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GIS APPROACH DELINEATION OF FLOOD VULNERABLE BUILDINGS ALONG RIVER AGBOYI

Olagoke Emmanuel Awodumi
Department of Urban and Regional Planning
University of Ibadan, Ibadan, Nigeria

ABSTRACT: *Managing complex environmental problems such as flood disaster require up to date technology. Much of these disasters can be prevented and reduced through the use of technology such as Geographic Information Systems (GIS) and remote sensing. The spatial analytic capacity of GIS is employed to identify the areas and buildings at risk to flood along the Agboyi River in the study area. Different datasets were extracted from satellite imagery (Ikonos) of the Study area. ArcGIS 10.3 and surfer 13.3 were used for the spatial analyses. Buffering, overlay operations, Digital Terrain Model (DTM) and 3D Analysis were also conducted. The coordinates used to develop the Digital Terrain Model (DTM) were extracted from satellite imagery using TCX software to depict the topography of the study area in Surfer 13.3. The results revealed that the study area is situated on near uniform lowland with the vulnerable zones located on the lowest part of the plain which is responsible for the high flood vulnerability experience in this area. It can be deduced that the magnitude of the flood hazard of a given area is a function of both the distance to the river and the elevation of the area in question. It is believed that the result of this research can be used as a means of regulating development along the plain and also serve as a decision support when making policies relating to flood management around the flood plain.*
KEYWORDS: GIS and remote sensing, spatial query, Digital Terrain Model and Flood vulnerable buildings

INTRODUCTION

In recent years, floods have become increasingly significant as an environmental hazard. Lagos and Nigeria in general have experienced a lot of flood incidences and the impact of flood has also increased due to population growth coupled with uncontrolled developmental practices which has resulted in pressure and congestion in urban areas. This forces a considerable number of people to settle in unsafe areas with inherent risks. Low purchasing power also motivates people to acquire cheap land regardless of inherent risk involved. Climate change which culminates into rising sea level is another causative factor. Flooding poses a tremendous risk to the human and physical environment. Flooding is a potential harm to residences along the Agboyi river channel because of it severity, magnitude of its impact and frequency of occurrence. This calls for a systematic management of the flood disaster. Defining the level of vulnerability and delineating risk areas can help in understanding the best option in managing, mitigating and adapting to the impact of flood hazard (Bahaeldeen, 2006). There is now greater emphasis on non-structural measures of flood management and control, rather than on structural measures. These measures include flood forecasting, flood-inundation mapping and flood plain zoning. GIS and remote sensing has

emerged as an indispensable tool in the study of floods, particularly with its capacity to provide near real-time data, enabling preparation of maps of inundated areas and assessment of damages. Several studies connected with floods (areal extent, zonation, damages) have been undertaken on the basis of Remote Sensing Techniques (Jain and Sinha, 2003). Geographical Information Systems (GIS) is also now being used in several studies to delineate the flood-hazard areas by incorporating meteorological, geomorphological, topographical, land use and demographical data, with the aim to achieve a reduction in the loss of life, disruption and damages caused by floods (Sanyal and Lu, 2003; Bapalu and Sinha, 2005). Though floods are disruptive events and the occurrences of floods cannot be prevented, they are actually natural features of a river system and their role in replenishing the floodplain cannot be ignored. The negative consequences can be lessened by an integrated approach to disaster management which comprises 4 elements such as: mitigation, preparedness, response and recovery (Quarantelli, E.1991). In this study, GIS, is intended to provide a broad range of tools for determining flood vulnerable areas and number of buildings that will be affected by flood and thus assist policy makers, town planners, environmentalists, governments, academics and stakeholders alike in solutions to flooding disaster.

Residents of Lagos and most Nigerian towns and villages, the rainy season is undoubtedly not the best time of the year. This period comes with the perennial problems of flooding which leaves many homes swamped with the resultant loss of property and sometimes human lives. Properties estimated at several millions of Naira were destroyed in many communities in the Ikorodu axis in 2010. It was gathered that the persistent overflow of River Ogun caused the disaster in the State. Also, the exceptional rainfall being witnessed globally this year (2012) had made the Atlantic Ocean level to rise, and this in turn forced Lagos Lagoon water to rise and spread into the flood prone areas of River Ogun (Etuenovbe, 2011). One of the major tributaries of river Ogun is Agboyi River. Flooding along the Agboyi River in Alapere area of Ketu is an annual occurrence. The unsafe condition of lives and properties along the rivers has over the years become an issue of serious concern to individuals, Local, State and the Federal Government. Properties amounting to billions of Naira are damaged yearly. The government disburses lots of resources to resettle flood victims and to provide relief materials (Tony, 2017). (Thisdays newspaper, 2016) stated that Agboyi community is a riverine community usually flooded during the wet season, while at the dry season the water dries up. (Tribune Online, 2017) stated that for the residents of Kukoyi Street in the Alapere area of Ketu, and Orisunbare Street in the Akowonjo area, both in Lagos State, living in the midst of flood is a part of life. The correspondent further that to many of the dwellers in Agboyi, Makinde, Kukoyi, Orisunbare and other areas close to the river channel is like living in the midst of flood has become a necessary evil they cannot do without. Some houses with low pavements have had them raised. But in spite of all these, most houses still get flooded. As stated by the correspondent, a dweller by the name Betty Nwankwo, said leaving Alapere is the only solution to the floods because incessant flooding has made life very difficult. Alapere is close to the swampy area leading to the lagoon. Therefore, whenever it rains heavily, the ensuing floods bring all sorts of debris into the environs. The state government anticipated such unwanted occurrence and spent millions of naira to dredge rivers and streams in the state. According to the Southwest Zonal Coordinator of the National Emergency Management Agency, the measures failed as water overflowed their banks and flooded a good number of areas in the city where over

300 houses were affected as most areas of the city of Alapere were ravaged. One of the major concerns and challenges for the policy makers is to determine the number of buildings and population at risk. Policy makers are also concerned with the number of buildings that contravene the 30-Meters along river channel in accordance to Regional Planning (Building Plan) Regulation of 1986. Thus, this aim can be achieved with optimum and accurate use of GIS and remote sensing which this research is centered upon. A viable tool for decision making in risk reduction is geo-spatial information. Flood risk mapping is the vital component in flood mitigation measures and land use planning. This research is aimed at delineating buildings that are susceptible to flood disaster along the Agboyi River in accordance to Regional Planning (Building Plan) Regulation of 1986.

The study seeks to:

- design a database for the study
- capture the spatial data within the study area using satellite Imagery
- develop a Digital Terrain Model to show drainage pattern of the study area
- produce risk maps which captures the at-risk buildings and delineate risk areas.

EPISODE OF FLOODINGS IN NIGERIA

Following the annual increase of flood disaster especially the devastating 2012 flood hazards in Nigeria coupled with improvement in the use of modern technologies for environmental monitoring such as remote sensing and GIS, the government of Nigeria and the relevant agencies have recently put all hands on deck for environmental monitoring and management especially flood disaster(Ikusemoran et al, 2014). Flood disaster monitoring and management involves several processes and data generation, the terrain has to be studied, the landuse and vegetation cover deeply assessed, while the impact of the drainage and the hydrology of such areas must also be analyzed. Several studies have been carried out by different authors on the use of geospatial techniques for flood assessment in the floodplains of Nigeria. For instance GIS and remote sensing has been used to model flood hazard and vulnerability of the floodplains of Adamawa State and GIS based techniques to investigate flood vulnerability of the floodplains of the Benue basin, applied geospatial techniques to the mapping and analysis of the 2012 flood disaster in the central parts of Nigeria (Ikusemoran et al, 2014). GIS, remote sensing and other spatial analysis techniques were inculcated to achieve the standard objectivity of this study.

Some other notable flood incidences in Nigeria are shown in the table below.

Year	Location	Causes	Estimated Damages	Source
2001	Abia,Adamawa, Akwa-Ibom States	Rainfall	5000 people affected	FamousObebi 2012
2001	Zamfara	Rainfall	12,300 persons Displaced	
2005	Taraba	Rainfall	50,000 people Displaced	
2008	Imo State (Awo-idemili)	Rainfall	12,250 people Displaced	Vanguard Newspaper 24/9/08
2008	Edo State (Benin City)	Rainfall	20 houses collapsed & four dead	Vanguardnewspaper 23/9/08
2008	Benue State	Rain storm	Destroyed 350 houses	Vanguard newspaper 27/9/08
2012	Plateau State (Jos)	Rainfall leading to overflow of Lamingo dam	39 people died 200 homes submerged 3000 people displaced	Wikipedia downloaded on 19/10/14

Table 1: A Review of some flood disaster cases in Nigeria, Emeribeole A (2015).

Study Area

The study area is located in Kosofe Local Government, Lagos Sate. Kosofe Local Government is situated in the southern part of Ogun State from which River Agboyi took its source from Ogun River. Kosofe is one of the twenty (20) Local Government Areas (LGAs) in Lagos state. It was created on the 27th of November, 1980. It is located at the northern part of the state; it is bounded by 3 local governments which include Ikeja, Ikorodu and Shomolu. It also shares a boundary with Ogun state. Its area of jurisdiction comprises of ten wards and encompasses an area of 178.85sq/km with its headquarters at Ogudu. NPC (2006) puts the population of Kosofe at 682,772 people with 358,935 males and 323,887 females. Using the 3.18% growth rate (NPC,2006), the projected population to year 2012 is 1,126,574.

Kosofe local government consists of so many communities which includes Oworosoki, Ifako, Sholuyi, Anthony village, Ajao estate, Ogudu, Ojota; Alapere, Orisigun, Kosofe, Ajelogo and Akanimodo; Ikosi, Ketu, Mile 12, Ayedere, Maiden; Isheri, Olowora, Shangisha, Magodo phase 1 & 2; Agboyi-1; Agboyi-2; Owode-Onirin, Ajegunle and Odo-Ogun among others. For the purpose of this research, areas or communities along River Agboyi from Ikorodu road to where it entered Lagoon will be considered. Some of these communities are Alapere, Agboyi 1,2 and 3, Owode- Onirin and Oosogun.

Figure 1: Flood incidence in the study area
Source: (Micheal Oyinloye et al, 2013)

LITERATURE REVIEW

Literature is extensive on the application of GIS to flood monitoring and risk disaster management. Studies in this area have been conducted across regions and countries. In particular, GIS techniques have been applied in the analysis of flood related issues in the Sindh province, Pakistan (Haq et al, 2012), Cape Town, South Africa (Musungu et al, 2012), San Sebastián, Guatemala (Guarín et al, 2004), Central Viet Nam (Tran, 2009 and Tran et al, 2009), India (Gangwar, 2013) and Trinidad, West Indies (Ramlal and Baban, 2008) to mention a few. Across these studies, several factors have been identified as the main causes of flooding. These factors include indicate that flooding was caused by several such as uncontrolled development in floodplains, poor agricultural practices and clear cutting of vegetative cover, especially in areas of steep slopes. Moreover these studies variously identified potable flood risk zones as built-up areas within the metropolis with large areas of impervious surfaces, as well as those that are close to watercourses. (Crichton, 2002) identified several factors that contribute to the damaging potential of flood hazards. He reported that these factors depend on indicators such as flood depth, duration, velocity, impulse (product of water level and velocity) and the rate of the rise of water levels, warning time and the frequency of occurrence. Among these, flood depth is one of most important parameters used in the determination of flood risk indices.

In Nigeria, a number of studies exist on the application of GIS to flood monitoring and risk disaster management. (Ikusemoran et al 2014) focused on the application of remotely sensed data and GIS techniques for terrain analysis for flood disaster vulnerability assessment of Niger State. They created and classified Digital Elevation Modeling (DEM) of the State into four: Niger valley, plains, uplands and highlands area using ArcGIS 9.3 software. It was revealed that the Niger valley and the plain terrain of the state, which are classified as “highly vulnerable” and “vulnerable” respectively to flood disaster, collectively cover a land area of 58.43% of the state total land area. (Emeribeole 2015) discovered that dumpsites within the river channel, structural development within the floodplain as well as high amount of rainfall are the major causes of inundation in the

Imo State, Nigeria, which becomes especially pronounced in the wet season. He applied remote sensing and GIS to determine areas that are prone to flood disaster in the state while creating a database using both cartographic and attributes data collected from various sources. Similarly, (Awola et al 2008) focused on the application of Geographic Information System (GIS) in the assessment of flood risk and sensitivity for Uyo urban, Nigeria. Data for the study were obtained from field measurements and observation as well as archives of relevant agencies. The data includes GPS coordinates and base maps and rainfall. They observed that a greater portion of the landuse pattern of Uyo urban is residential mostly constructed across natural drainage routes resulting in serious erosion menace in the city particularly within the residential areas. Moreover, Ogba et al (2009) developed digital terrain model (DTM) for Calabar, Cross River State and observed that floodplains are highly liable to flooding, while areas that are poorly planned with no drainage facilities were found to be highly susceptible to flooding. Udo et al (2015) assessed the spatial variations in flood hazard levels, as well as the spatial and economic impact of the 2012 flood disaster using GIS and Remote Sensing Approach in flood management in Anambra State. They equally examined the population exposed to different levels of risk. These researchers observed that a total landed area of 1078Sq.kms was covered by flood excluding the original extent of the river while property worth of twenty three billion naira was damaged. It further revealed that area of land of 2106.78km2(43.40%), 55.392km2(19.68%), 835.054km2(17.20%), 555.48km2(11.44%), and 402.334km2(8.29%) are occupied by very high, high, moderate, low and no hazard categories while total number of population of 1814733(43.40%), 822953(19.68%), 719298(17.20%), 478486(11.44%), and 346561(8.29%) are residing at very high, high, moderately high, low, and no hazard zones. Isa Ibrahim et al (2015) only identified suitable sites for resettlement of flood disaster victims in Lokoja environs using Remote Sensing and GIS.

The review of literature clearly shows that GIS and remote sensing techniques have been deployed variously in analysis flooding, its effects and management in Nigeria. However, despite the growing interest in this area in the country, studies appear to be less aware of latest development in GIS application such as the use of ArcGIS 10.3 being one of the latest versions of ESRI and the application of Surfer 13.3 for terrain modeling to know the drainage pattern of area of concentration. Moreover, most of these studies could not assess the number of buildings at risk while failing to consider urban planning criteria in erecting buildings along river channel. In addition, despite the susceptibility and the various accounts of flooding in the South Western part of Nigeria, there appears to be limited study of the area. This study therefore contributes to the literature by focusing on areas of Agboyi river channel in Alapere areas of Ketu, one of the largest city in Lagos State where poor town planning and waste disposal habit is evident. In particular, the study applied one of the latest advancement in GIS technique, ArcGIS 10.3 and surfer 13.3(Golden Software product), to analyze the special case of Agboyi River, one of the major tributaries of Ogun River while considering urban planning criteria for erecting buildings along river channel.

METHODOLOGY

This study integrates GIS and other geospatial analytical tools such as surfer and TCX converter. To determine flood vulnerable areas along Agboyi River channel, buffering operation was carried out in accordance to the Nigerian urban planning standard criteria of 30 meters buildings away

from rivers channels. In addition to this, based on the previous flood extent experienced in the study area, buildings that are 50 meters away from Agboyi River were also considered. Overlay operation was performed to intersect all the vulnerable buildings with meter buffered along the river. The attributes data (household number and building type) of each of the vulnerable buildings were obtained through primary data (questionnaire). The coordinate of the study area were taken using TCX converter while these coordinates were integrated into Surfer 13.3 to show the Digital Terrain model (DTM) of the study area.

Data acquisition

Data acquisition is one of the basic subsystems in any GIS environment. The creation of database for all the vulnerable building involves the collection of both spatial and attributes data of the perceived entities within the city.

Data source

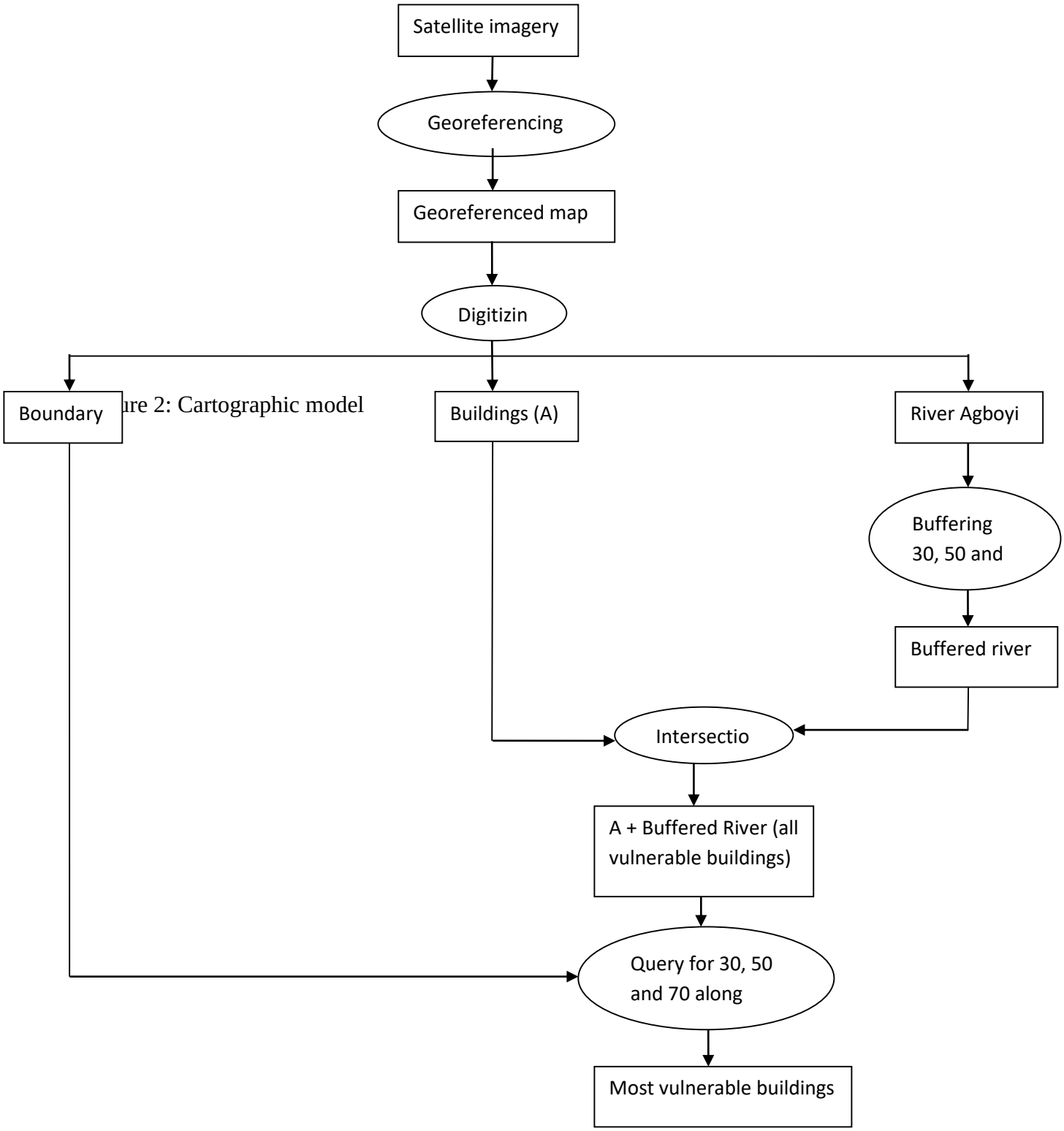
The data source for this project came from two sources which are primary and secondary sources

Primary source: This involves direct acquisition of locational data. The process carried out involved the collection of primary data, that is, attribute data of all the vulnerable buildings and length and extent of river Agboyi which are the main concerned entity of this research.

Secondary source: This involves acquisition of data through existing imagery and archives. The ikonos image of the study area was collected with 2m resolution were sourced for the year 2017. The coordinates used for Digital Terrain Modeling were obtained through TCX converter. Nigerian Bureau of Statistics (NBS) average number of household in Nigeria

CARTOGRAHY MODELING

It is the process of linking or organizing basic analysis operation in a logical sequence such that the output from one is the input to the next. In this research, the cartographic model reveals the step by step procedures of combination of declared data to derive areas and buildings prone to flood in the study area.



ure 2: Cartographic model

Criteria for the Buffer Operation

- Buildings must be at least 30meters away from the course of the river. Regional Planning (Building Plan) Regulation, 1986.
- Fifty meters (50m) away from the river. This criterion was based on the previous flood extent experienced in the study area.
- Seventy meters (70m) away from the river. This criterion was included in this study to give room for eventualities "what if flood extends beyond the previous extents". Which areas will be affected under such circumstances

Spatial Analyses

One of the important capabilities of GIS is its ability to carry out spatial analysis on real world data. Some of the analysis used in this research work includes buffering (creating zone of interest round a feature), overlay operation including intersection and spatial queries. However, these spatial analyses were carried out to analyze all the established criteria necessary to determine flood vulnerable areas. Multiple buffering was used to determine houses that fall within 30m (most vulnerable), 50m (vulnerable) and 70m(less vulnerable) along Agboyi River as shown in the figure below. This multiple buffering therefore produced houses that are all vulnerable to flood in the study area.

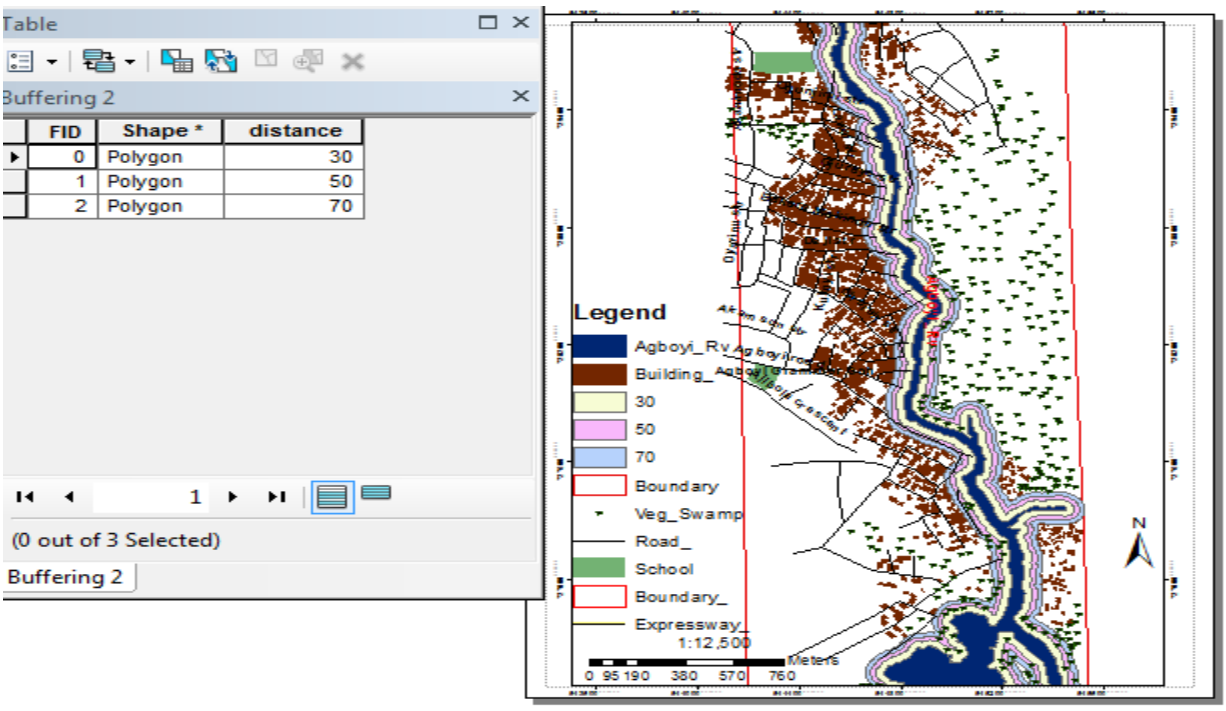


Figure 3: Multiple buffering of 30, 50 and 70meters along the river

Spatial search

This is one of analytical operations carried out on the attribute table of entities. Database queries are achieved through a query expression built to precisely define what to be selected. Building a

query expression is a powerful way to select feature. Expressions include single criterion queries and calculations. After all buffering and overlay operations have been done to structure the vulnerable buildings, the operation queried the database to select the most vulnerable buildings in the study area.

Double criterions

(a) Selection of all buildings 70meters along river Agboyi. Input expression(from all vulnerable buildings WHERE "distance" >50 and <=70)

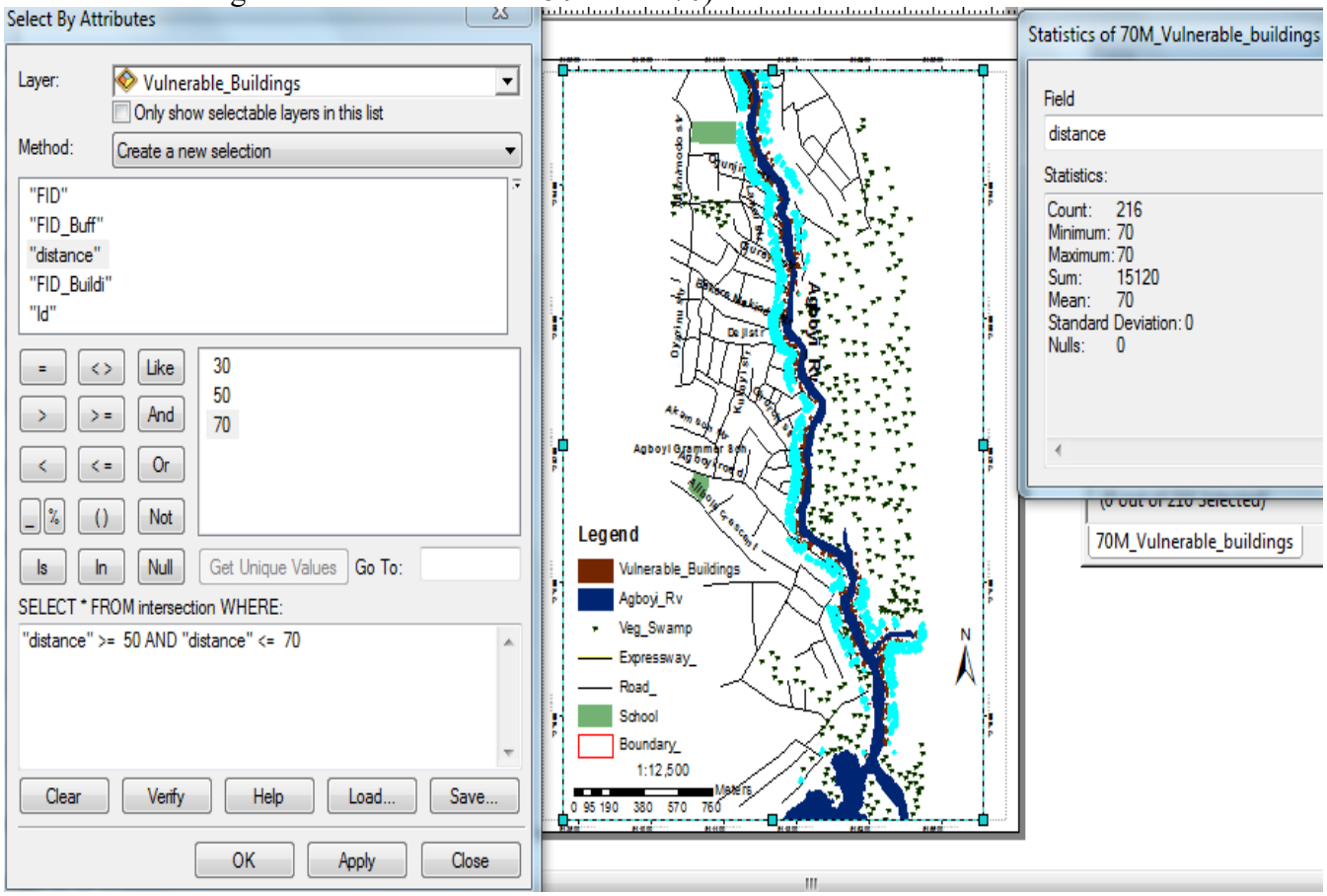


Figure 4: Query and expressions of single criteria for the entire 50m to 70M vulnerable buildings along Agboyi River

From the above fig 4, the spatial query shows 216 buildings between 50m to 70m along Agboyi river channel are going to be affected. The average number of household as estimated by Nigerian Bureau of Statistics which is 5, this however shows that estimated 1080 households are going to be affected

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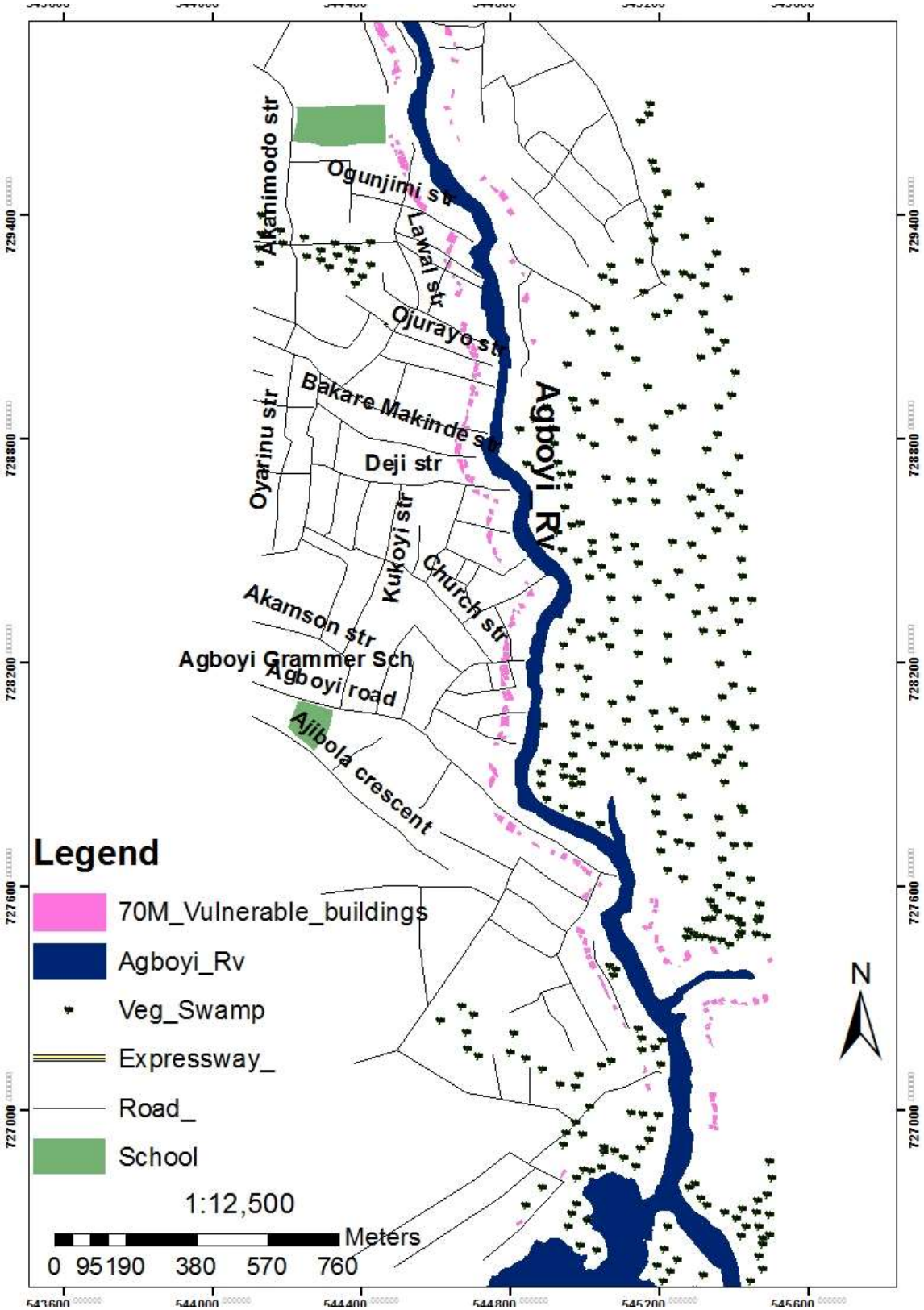

Figure 5: Map of 50m to 70meters vulnerable buildings along the river

(b) Selection of all the buildings 50meters along Agboyi River. Input expression(from all vulnerable buildings WHERE "distance" >30 and <=50)

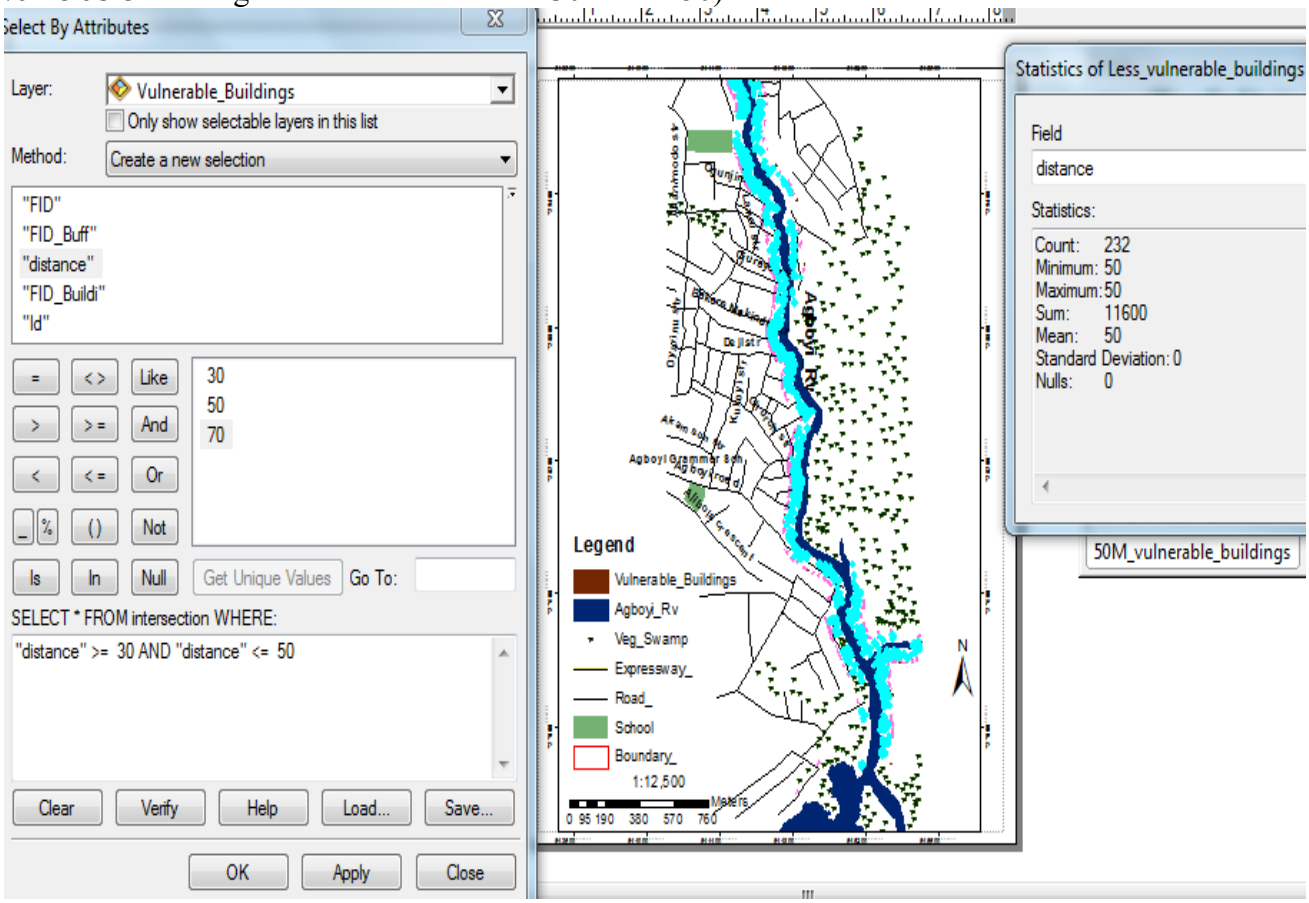

Figure 6: Query and expressions of single criteria for the entire 50M buildings along Agboyi River

From the above Fig 6, the spatial query shows 232 buildings between 30m to 50m along Agboyi river channel are going to be affected. The average number of household as given by Nigerian Bureau of Statistics which is 5, this however shows the estimated number of 1080 households are going to be affected

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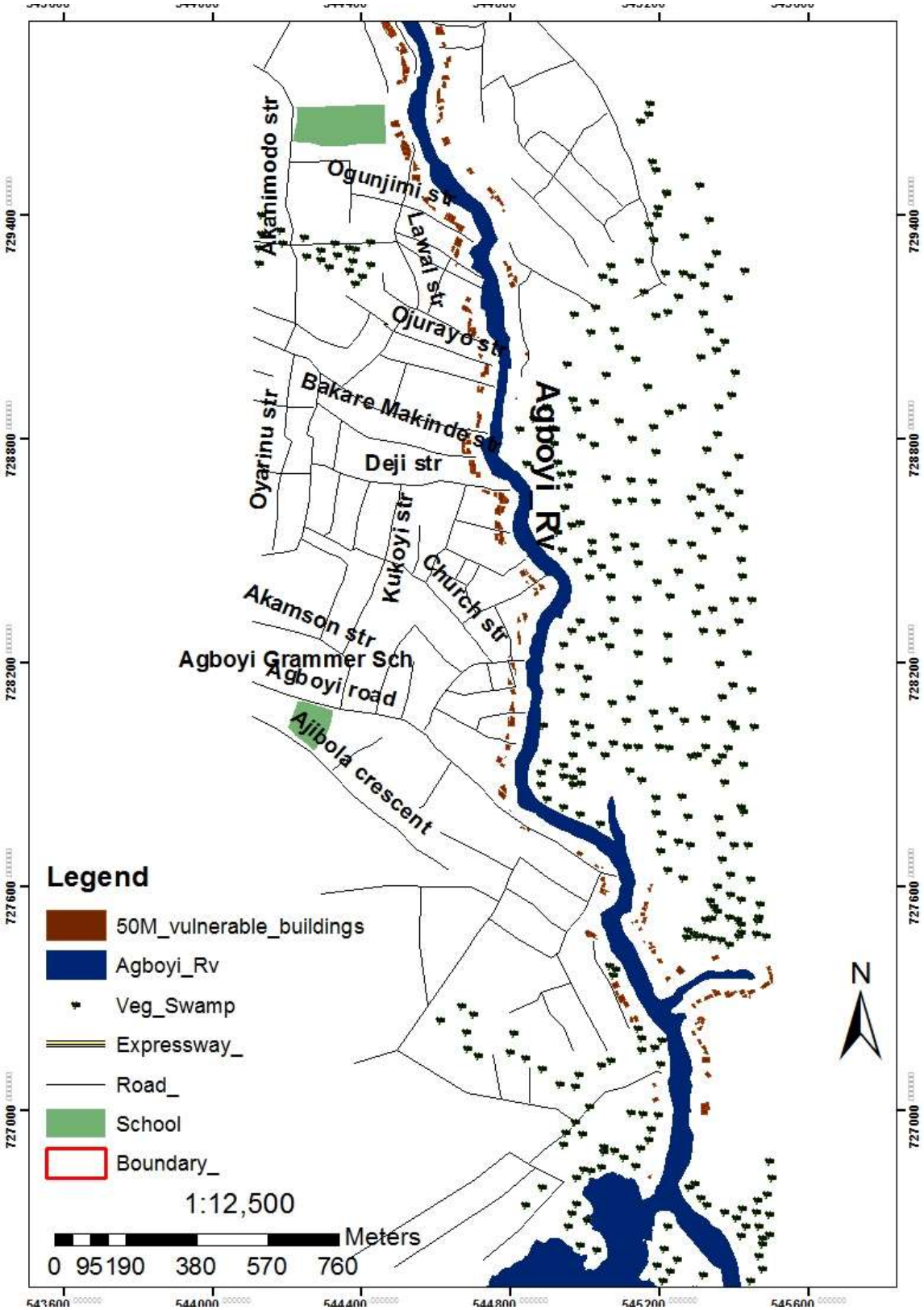

Figure 7: Map of 50meters venerable buildings along the river

(c) Selection of all the buildings 50meters along Agboyi River. Input expression(from all vulnerable buildings WHERE "distance" >30)

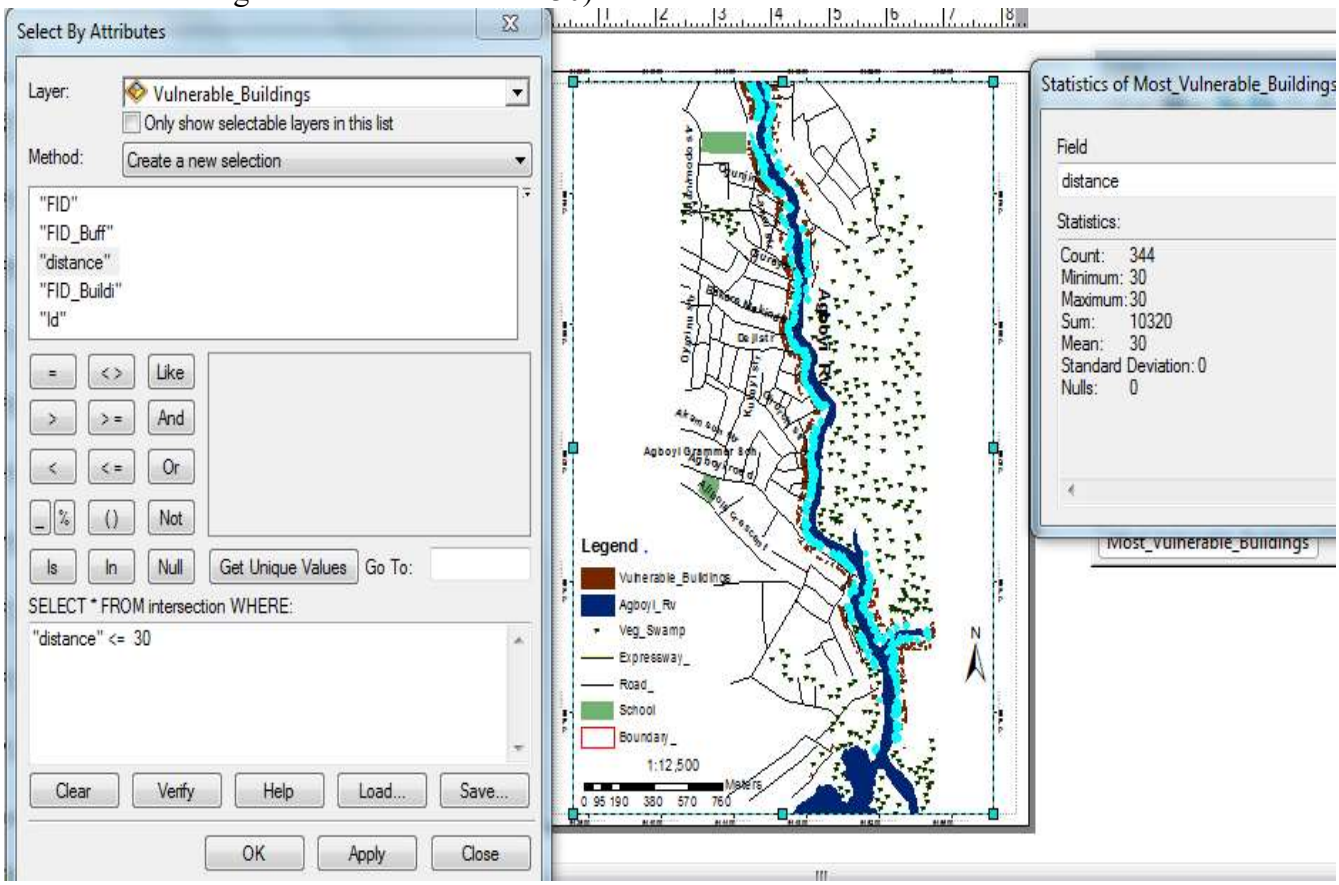

Figure 8: Query and expressions of single criteria for the entire buildings less than 30m (most vulnerable buildings) along Agboyi River

The above spatial query shows 344 buildings are less than 30m away from Agboyi river channel and are most vulnerable to flood. With the given average number of household, the estimated number of 1080 will be affected the by flood.

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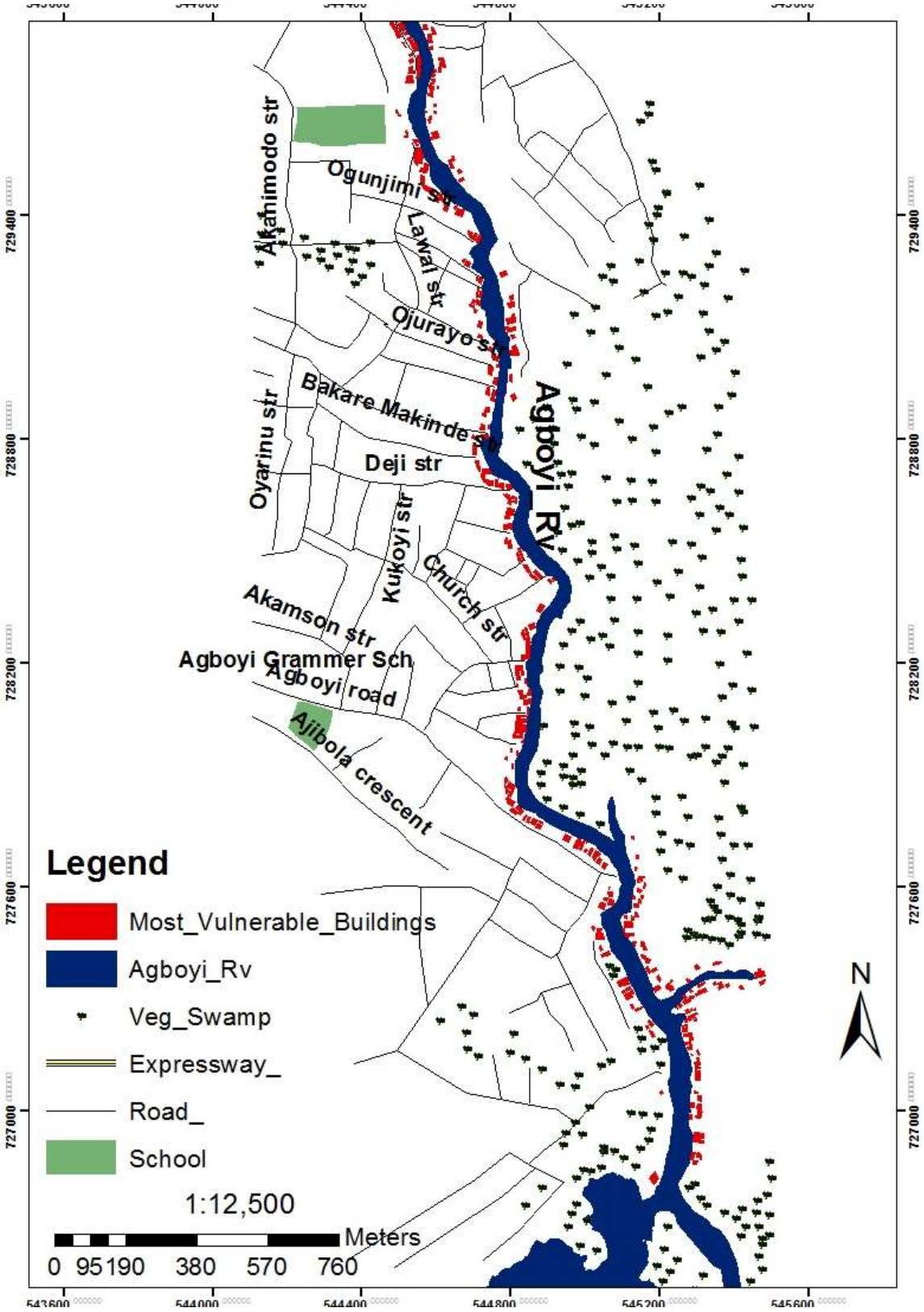

Figure 9: Map of buildings less than 30meters (most venerable buildings) along the river channel

DISCUSSION OF FINDINGS

As hazardous areas are low-lying areas and closer to the rivers channel, it can be deduced that the magnitude of the flood hazard of a given area is a function of both the distance to the river and the elevation of the area in question. This research shows 1,007 buildings are prone and vulnerable to flood along the river channel and going by the average number of household in Nigeria given by the Nigerian Bureau of Statistics (NBS) which is 5, the estimated 5,035 number of household are prone to flood risk disaster. 344 buildings are 30m close to the river channel while some are even within the river basin and these are most vulnerable to flood base on the standard criteria of Regional Planning (Building Plan) Regulation of 1986 which is still active till date while estimated 1720 number of household are highly prone to flood risk disaster. Between 30m to 50m along the river channel, 232 buildings are going to be affected, these are also vulnerable but not the most vulnerable compare to the buildings less than 30m from river channel, by this, the total numbers of 1,160 households are prone to flood risk disaster. For eventuality, 216 number of buildings between 50m to 70m away from the river channel and are considered less vulnerable building, thus, 1,080 number of household are prone to flood disaster but less compare to the first two (30m and 50m) as shown in the table below.

Areas	**Number of vulnerable buildings**	**Average No of Household**	**Number of household**
Most vulnerable(30m)	344	5	1720
Vulnerable(50m)	232	5	1,160
Less vulnerable(70m)	216	5	1080
Total	883		3,960

Table 2: Number of vulnerable building and number of household
Source: Author

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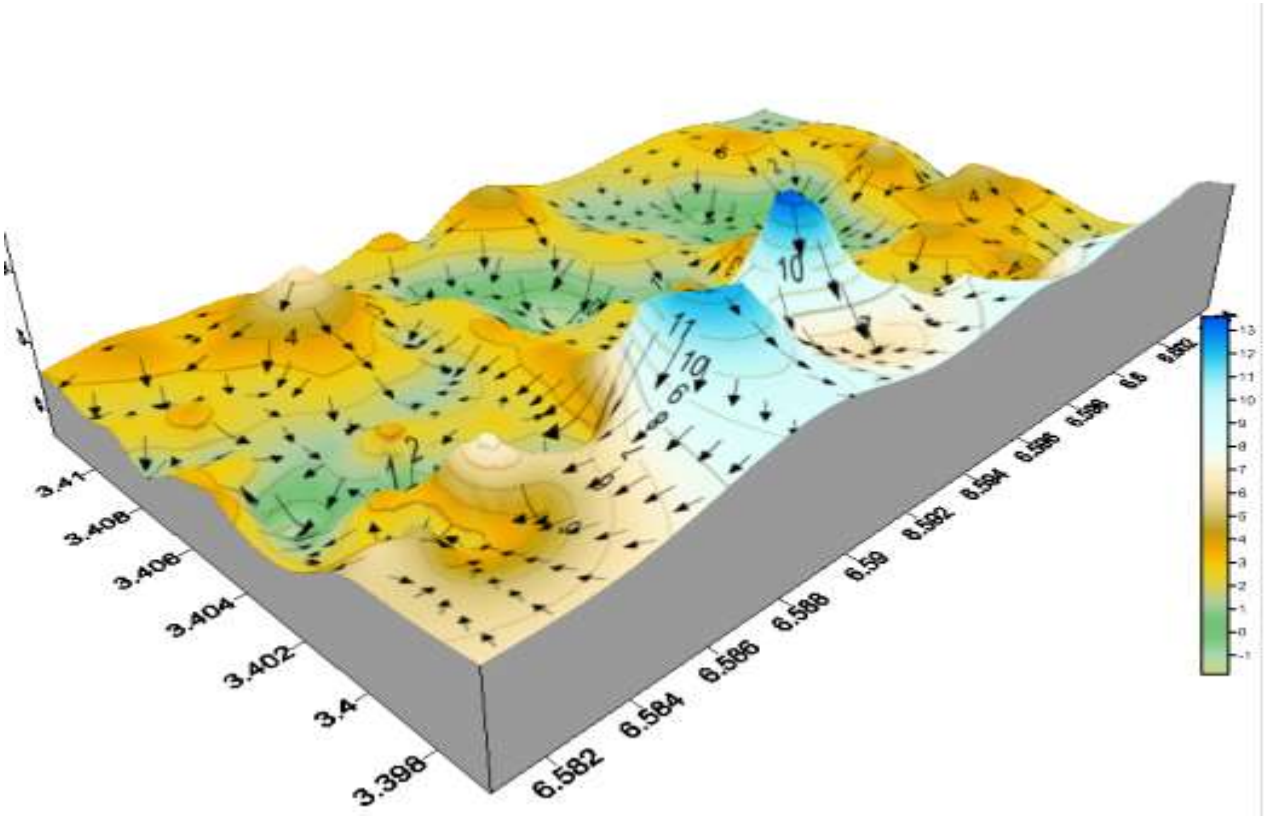

Figure 1: Digital Terrain Modeling (DTM) of the study area

This terrain modeling shows that the highest elevation of the study is is 13 meters above the sea level and the minimum is 1meter. The other side of the river which is occupied by vegetation has higher elevation than the residential areas, thus, this terrain modeling ascertain the fact that distance to river channel is not only factor causing flood hazard but elevation of the area in question. Agboyi River will find it difficult to escape from flood hazard

SUMMARY, RECOMMENDATION AND CONCLUSION

Summary

This study accessed the flood vulnerable buildings along Agboyi River, Kosofe LGA; Lagos State. This study was therefore used as a Spatial Decision Support System (SDSS) which is an aid to support decision making. Data set for the study included spatial and non-spatial data. Imagery of the study area was downloaded via the Google Earth pro, geo-referenced and digitize in ArcGIS 10.3 from the various analyses. The various features were represented by symbols, well-structured database was created through proper design and construction faces using ArcGIS 10.3 for the implementation of the data analysis, queries were issued and buffering was done in respect to criteria of urban planning. The data generated was analyzed through ArcGIS 10.3 software and the buffering of Agboyi River was overlaid to know buildings that are most vulnerable to flood disaster. The buffered distance was used to classify the area into most vulnerable (30m buffer), vulnerable (50m buffer) and less vulnerable (70m buffer). Based on planning regulations,

buildings must be at least 30 meters away from the river bank. The DTM of the study area was also used to show the drainage pattern and terrain of the study area and these shows there is no way buildings that are 30 meters along the river channel can escape from flood.

Recommendation

It is expected of the government to strictly enforce all relevant laws and planning that prohibit erection of structures along the flood plain. Development can be permitted in areas beyond 50 meters but quality building materials and embankments that can withstand the impact of flooding must be used. Indiscriminate dumping of waste in drainages and river banks should be checked with penalty to violators of such policy. And all drainages that lead to the main river should be cleared and opened up before the onset of raining season.

CONCLUSION

Flood is an inevitable occurrence but it could be prevented and reduced through effective management and mitigation measures and giving sufficient information to residence and prospective developers. Geographic Information System is embedded with analytical capacity which can be used as a decision support system for prevention/mitigation, preparedness, response, recovery and also planning for operational activities; immediately before, during (taking initiative to evacuate people to save places) and after flood (reconstruction activities). This spatial analytical capacity is utilized for this study. To reduce the impact of flooding, adherence to appropriate building plan along Agboyi River channel and dredging is recommended.

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