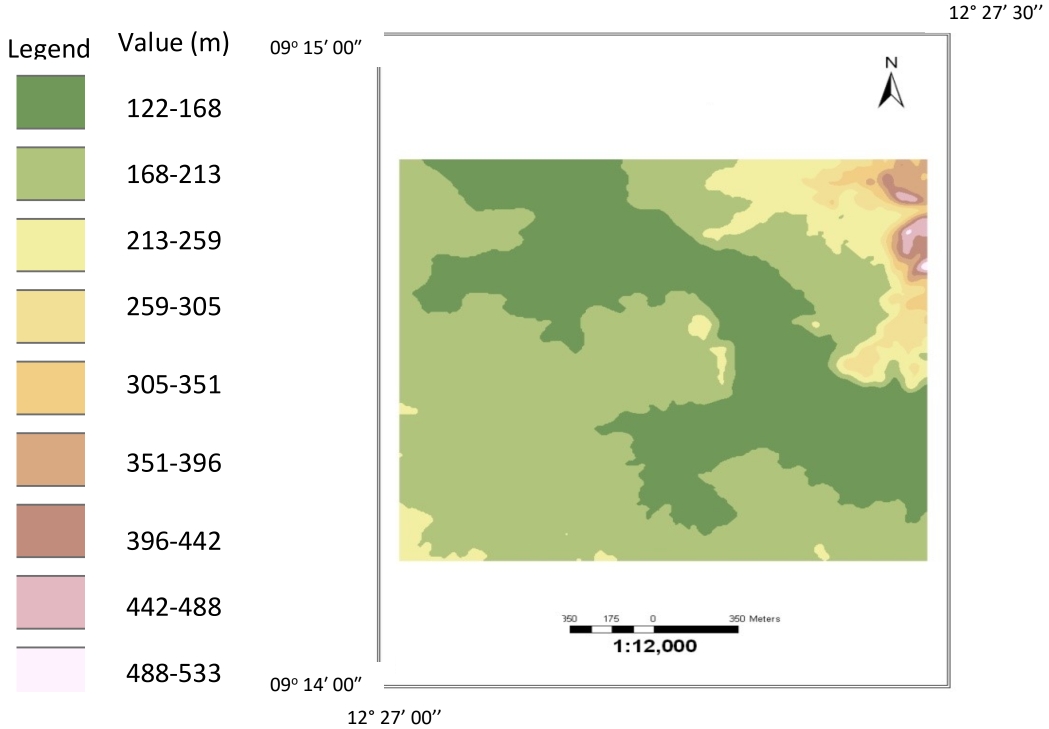


Figure 4.2: Digital Elevation Model (DEM) of the Study Area

2.7 Spatial Analysis

From the elevation model, the lowest areas were selected as a flood vulnerable area. Built up areas and structures were overlaid on the lowland area to know which area lie in the flood plain and which area lies outside the flood plain.

Intersection of the elevation model and the built up areas, gives the built up area that lies within the flood plain. It was indicated in red. See figure 4.3

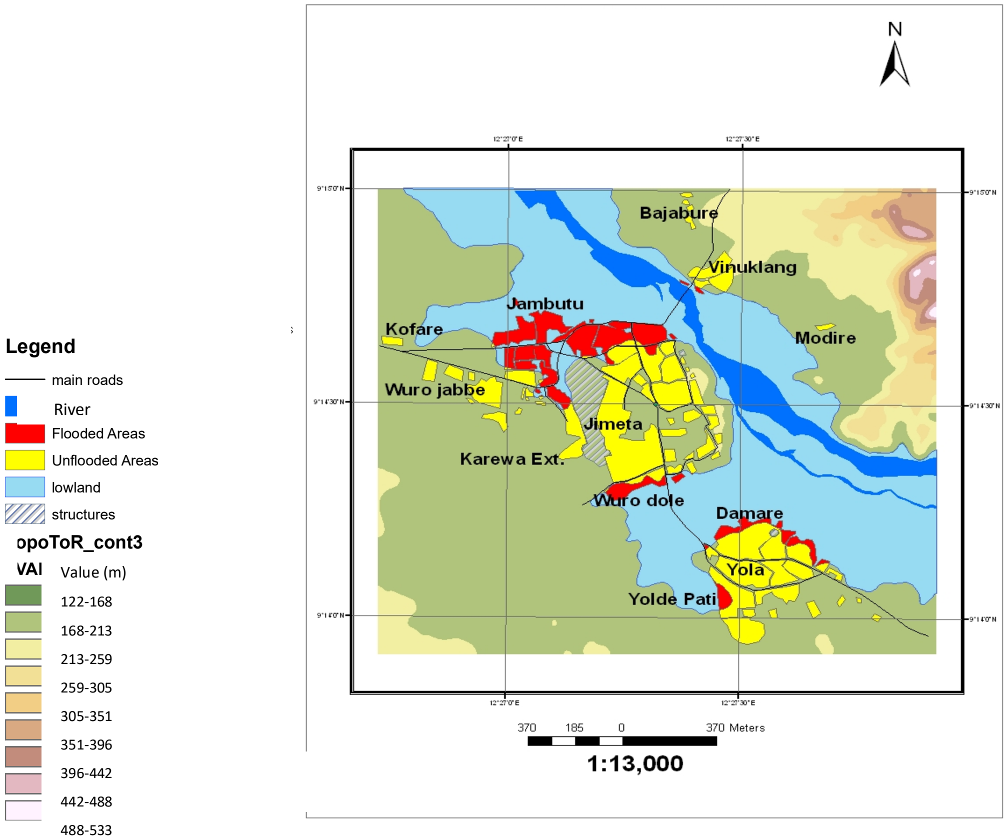


Figure 4.3: Flood mitigation map of Jimeta/Yola, Nigeria

3.0 Results

Both the topographical map sheets and the remotely sensed image covering Jimeta/Yola were georeferenced using the ground control in table 4.1

Table 4.1: Ground control points

S/N	EASTINGS	NORTHINGS	DESCRIPTION
1	220576m	1023171m	Bajabure junction
2	220325m	1022811m	Mubi round about
3	219967m	1022647m	Airport junction
4	220428m	1022314m	Karewa junction
5	220925m	1021919m	Fufure junction
6	221433m	1021580m	Rumde Doma junction
7	219477m	1023382m	Damare Primary School

In this study, the Root Mean Square Error obtained for the georeferencing of the topographical map was 0.26807meters.

Figure 4.2 is the georeferenced topographical map of the study area with the control points and the RMS error.

A topographical map was produced. Built up areas, roads, river and contour lines were shown as depicted in figure 4.1. The final map produced shows those affected areas in red while the unaffected areas in yellow. All features in red are areas likely to get flooded. From the result of this study, the total area liable to flood was **1418892.695sqm.** The area covers a shape length of **10664.202meter**s. A final flood mitigation map of the study area is as depicted in figure 4.3.

4. 0 Discussion

4.1 Map Registration

This is a technique of matching the position of points in the image acquired against their corresponding positions on the ground using ground control points. Most of the GCP used to georeference the image are road junctions and center of roundabout. Generally, geodetic points (trig points, pillars) were not seen and located in the image. That was why features such as road junctions were used as control points.

How accurate such matching is, would be determined by a statistical approach. The Root Mean Square (RMS) error of 0.26807 meters for the topographical map and 0.320 meters for the image represents the difference between the original control points acquired with the Global Positioning System (GPS) and the new control point locations calculated by the transformation process. The transformation scale indicates how much the map and image being digitized was scaled to match the real-world coordinates.

4.2 Built up areas liable to flooding

Jimeta/Yola town lies on an elevation of range 400m to 700m above the mean sea level (MSL). 400m to 550m elevation occupies an area of 141.889 hectares and was considered as a flood plain. Elevations between 1000m to 1,700 are the hilly area. Most of the hills are located at the North-Eastern part of the study area. The hilly area are close the neighbouring settlement called Girei. Elevations from 550m to 700m above the MSL are areas that are not within the flood plain. It is the most suitable areas for settlements. It occupies an area of 243.201 hectares of the study area. Most of these areas built up areas. 700m to 1000m are averagely elevated areas and can also hardly experience flooding.

From the results, Jambutu has the largest built up area that is likely to get flooded. Jambutu lies in the north-eastern part of the study area. The flooded area in Jambutu has an area of averagely 12.296hectares. The area is fast growing towards the flood plain. Other areas identified to get flooded are Wuro dole and Hayingada in Jimeta. The two areas have an area of 1.062hectares.

In Yola, areas likely to get flooded are less compared to Jimeta. Damare is the most affected area that was likely to get flooded. It has a built up area of averagely 1.759hectares. Damare area is also fast expanding towards the Benue River. Yolde pati in the north-west of Yola was also identified as a flood risk area. It covers an area of 5119.51msqr.

4.3 Total Built Up Area Lost To Flooding

From the result obtained, Jimeta has the largest built up area to be lost to flooding. It covers 13.358 hectares. The most flooded area is Jambutu. In yola town, the flooded area is Damare and

Yolde pati. The two has a total area of 2.278 hectares. The combine total built up area to be lost to flooding in the study area is 15.636 hectares.

4.4 Flood Mitigation Mapping

The most effective way of reducing the risk of losing lives and property is through the production of flood mitigation maps. Most countries in the developed world have maps which show areas prone to flooding. In this study a flood mitigation map was produced which show areas at risk in Jimeta/Yola town and environs. The red areas are the flood prone areas, while the yellow shows the areas that are not prone to floods.

5.1 Conclusion and Recommendation

Topographical maps of study area were used to create digital elevation model of the area. Low lying areas were later extracted from the elevation model created. The features obtained from the image were overlaid on the low land area in order to see which of those built up areas falls within the low land area and outside the lowland area.

The final information obtained is flood mitigation map of Jimeta/Yola, map showing built up areas that are liable to flood and those areas that are outside the flood plain. Total area of land that was vulnerable to flood as the time of this study was 142Hectares with a total perimeter of 10664.202meters. The built up area to be lost to flooding is 15.636 hectares.

Once again the integration of remote sensing with GIS has proved to be a very reliable and effective means of delineating flood prone areas. With dwindling resources made available for hazard identification and mitigation in the third world, the GIS has proved to be an excellent means of integrating the numerous freely available environmental data into reliable accurate information. This translates into a reduction in the overall cost of producing needed information without the unnecessary drudgery and time wastage associated with manual approaches

Base on the results from the analysis the study proffered the following recommendations.

i. Adamawa state government should relocate all the occupants of Jambutu and Wuro Dole in Jimeta to wuro Jabbe or Karewa extension. The state government should equally relocate the inhabitants of Damare and Yolde Pati in Yola to Karewa extension or any suitable area with low risk to flood.
ii. The government should continue monitoring all developments within Jimeta/Yola town. This will reduce the rate of spread of residential buildings within the flood plain. A typical area that needed monitoring urgently is Jambutu in Jimeta and Damare areas in Yola.
iii. The map produced as a result of this study should be utilized in the decision making for developments in the town. The map will be useful more especially in the design and construction of roads and drainages.
iv. The flood prone areas should be used strictly for agricultural purposes and other hydrographic activities.
v. There is the need for the government to continue updating this flood mitigation map at every five years in order to see if there are significant changes in the nature of the river and flood areas.

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