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FLOOD RISK ASSESSMENT OF TRADEMORE ESTATE AND ITS ENVIRONS IN THE FEDERAL CAPITAL TERRITORY ABUJA, NIGERIA

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ABSTRACT

Flood is a common disaster affecting the liveshood and properties of humans. It has a history of causing great damage to infrastructure, disrupt transportation activities and land. It is therefore prudent that such natural hazard is addressed in a way to reduce the impact it causes on people and the environment. This research aimed at carrying out Flood risk assessment of Trademore Estate and its environs by analyzing the effect of changes in Land use land cover (LULC), susceptibility of the area to flood and evaluate the potential impact of increase in the level of runoff water on the infrastructure. This study employed multidisciplinary approach combining Remote Sensing, Geographical Information System (GIS) and ground Surveying method. The results of this study show a significant change in land use land cover between 2014 and 2024 by 41.82% increase in built up area, 13.44% decrease in vegetation, 3.16% decrease in water, 8.16 % increase in bare land and 32.97% decrease in farmland. Using the weight sum analysis, the impact level is categorized into high, moderate, low and least impact; the extent covered by each category are: 8.07 km^2 (19.2%) for high impact, 10.16 km^2 (24.2%) for moderate, 12.73 km^2 (30.3%) for low and 11 km^2 (26.2%) for least impact. Trademore Estate and its environs occupies a total area of 41.96km^2 and the flood susceptibility analyses shows that Highly susceptible area occupies 2.15km^2, susceptible area occupies 28.50km^2, less susceptible area occupies 11.29km^2 and least susceptible occupies 0.02km^2. There are total of 3712 houses within the existing estate in the study area captured from the satellite image, the flood risk assessment shows that 366 houses has a highly vulnerable impact of 5m rise in water level, 387 houses occupy moderately vulnerable area and 3000 houses occupies least vulnerable areas. The study is a necessary input for mitigating flood hazards in the study area and will serve a good purpose in decisions making for the Government, urban planners and policy makers by emphasizing the need for stakeholder's investment in building flood resilient infrastructure, make regulations to prevent new development in flood prone area and provide shelter centers within to safeguard people during flooding.

Keywords: *Flood risk assessment, Remote Sensing, LULC, GIS, Urbanization.*

1.0 Introduction

Water is one of Earth's most precious natural resources. Without it, there would be no life on the Planet. The overflowing of water onto land that is normally dry [5] has adversely affected the environment in recent times. Flooding is one of the natural hazards in the world [10]. Flooding results when there is runoff of river and stream inflow makes a stream channel full to capacity, filling the storm channel and spilling over. Also, when there is low infiltration capacity and poor drainage, rise in hydrological water table above the surface results to flooding, sometimes this happens due to collapse of dams and when there is heavy rainfall [6].

Increased population, climate variability, change in the catchment and channel management, modified land use and land cover, and natural change of flood plains and river channels all lead to changes in flood dynamics with direct or indirect consequence on the social welfare of humans [2].

The need to reduce the effects of flood hazards or disaster becomes very imperative because it is difficult to control basic atmospheric processes which produce floods. The first step attempt by man in the process of flood disaster reduction is to identify the factors responsible for flood in any flood prone areas.

Consequently, there has been unprecedented occurrence of floods and its associated negativities in most of the urban centers of developing countries [4]. For instance, in Nigeria, reports have shown that devastating flood disaster had occurred in Ibadan (1985, 1987, 1990, and 2011), Osogbo (1992, 1996, 2002, and 2010), Yobe (2000), Akure (1996, 2000, 2002, 2004 and 2006) and the coastal cities of Lagos, Ogun, Port Harcourt, Calabar, Uyo, Warri among others [8].

The temporal and spatial pattern of floods is attributed to several factors of Global change which includes Changes in Land Use/Land Cover and encroachment of developments to flood prone areas. The incursion into such areas have being progressive until now because of unprecedented urbanization and industrialization which has undoubtedly resulted into large scale massive deforestation, loss of surface vegetation and farmlands.

According to Oyebande [9] water will always find its way if not well channelized. Its choice route often poses problems to man by tampering with his physical environment, health and products of agriculture, urbanization and industrialization. This has created a lot of social and economic cost on the environment and the citizenry. Few among these social and economic impacts on the environment are: outbreak of health diseases, infrastructure failure, mental health effects, building and collapse, destruction of agricultural farmland and products.

Flood has been a major problem in Nigeria caused by a heavy downpour of rain displacing residents with severe occurrences notable for states along River Niger and Benue. One way to understand flood displacement is to check the source of the occurrence.

The occurrence of flood in Trademore Estate and its environs in the Federal Capital Territory in 2023 is one of the most recent severe flood disasters in the Federal Capital Territory (FCT). There are no records of flood disaster reported in the Federal Capital Territory before 2012, which indicates that flooding in the area can be attributed to the influx of people into Federal Capital Territory (FCT) which led to the emergence of various human activities in the area in recent time. Likewise, most of the Estate in Federal Capital Territory (FCT) are characterized by uncontrolled development, inadequate setback from flood plain, provision and construction of substandard infrastructure such as bridges, covert and poor planning process and administration, weak urban governance, poor land use structure resulting to slum.

The flood that occurred in Trade More Estate and its environs in the Federal Capital Territory (FCT) in 2023 is a flash flood that normally occurs in a low land area and is caused as a result of heavy down pour or excessive rainfall. The intensity and the occurrence of flash flooding can be determined by the intensity and the distribution of the rainfall, the nature of the topography, land use and soil type within the environment.

There are many contributing factors that lead to these flooding and among these are the following: "long-term changes of land-use and land cover structure, drainage system, shortening of the river network and the modifications of streams and floodplains". The truth of the matter is, if the gutters, waterways, conduits, underground channels and shoulder culverts are well designed, constructed according to the approved designed by Department of Development Control and managed there would be fewer flash floods within the Estate and its environs.

The flood that occurred in Trademore Estate and its environs in the Federal Capital Territory (FCT) has been reported as a major and devastating problem affecting the social-economy activities of the residents of the Estate. Its effects are very severe to virtually all forms of man's activities and its impact is also reflected on the rate at which the occupants of the buildings within the Estate moved out and the numbers of houses abandon within the Flood plain zone. Thus, if adequate attention in terms of preventive measures are not put in place towards controlling its periodic occurrence and its associated impacts particularly during rainy season, its incidence can turn a developed Estate back into a developing Estate. Hence there is need to examine the phenomenon and proffer solution in order to forestall further damages to properties and loss of lives to flooding in the Estate and its environs.

Due to existence yearly flooding's within the Estate and its environs for a decade, this research aimed at carrying out the flood risk assessment of the buildings and infrastructure within Trademore Estate and its environs.

2.0 The Study Area

The history of the Federal Capital Territory (FCT) dates back to the early 1970s when the Nigerian government decided to move the Country's Capital from Lagos to a more central location. This decision was aimed at promoting national unity, reducing disparities between the regions, and ensuring the equitable distribution of the Country's resources.

The Federal Capital Territory is located in North Central Region of Nigeria and Abuja as the Capital City was formed in 1976 from parts of old Kaduna, Kwara, Niger, and Plateau states, with the bulk of land mass carved out of Niger state. The study area is a sub-catchment of river Usuma situated within Longitude 7°21'00"E to 7°27'00"E and Latitude 8°55'30"N to 9°0'00"N covering an area of 42.18km^2.

It is located in Abuja Municipal Area Council (AMAC) Federal Capital Territory, Abuja. It falls within Savanah ecological zone of Nigeria. The climate is characterized by rainy season which usually occurs in April with full commencement of rainy season in May and stopping in October of each year and the dry season that starts from November and end in March. The region records its highest temperature and greatest diurnal ranges during the dry season months. The temperature throughout the year ranges from 26˚C to 36˚C and an annual rainfall of about 1469mm (57.8 inch of precipitation).

Elevation of the study area ranges from 339.5 m to 526m marked by undulating terrain with highest elevation in the Eastern part and lowest elevation in the Western part.

The rock formations and geological materials present in the territory have some characteristics that variously influence the nature of the local soils. This explains the predominance of sandy soils with

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characteristic stoniness (Balogun, 2001). Ojigi added that the FCT is predominantly of a thin soil structure therefore its basin hydrology has high runoff potential. The texture of FCT soil is generally sandy with smaller occurrences of loam ([7].

The vegetation of the immediate environment and most part of the area is savannah. The vegetation is made of species such as micro-carpom which are trees while the grass species that are locally dominated are and ropen gayanus, pseudaprius, loudetia arundinacea [1].

Flash floods are generally believed to be typically of the savannah environment their occurrences are said to be mainly due to the torrential nature of the rainfall as well as high run-offs, which lead to low infiltration capacity and consequently run-offs begin immediately after the start of rainfall [3].

Farming is one of the major occupations of the people, providing income and employment for over 30% of the population. They are mainly farmers who engage in food, cash crop production and animal husbandry.

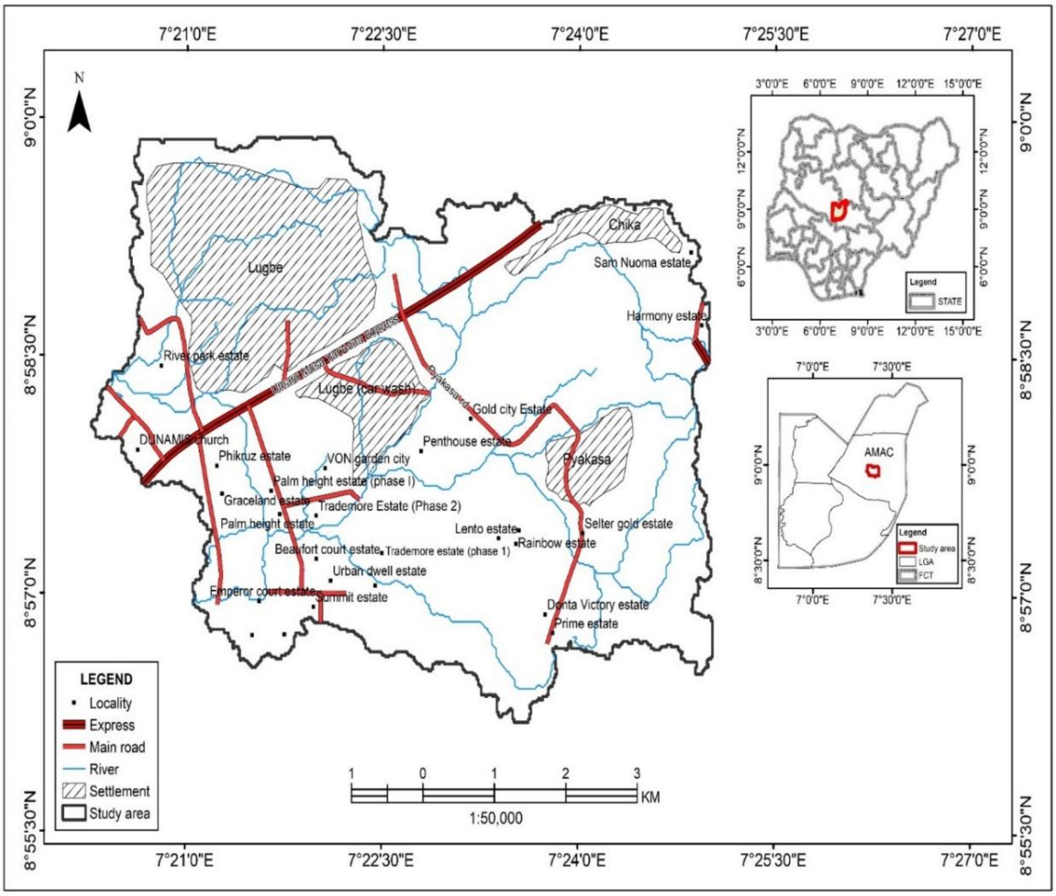

Figure 1: Map of the Study Area (Source: Department of Surveying and Mapping, FCDA).

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3.0 Materials and methods

The data and materials used for this research were gathered from two sources, namely primary and secondary. The primary data collected were the coordinates of the infrastructure (buildings, communication masks, powerline health facilities ect.) within the study area. The secondary data obtained were the FCT administrative map containing Lugbe District, USGS satellite images covering the study area, Digital elevation model (DEM) and annual precipitation data. The information on the adopted data and their attributes are presented in Table 1.

Table 1: The Adopted Data and their Attributes

Data	Source	Resolution	Purpose
Digital Elevation Model (DEM)	http://asterweb.jpl.nasa.gov/gdem.asp	1 arc second	To execute terrain & hydrological analysis e.g. watershed, Drainage network, river density, TWI, Slope.
Landsat 8 OLI satellite imagery (2014 & 2024)	https://earthexplorer.usgs.gov/.	30m and 15m (panchromatic)	Production of Land Use Land Cover (LULC) Map of the study area.
Annual Precipitation data	https://chrsdata.eng.uci.edu/		To acquire the annual rainfall of six years
Shapefile of Nigeria administrative. Map	FCDA		To produce location map which stand as overview/Inset map of the study area.

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Coordinates & name of infrastructures	Field observation		To know spatial distribution of infrastructures within the study area

Landsat 8 OLI Satellite imagery with path/row 189/054 of 5/1/2014 and 17/1/2024 was downloaded from the USGS web site. The imagery is ortho-rectified and georeferenced in UTM Zone 32N (WGS84), The study area was clipped out from the Administrative map of FCT which shows the extent of the study area, the existing villages, estates and other infrastructure. Supervised classification with maximum likelihood algorithm was used to classified the composite imagery into thematic classes (built-up, water, vegetation, bareland and farmland) using Envi 5.3 image processing software which was also used to carry out change detection analysis and generate the change statistics in figure 32.1 and 303. The classified imageries were subsequently exported into Arcmap 10.4 software to prepare the Land use Land cover maps. The Digital Elevation model (DEM) was used to perform the terrain analysis which include: watershed analysis, drainage network, drainage density, topographic wetness index (TWI), distance to river and slope. Appropriate Landsat bands were used to calculate the different indices used for the research and apply them to obtain the index-based algorithms. The output of these algorithms in a raster format was used to analysis the land use land cover changes, susceptibility of the study area to flooding and the potential impact of 5m water level increase on the infrastructure in the study area.

4.0 Results and Discussion

This section presents analysis and database modelling of the data collected for the project. The result is presented in maps, charts and tables to ensure they are comprehensive, understanding and visually accessible.

4.1 Change in land use and land cover in the study are from 2014 to 2024.

Land use land cover of year 2014 was classified into five thematic classes consist of built-up covering 7.67 km^2 (18.17%), Vegetation covering 5.66 km^2 (13.42%), Water covering 5.59 km^2 (13.26%), bare land covering 10.31 km^2 (24.44%) and farmland covering 12.95 km^2 (30.71%) while year 2024 consist of built-up covering 17.41km^2 (41.28%), Vegetation covering 2.53km^2 (6%), Water covering

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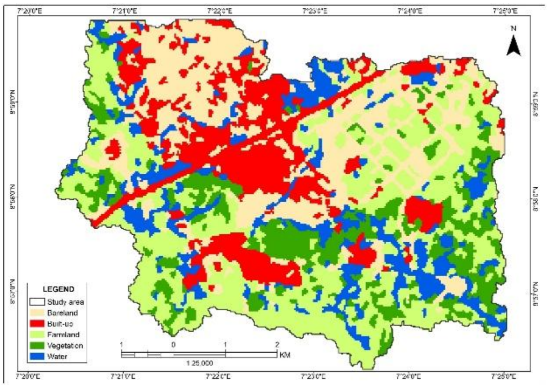
4.75km^2 (11.27%), bare land covering 12.21km^2 (28.95%) and farmland covering 5.27km^2 (12.50%). The changes in land use land cover between year 2014 and 2024 show 41.82% increase in built-up area, 13.44% decrease in vegetation, 3.61% decrease in water, 8.16% increase in bareland and 32.97% decrease in farmland. Table 2 shows the statistics of changes in land use and land cover between year 2014 and 2024.

Table 2: Land use Land Cover changes between 2014 and 2024

	2014 LULC		**2024 LULC**			
CLASS NAME	**AREA**	**PERCENTAGE**	**AREA**	**PERCENTAGE**	**CHANGE IN AREA**	**% CHANGE**
BUILT-UP	7.67	18.17	17.41	41.28	9.74	41.82
VEGETATION	5.66	13.42	2.53	6.00	-3.13	-13.44
WATER	5.59	13.26	4.75	11.27	-0.84	-3.61
BARELAND	10.31	24.44	12.21	28.95	1.90	8.16
FARMLAND	12.95	30.71	5.27	12.50	-7.68	-32.97



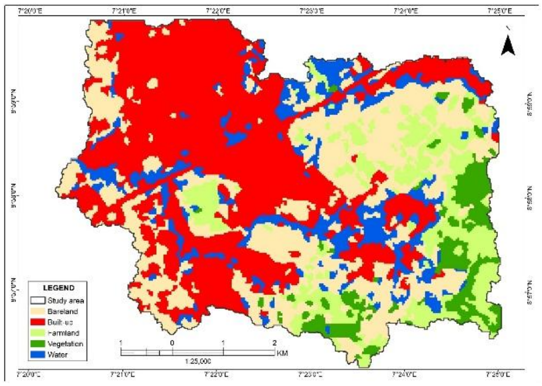


Figure 4.1: 2014 Land Use Land Cover Map Figure 4.2:2024 Land Use Land Cover map

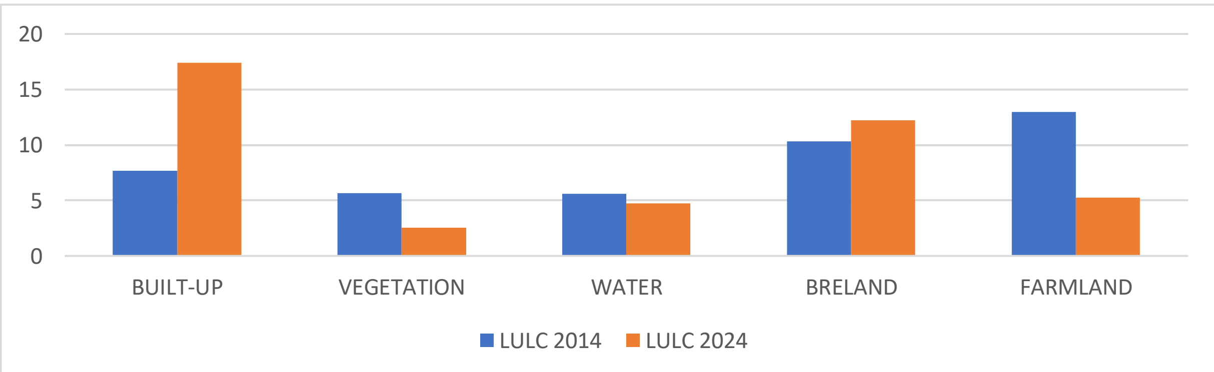


Figure 4.3: Land use land cover chart of Trademore Estate and surrounding area between year 2014 and 2024.

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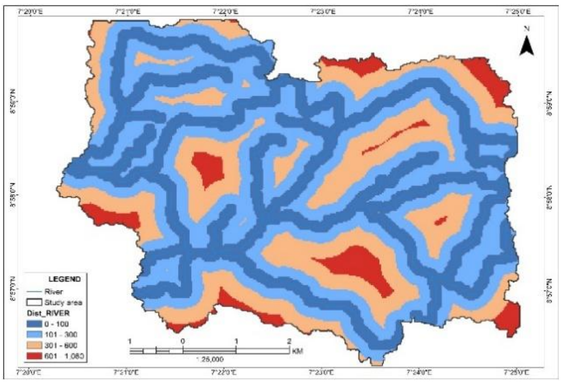
4.2 Susceptibility of the study area to flooding

Criteria weight computed with AHP using rating scale in the order of distance to river > topography > rainfall > land cover >TWI > river density as shown in the computation in table 3.

Table 3: Computation of criteria weight with AHP technique

CRITERIA	RAINFALL	LULC	D_DENSITY	D_RIVER	TWI	TOPO	CRITERIA WEIGHT
RAINFALL	1	2	3	0.33	3	0.25	0.15
LULC	0.5	1	4	0.5	4	0.25	0.14
D_DENSITY	0.33	0.25	1	0.25	0.5	0.33	0.05
D_RIVER	3	2	4	1	3	2	0.31
TWI	0.33	0.25	2	0.33	1	0.33	0.07
TOPO	4	4	3	0.5	3	1	0.28

Results of spatial analysis of the criteria weight to determine the flood susceptibility are shown in Figure 4.4 to 4.8



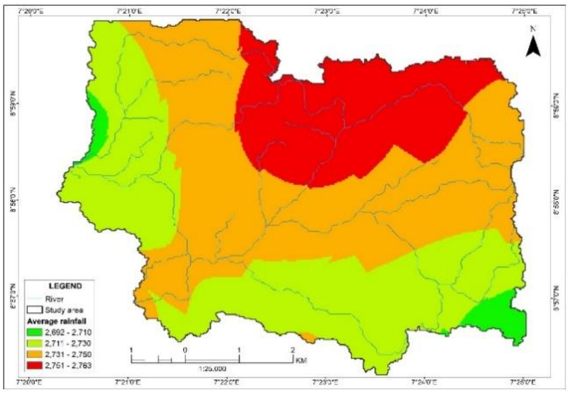
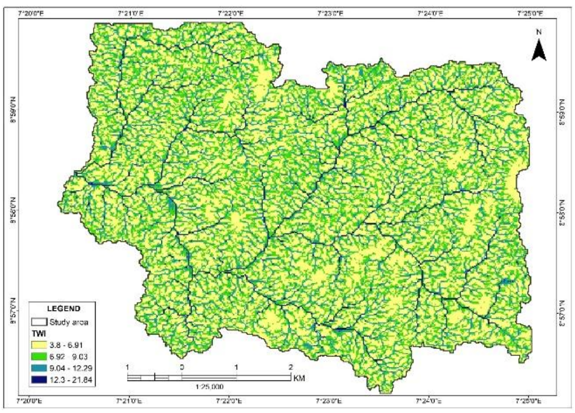


Figure 4.4: Distance to river analysis

Figure 4.5: Average annual rainfall



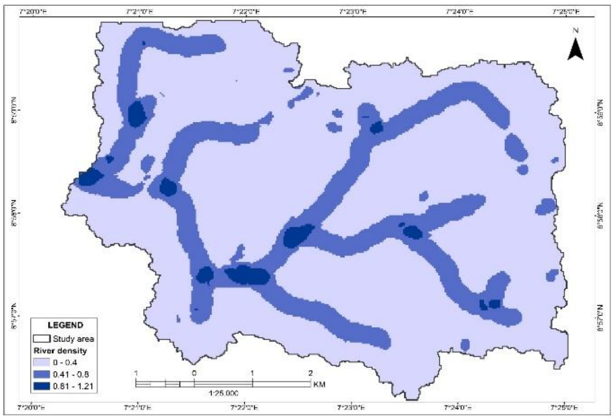


Figure 4.6: TWI analysis

Figure 4.7: River density map

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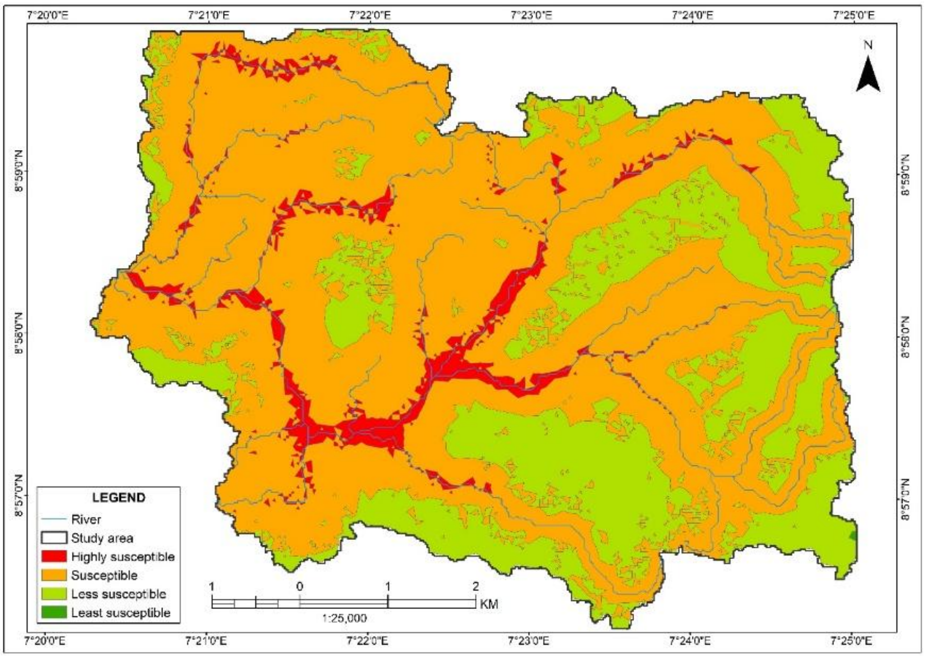

Figure 4.8: Flood susceptibility map

Table 4: Extent of flood susceptibility level in the study area

SUSCEPTIBILITY	AREA COVERED IN (KM^2)	PERCENTAGE
HIGHLY SUSCEPTIBLE	2.15	5.125
SUSCEPTIBLE	28.50	67.945
LESS SUSCEPTIBLE	11.29	26.916
LEAST SUSCEPTIBLE	0.006	0.014
SUM	**41.946**	**100**

4.3 Potential impact of a 5m water level increase on infrastructure in the study area

This is a means of forecasting and evaluating areas and basic infrastructure that will suffer effect of flooding at 5m increase in water/flood level. Following the weighted sum analysis where the impact level is categorized into High, Moderate, Low, and Least impact; the extent covered by each category are: 8.07 km^2 (19.2%) for high impact, 10.16 km^2 (24.2%) for moderate, 12.73 km^2 (30.3%) for low and 11 km^2 (26.2%) for least impact, as indicated in table 4.5. Total number of 90 prominent infrastructure were acquired from field observation consisting of 35 housing estates, 2 Churches, 3 Fuel stations, 2 Hospitality facility, 2 Health facility, 1 market, 5 Communication mast, 1 Mosque, 4

Government office, 4 Schools, 1 Corner shop and 30 Powerline poles. Spatial distribution of the impact level with overlay of the infrastructure is shown in figure 4.9.

Table 5: Percentage coverage of Flood risk areas.

IMPACT LEVEL	AREA (Km^2)	PERCENTAGE	NAMES OF ESTATE
HIGH IMPACT	8.07	19.232602	Trademore estate, Parkline estate, Aiben Trafford estate and Clobek Crown estate.
MODERATE IMPACT	10.16	24.213537	Lugbe Village 1
LOW IMPACT	12.73	30.338418	
LEAST IMPACT	11	26.215443	

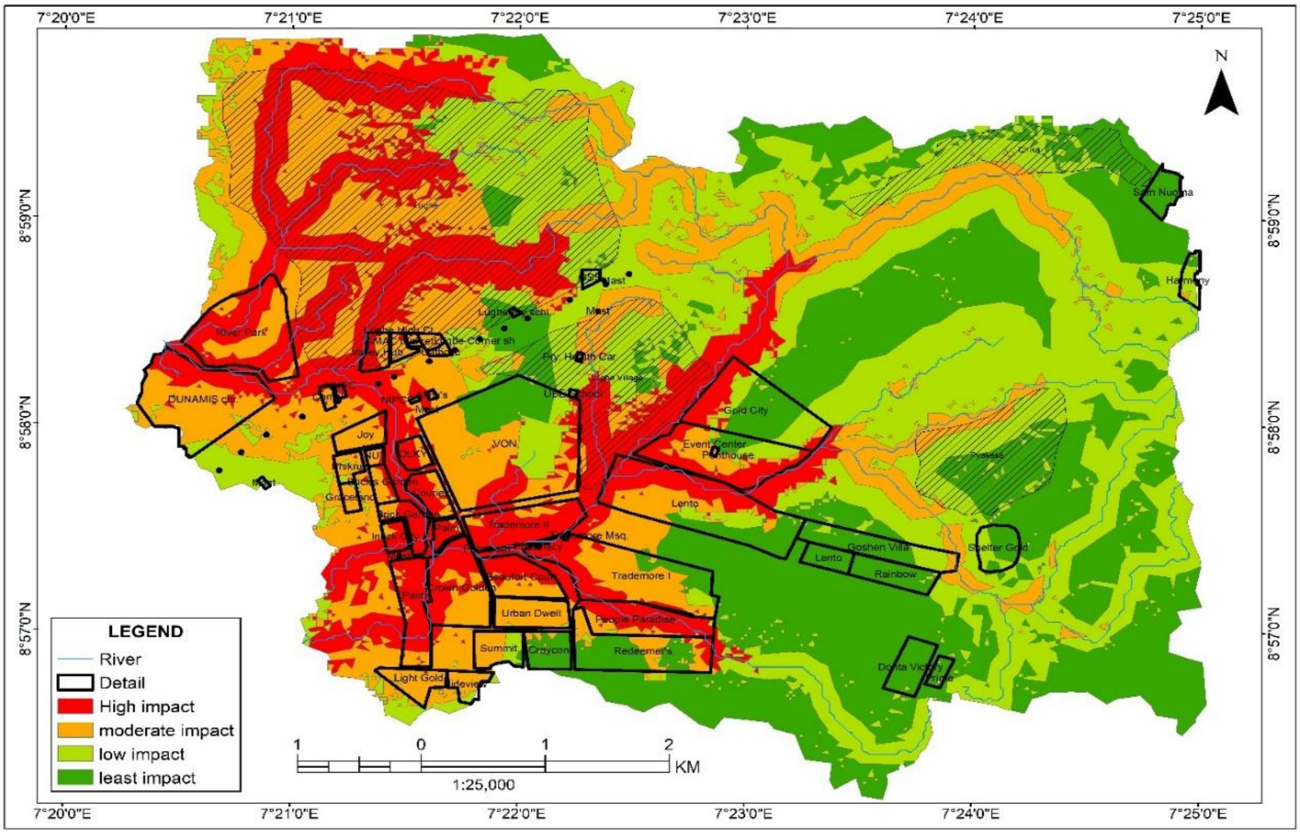

Figure 4.9: Potential impact of 5m water level increase

5.0 Conclusion and recommendations

Flood is one of the agents of serious destruction of properties, infrastructure, transportation systems within a location. Flooding is an environmental problem caused by different factors which can pose devastating effect on the environment and human. This requires insight into the susceptible areas and possible impact with elevated flood levels to plan towards remedial action and take informed decision to mitigate the impact. Changes in Land Use Land Cover between year 2014 and 2024 indicated significant increase in Built up and Bareland by 41.82% and 8.16% while Farmland, Vegetation, and water decreased by 32.97, 13.44% and 3.61%. This change implies alteration in the land cover which can be a contributing factor to flood occurrence and its exacerbation in the study area. The flood susceptibility of the study area classified into highly susceptible, susceptible, less susceptible and least susceptible area covers an extent of 2.15Km2, 28.5 Km^2, 11.29 Km^2 and 0.006 Km^2. Level of impact at 5m increase in water level on infrastructure revealed high impact, moderate impact, low impact and least impact area covering an extent of 8.07 Km^2, 10.16 Km^2, 12.73 Km^2 and 11 Km^2 respectively. The flood Susceptibility is expected to have different rate of devastation on infrastructure of the study area which include housing estate, Government office, communication mast, fuel station, market and power line pole. This study therefore provides relevant geospatial information for pre-disaster planning and policy formulation that will provide crucial support for appropriate management of flood event. Therefore, it is recommended that the Government should invest in building flood-resilient infrastructure that can withstand the effect of flooding and also provide shelter centers to safeguard people from helpless situation which is an integral part of disaster risk reduction (DDR).

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