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Floodplain mapping of Rima River Using GIS and Remote Sensing (Argungu Axis, Nigeria)

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Abstract: *The world has recorded severaldisasters within this decade, most of which are deadly, apart from lives and propertieslost, Billions of dollars have been wasted and used to build camps and relocation of victims. One of the commonest of them is flood. In Asia, Europe, Africa and Arab Nation this menace as being a serious threat to national development. Argungu is well-known town for its Argungu Fishing festival, this same local government has experienced several degree of flood. This paper seeks to provide one of the solution that can assist in solving problem of flood by providing the floodplain map of Argungu local government of Nigeria. The GIS and Remote Sensing method was used. Landsat Image and Shuttle Radar Topography Mission (SRTM) DEM Data were downloaded from USGS Earth Explorer. Subsetting (Clipping), correction for cloud cover and atmospheric effect was made, the image was classified into four classes using the supervised classification approach. These areCommunities, Water, Fadama and Farmland. This will assist in knowing the area of flooding, The flood risk zone are classified into four namely:-High Flood Risk Zone, Average Flood Risk zone, Low Flood Risk zone and Very Low Flood Risk zone. It was observed that, the High Flood risk zone with land coverage of 7,888.026Heacatres, Average Flood Risk Zone with 8268.818 Hectares, Low flood risk Zone with 8807.854 hectares and Very low flood risk Zone with 9,3723,152. Some of the villages are within the high Risk zone, which is dangerous to their lives and properties. The built environment with the high flood risk zone can be relocated to avert any disaster in the future. It could therefore be concluded that Floodplain Mapping is very essential in order to sustain any meaningful Local, State, National and international development.*

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I. Introduction

Flood occur when there is heavy and continuous rainfall exceeding the rate of absorption by the soil leading to overflow from either the river, stream and coastal area. Area that are liable to flood are normally situated close to these water bodies are referred to as floodplain. These are hazardous to development activities.

There are three primary sorts of flooding: Coastal, Fluvial and Pluvial flooding.

Coastal Flooding are experienced along the coast of large water bodies e.g Coast of the Sea, Ocean and River. Water level increases because of Tidal effect or high winds from Storms that moves the water onshore. The coastal flood can be categories into minor, moderate and major each understood as the name implied with corresponding damaging effect.

Fluvial Flooding is caused by an excessive overflowing of water mostly rainwater from the river to the surrounding environment and filling up smaller streams, rivers and Lakes. The resultant effect is the breakage of dams, dikes and thereafter making the surrounding environments swampy this type of flood can be classified into two. Overbank and Flash flooding. The degree of the fluvial flooding is resolute by the quantity of rainfall, the absorption capacity of the soil and the undulation.

A pluvial, or surface water flood, is caused when overwhelming precipitation makes a flood without considering flooding water body within the surrounding. One of the most well-known misguided judgments about flood hazard is that one must be situated close to a waterway to be in danger. Pluvial flooding exposes that fantasy, as it can occur in any urban zone, significantly higher height territories that lie above beach front and waterway floodplains.

There are two normal kinds of pluvial flooding:

- Intense downpour soaks urban channels and canals. Theses becomes overpowered and water streams out into avenues and cover up structures.
- Run-off or streaming water from downpour falling on slopes that can't take in the water. These excess water moves along the slopes and fill in the streets.

Pluvial flooding regularly happens in mix with Surge and fluvial flooding, although commonly just a couple of centimetres down, a pluvial flood can cause critical property harm

Flood have caused a number of havoc all over the world, according to floodlist.com of 21 August 2019, In Pakistan 12 people where reported to have being killed from flood and landslide rising the death toll to 221 from 1st July to 21 August 2019.

Sudan new Agency reported on 15 August 2019 that flood across the country have at least 46 people dead and damaged almost 10,000 houses

17th and 18th August 2019 was a bad day at Naina and Devi in Bilas pur and Berthin districts, where it was reported that 360mm and 240mm of rainfall respective where experienced which caused the death of 8 people at Shinla, 2people each at Kullu, Sirmaur, Solan and Chamba, and 1 person each at Una,Lahaul,-Spiti districts.

Japan with the aim of resisting flood which devastated a large portion of its urban communities in the past utilized about 2.6 billion US dollars to build flood under ground Channels at Tokyo which they called the G-Cans. The development was somewhere in the range of 1993 and 2007, it comprises of 6.4km of passage up to 50m height from the surface, linking five massive compartments 6.5m high and 32m wide to a giant tank. Flood from the city's seepage framework is channelled through the passage and runs into the compartment, which go about as stream controllers from where the water is directed into the flood chamber. When the water arrives at a specific level, four turbines fuelled by 737 estimated fly motor, siphons the water out of the chamber at a joined pace of 200m3 (53,000 gallons) every seconds, discharging it into the Edo River at a point where the River has the ability to convey the water into the sea moving forward without any more flooding.

In a similar case, a SMART (Storm-water Management And Road Tunnel) was built at Kuala Lumpur Malaysia, the longest tempest water channel in Southeast Asia and second longest in Asia all in all at 9.7Km. The expectation was to occupy storm water from water Klang and Ampang away from the city. The development cost an aggregate of RM1.887Billion (US$514.6million).

According to Richard Davis in Africa News of 19th September 2018 Nigeria being part of the worldwide town isn't forgotten about as overwhelming precipitation on 27 August 2018 caused flooding in Niger, Kano and Nasarawa States, while on 30 August 2018 Nigeria's Hydrological Services Agency (NIHSA) cautioned dwellers in Kebbi, Niger, Kwara, Kogi, Anambra, Delta and Bayelsa states that inexorably high waterway levels could cause significant flooding. The Shiroro, Kainji and Jebba dams were at that point discharging water and levels of the Niger River at Lokoja were equivalent or higher than those seen in 2012. Flooding influenced portions of Jigawa State toward the beginning of September. Further substantial downpour on eighth September 2018 caused flooding in Rikkos, Jos North Local Government Area, Plateau State, and 200 family units were dislodged, as indicated by News Agency of Nigeria (NAN). On 10 September, 2018 around 1,000 houses were destroyed after substantial downpour caused flooding in Etsako Central Local Government Area of Edo State News Agency of Nigeria. BBC announced on 17th Sept. 2018 that in the last two weeks over 100 persons had passed on due to the effect of flood water within the country. Nigeria Hydrological Service Agency (NIHSA) cautioned of flooding from the Niger and Benue streams and National Emergency Management Agency (NEMA) announced a highly sensitive situation in four states along the delta. Millions of people are at present influenced by flooding in 8 State of the nation. At any rate 108 individuals have lost their lives in the flooding, with a further 192 harmed. African News (25th September, 2018). The States involved are Anambra, Benue, Delta, Edo, Kebbi, Kogi, Kwara, and Niger each having a significantly high casualty rate.

The year 2019 rainfall came from flood in various part of the county, in Imo State, about 6,000 people were displaced and about 200 houses were submerged due to flood around the lowland of the state, which is surrounded, by Orashi River and Oguta Lake. Some of the communities affected are Mmahu, Etekuru, Obiaakpu, Abor,Oguta I and II, Ezi, Orsu, OrsuObodo, Umuorji and Abacheke.

On Friday 2nd August 2019, Yola received its own potion of the flood where it was recorded that about five children feared dead, many homes and business were over flood with the overflowing water from the gutters, the affected area were Jambutu, Bachure and other part of the main town of Jimeta.

Kebbi State have experienced several flood in various capacity over the years this claimed lives, render many homeless and destroyed properties worth millions of NairaOut of the 21 nearby government zones in Kebbi State, 14 main occupation is to plant rice. Nine out of the 14: Yauri, Shanga, Bunza, Suru, Argungu, Augie, Birnin Kebbi, Dandi and Bagudo are significant rice-creating zones. Administrator of the Rice Farmers Association (RFA) in the state, Alhaji Sahabi Augie, portrayed it as a fiasco and difficulty to rice generation exercises in the state.

Figure 1 Flood in Kebbi State

Source: Daily Trust date

Daily Trust (2018). This investigation will in general guide the Rima River flood plain just like the significant supporter of the flood cases inside Birnin Kebbi separated from the ones brought about by surface flood.This work is to map the floodplain along the Rima River Argungu axis.

II. Statement Of Problem

The depletion of the ozone layer which brought about the global warming has led to an increase in the water level of most of the rivers worldwide.Whereas an unnatural weather change may mean hotter climate, it has lead to numerous adjustments in our ordinary lives. Ocean levels ascend; as hotter climate would liquefy the polar ice tops, and Water Supplies may be influenced to increase. In certain territories there will be more downpour, while different zones may encounter drier climate and in the long run dry recurrence. Paula and Bachdahl (2002). As a result of the increase in the water level which turned out to be excess rainfall and its resultant effect is flood, with these effect, there is need to map the floodplain as a provide measures to destruction of live and properties. This work seeks to map the Rima River floodplain in Argungu Local Government Area.

Aim

The aim is to map the floodplain in Argungu along the Rima River using Remote Sensing and GIS.

Objective

i. Download LandSat 8 OLI for the study area
ii. Subsetting or clipping Rima river in Argungu
iii. Pre-Processing and Processing
iv. Download SRTM of the Area
v. Analysis of Data
vi. Preparation of map showing the Floodplain

Study Area

Argungu Local Government is situated within Kebbi state which lies within latitude 120 45’ 47.93’’ longitude 040 11’ 39.15’’ minimum latitude 120 28’ 33.09’’and longitude 040 14’ 54.05’’. It was established in 1991 during Gen. Ibrahim Badamasi Babangida regime. The local government shares boundaries with Birnin Kebbi, Gwandu, Kalgo, and Kangiwa. Apart from the basic agricultural produce which includes Rice, wheat, Millet, Water Melonand beans, it encompasses majorly high-density residential and commercial area this include banks, hotels, market, emir palace, churches, mosques and Shopping complex. Within the area traverse the Rima River which takes its source from River Kaduna to River Niger through Zamfara, Sokoto and Kebbi State. The River serves a major source of water for dry season farming.

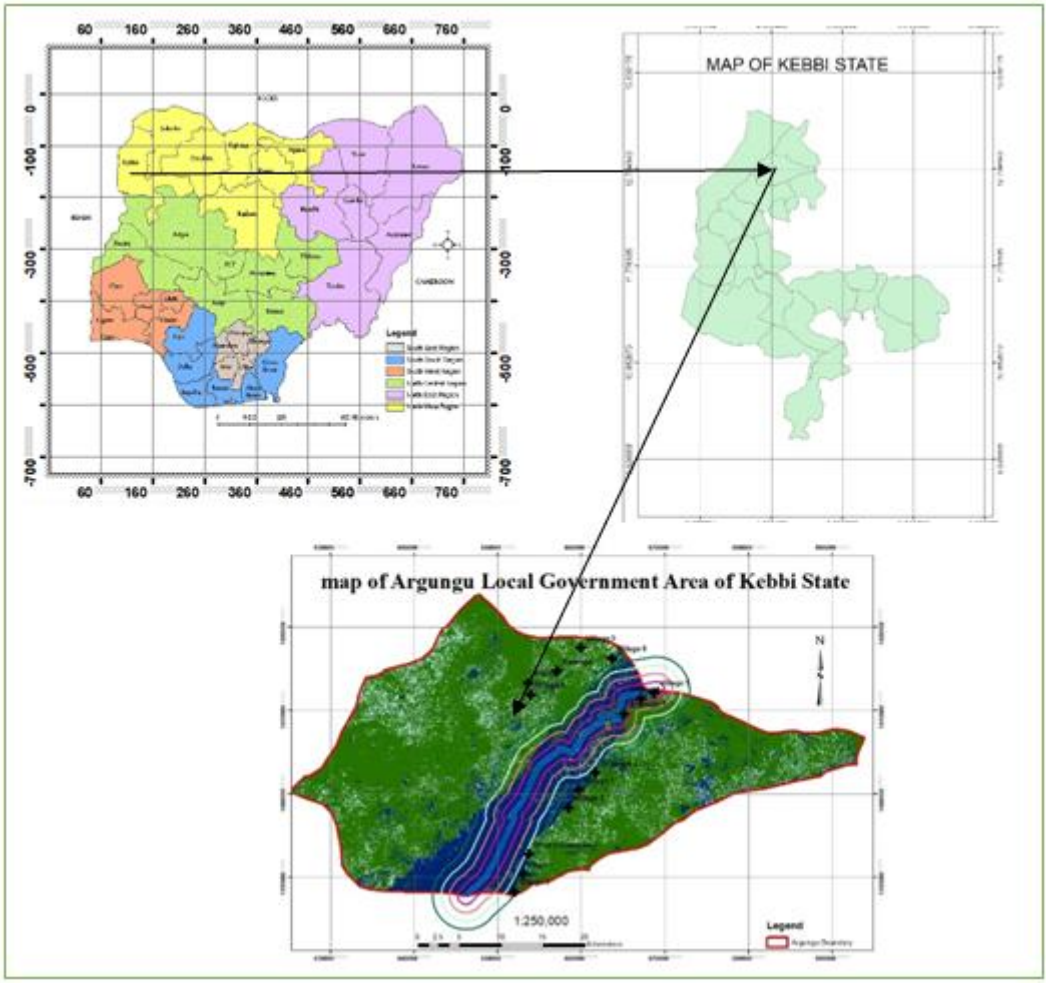

Figure 2: -Map of Nigeria Showing Argungu Local Government Study Area
Source: Author, GIS data processing, November 2019

III. Methodology

Data Source and method of acquisition

i. Landsat 8 OLI/TIRS imagery of November 2019 was downloaded from United States Geological Survey (USGS) earth explorer.
ii. Argungu shapefile was obtained from the administrative shapefile of Kebbi, Nigeria
iii. Shuttle Radar Topography Mission (SRTM) DEM Data from USGS Earth Explorer

Preprocessing Of Landsat Image

Identifying area of interest

The area of interest was delineated in Google earth, downloaded through El-shayal software which allows the retention of the Coordinate system and avoid geo-referencing in ArcGIS environment. The Saved Google earth with the area of interest was imported into the ArcGIS 10.2 environment and digitized, this is to create a shapefile of the Area of Interest which was done.

Subsetting (Clipping)

Landsat 8 OLI/TIRS (Three Scenes) covering the Area of Interest was imported into the ArcGIS environment and mosaic, the following steps were followed to clip the Area of Interest. Arc Toolbox → Data Management → Raster = Raster Processing → import Shapefile of Area of Interest → import Mosaic Landsat 8 OLI/TIRS imagery → Create Output Folder → Clip. Figure 3 is the clipped imagery.

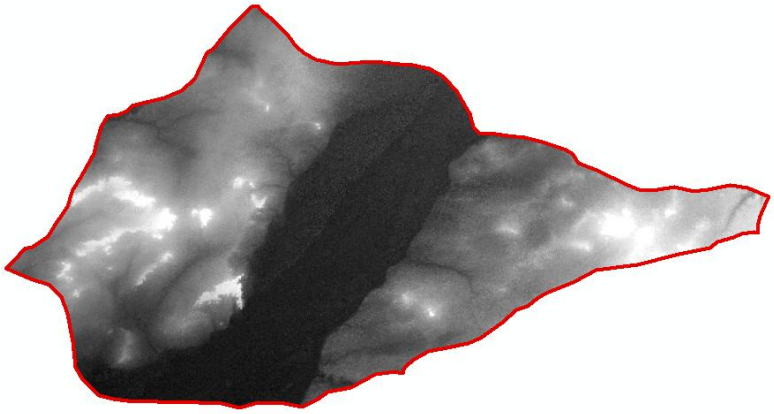

Figure 3: -Clipping of Argungu Local Government Area.
Source: Author, GIS data processing, November 2019

Conversion of (DN) Digital Number to (TOA) To of Atmosphere reflectance and Application of Normalized Difference Water Index

Landsat 8 OLI/TIRS was downloaded from USGS, Atmospheric correction was carried out on the image, The remotely sensed image has gone through several complications and errors like cloud cover and scattering at the time of capturing, these causes some misinterpretations from the earth to the satellite sensors the purpose of this correction is to retrieve the surface reflectance from remotely sensed imageries by removing the atmospheric effect. These formulae were used in Raster Calculator:
Conversion of Digital Number (DN) to Top of Atmosphere (TOA) reflectance = Specific Reflectance Multiplicative Band ***** DN value + Reflectance Additive Band

Correction for Sun Angle = $\frac{\text{TOA Reflectance}}{\text{Sin (Sun Elevation)}}$

The additive, Multiplicative, sun Elevation and sin (sun elevation) are found in the metadata attached to the downloaded image.
Another important aspect of preprocessing that was carried out is to correct for Normalized Difference Water Index (NDWI), this is to obtain a distinct difference between other land features and water bodies.The formula is

NDWI = $\frac{Band\ 2\ (Green) - Band\ 4\ (Near\ Infrared\ )}{Band\ 2\ (Green) + Band\ 4\ (Near\ Infrared\ )}$

Raster calculator was used to perform the operations, the steps are:-
Arc Toolbox → Spatial Analyst Tool → Map Algebra → Raster Calculator.

Image Processing

Extraction of Rima River and its Tributaries

Supervised classification was used- coordinates of different locations different features such as water, farmland, fadama and communities were obtained on the water and ground. These coordinates were used to create training site in the ArcGIS environment for identifying the location of water bodies and other feature on the imagery.

Generation of Coordinates, formation of Contour and Digital Elevation Model.

A coordinate system of the Data frame was selected = create fishnet tool was selected, this can be found under Data Management tools, A dialog box open and the following information were supplied. Output feature class (Clipped STRM), Tolerance extent (Argungu Shapefile), cell size width (500), cell size height (500), geometry type (Polygon), and create label point box was checked. The output is a 500 by 500 girds were created with a small polygon in the middlefigure 4

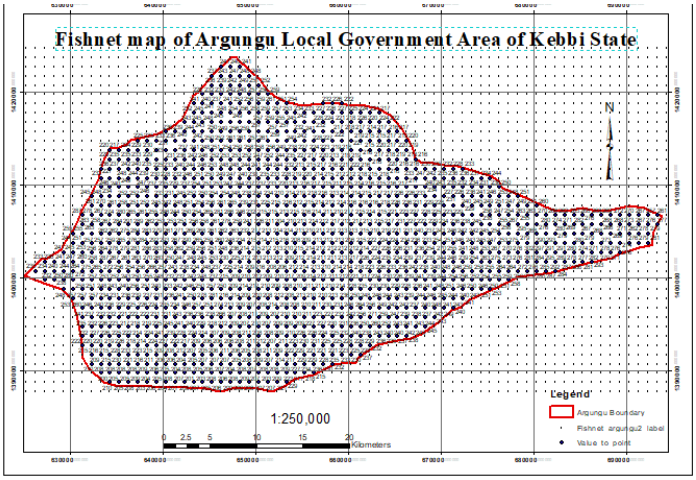

Figure 4 Showing Fishnet of Argungu Local Government Study Area
Source: Author, GIS Data processing, November 2019

Through create value to point, the heights of each of the points were obtained and coordinates generated from the attribute Data.The coordinates were utilized in ArcGIS to create Contour, Aspect and Hillshade has shown in figures 5,6 and 7 respectively.

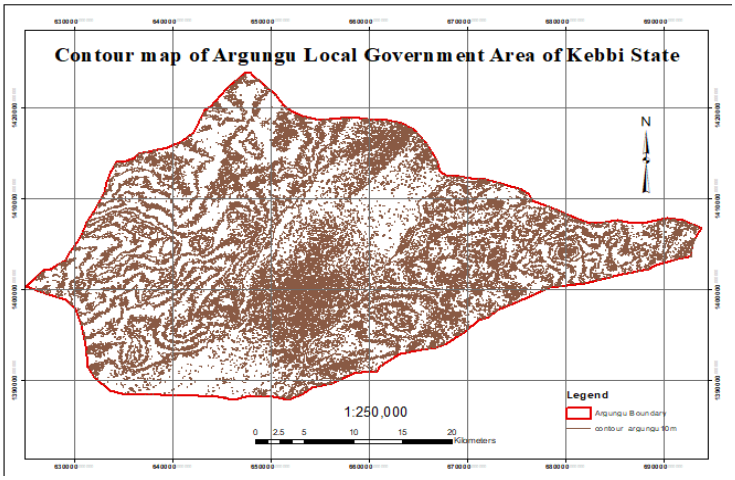

Figure 5 Showing Contour map of Argungu Local Government Area
Source: Author, GIS Data Processing, November 2019

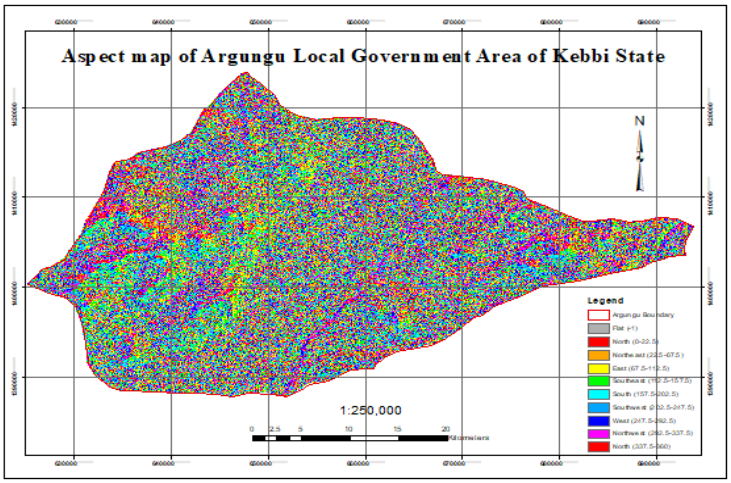

Figure 6 Showing Aspect map of Argungu Local Government Area
Source: Author, GIS Data processing, November 2019

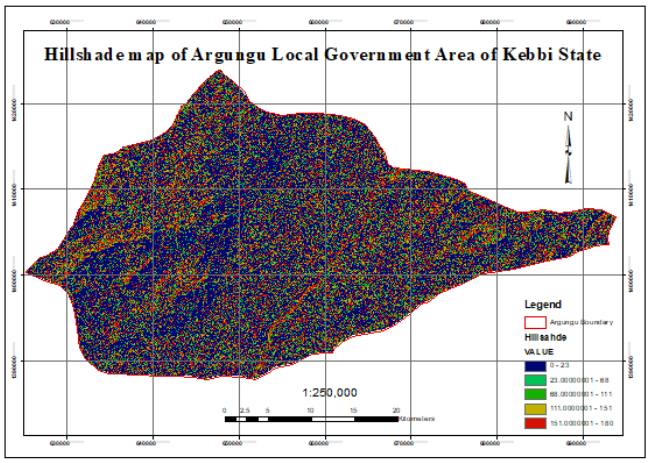

Figure 7 showing Hillshade map of Argungu Local Government
Source: Author, GIS Data processing, November 2019

Buffering and delineating floodplain area.

River Rima (also known as Sokoto River) was buffered using an offset of between 500m and 1000m (1Km), the result is as shown in figure 8. The deep green color represents Flood of very low risk zone, cyan line is flood low risk zone, light purple stands for flood average risk zone, and purple represents flood high risk zone.

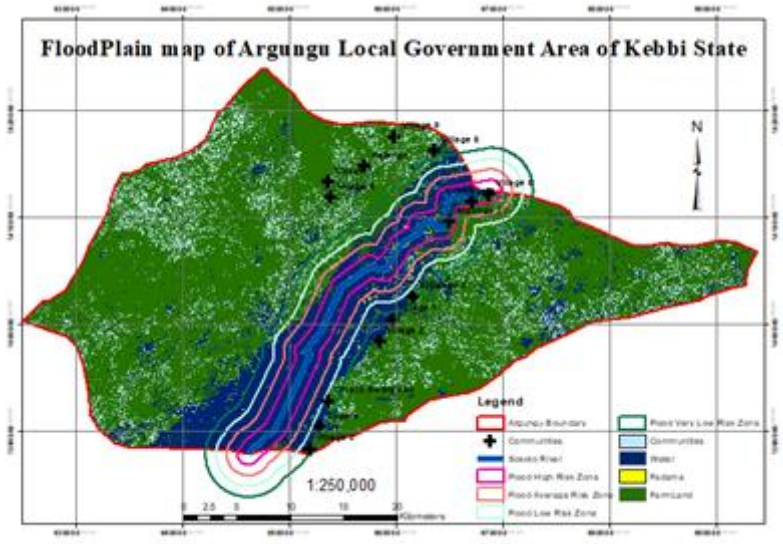

Figure 7 Floodplain map of Argungu Local Government Area
Source: Author, GIS Data processing, November 2019

Analysis

It was observed that village 4, 5 and Argungu1 are at the high Flood risk zone aa such will be submerged at any rise in the water level of River Rima. Villages 3, Argungu2, Dagere, and Umaru Gwargwari will be affected, at the Flood very low risk zone, but this will be on a very server flood cases.

The total area cover by each of the zone is given as: -

Flood High risk zone	7,888.026 Hectares
Flood Average Risk Zone	8,268.818 Hectares
Flood Low Risk Zone	8,807.854 Hectares
Flood Very Low Risk Zone	9,372.152 Hectares

Most of the flood risk is towards the eastern zone, the western zone is not flooded because most of the resident, and arable farmland is towards the eastern Zone. Majorly the western zone occupies area use for rice farming, in which much water is needed.

IV. Summary/ conclusion

Flood is one of the deadliest disaster in the world and especially in some part of Asia, Europe and African nation such as Nigeria, for the past four month the rate of flooding in Nigeria is becoming alarming in states like Lagos, Abuja, Kaduna, Adamawa and the likes. Some of its effects can be averted on proper planning, and execution. This prompt the mapping the Rima River floodplain of Argungu a well-known local government Headquarter in Nigeria, Known for its fishing festival along the Rima (Sokoto) River.

The Method adopted is the GIS and Remote Sensing Approach, and the result and analysis shows that most of the flood is towards the eastern part of the Local Government Area where is more populated with lives and properties. It was also discovered that the western part is mainly Fadama used for rice farming and needed more water for more yield. Some of the villages, towns and farmland will be submerged at any rise in the water level along the river bank. The rate of submerging is categorized into four, High Flood risk zone with land coverage of 7,888.026Heacatres, Average Flood Risk Zone with 8268.818 Hectares, Low flood risk Zone with 8807.854 hectares and Very low flood risk Zone with 9,3723,152. The built environment with the high flood risk zone can be relocated to avert any disaster in the future.

It could therefore be concluded that Mapping is very essential in this country and the world at large, destruction and loss of lives and properties can be reduced or averted.

V. Recommendation

The following are the recommendation that could be of help to the communities and government in securing lives and properties and also increase the live expectancy of persons within the locality.

i. The government of the state should embark in massive floodplain mapping of the state.
ii. There is need for massive campaign of the need to relocate from floodplain, most especially the high flood risk zone
iii. It is also recommended that the floodplain can be utilized for revenue generation, in term of rice farming and other plants that do well in water logged area.
iv. The Argungu Floodplain can still be harness to expand the festival instead of maintain same location for years.

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