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Assessment of Schistosomiasis Risk Zone in Abuja Using Geospatial Technique

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Abstract

Alterations in the physical parameters of the environment are mostly responsible for the rapid proliferation of disease vectors and micro-organisms and the abundance of such diseases as schistosomiasis. Environmental factors such as distance to water body, rainfall, temperature, DEM, slope, land use land cover and NDVI were used geospatially (Multicriteria analysis) to model schistosomiasis risk zones in Abuja. The results signify that 40% of the total area covered in Abuja falls within high and very high risk zones. The villages covered 88.76% while sub urban and town have 10.65%, 0.59% respectively. The findings documented large area of schistosomiasis risk zone which threaten WHO schistosomiasis elimination target but can still be achieved by proper health education to change the behaviour of populations at risk and encourage communities to improve sanitation and infrastructure in order to reduce contact with surface water.

Subject Areas

Epidemiology

Keywords

Assessment, Schistosomiasis, Risk Zone, Geospatial, Technique and Abuja

1. Introduction

Schistosomiasis, also known as bilharzia, is one of the most important neglected tropical diseases (NTDs) in sub-Saharan Africa [1] [2]. This parasitic disease is caused by water-borne trematode worms (blood flukes) of the genus Schistosoma, the developmental cycle of which requires infection of specific aqueous Snails of the genera; Biomphlaria, Bulinus, and Oncomelania serving as intermediate host and playing a vital role in the transmission of the disease [3]. More than 206 million people across 78 countries are currently affected, with approximately 24,000 deaths and 2.5 million disability-adjusted life years recorded annually [4]. Schistosomiasis is endemic in 78 countries, with more than 90% of people infected with the disease living in Africa [4]. Within several national health systems, there is a focus on disease control and elimination through schistosomiasis control programs [5]. The WHO has set new targets for NTD control and elimination for 2021-2030 with schistosomiasis being planned for elimination by 2030. The pillars for meeting these targets are country-specific, however, strategies for control are focused on a mix of policies including Water, Sanitation and Health education (WASH) activities, preventative chemotherapy in form of Mass Drug Administration (MDA), environmental control and disease surveillance [6] [7]. With three fourths of emerging infectious diseases being of zoonotic origin, understanding the dynamics of vector and disease spread in human and animal populations can be accomplished only by a One Health approach that leverages multiple disciplines [8]. These measures alone appear insufficient for schistosomiasis elimination since many countries are yet to eliminate the disease hence the use of space in assessing the risk area for this disease to assist in control strategy [9]. Remote sensing data provide real-time information about the dynamic processes of the surrounding ecosystem and air-pollution trends, as well as help track and forecast vector-borne disease outbreaks [10].

In Abuja, the capital city of Nigeria, several factors such as rivers and lakes, irrigation systems, poor sanitation and waste management, stagnant water bodies, urban development and construction contribute to the presence and proliferation of schistosomiasis vectors and their habitats [11]. In view of the above, the thrust of this study is to apply geospatial technology in mapping out schistosomiasis risk zones over Abuja with a view to determining the degree of vulnerability of the study area and reducing schistosomiasis incidence through appropriate medical intervention.

2. Materials and Method

2.1. Study Area

The Federal Capital Territory Act of 1976 gave Nigeria's capital, Abuja, legal status. It is situated in the Federal Capital Territory (FCT) of Nigeria. The City proper has a total land size of 250 square kilometers, whereas the Federal Capital Territory has a land area of 8000 square kilometers. The FCT is surrounded by

Kaduna State to the north, Niger State to the west, Plateau State to the east and southeast, and Kogi State to the southwest. It is located between 7˚25'N and 9˚20'N of the equator, and between 5˚45'E and 7˚39'E of the meridian. Abuja was primarily constructed in the 1980s and is a planned metropolis [12]. On December 12, 1991, it was formally proclaimed as Nigeria's capital, taking the place of the former capital, Lagos. The Federal Capital Territory's population is estimated at 778,567 people [13]. In the south of Abuja, dense tropical rain forests may be found, while Savannah grasslands can be found in the city's northern and central regions. The Nigerian capital is fortunate to have both a temperate climate all year long and rich agricultural land. (**Figure 1**)

2.2. Data Source

The study utilized secondary data which include high resolution satellite images as shown in **Table 1**.

Table 1. Data and their source.

S/N	Data	Format	Resolution	Source
1	Administrative boundary	Shape file		OSGOF
2	Landsat 9 TIRS	Geo TIFF	30 m × 30 m	Earth explorer USGS
3	STRM DEM	Geo TIFF	30 m × 30 m	Earth explorer USGS
4	Rainfall data	Geo TIFF	0.24 km × 0.24 km	CHRS DATA
5	Communities, stream lines	Shape file		OSGOF

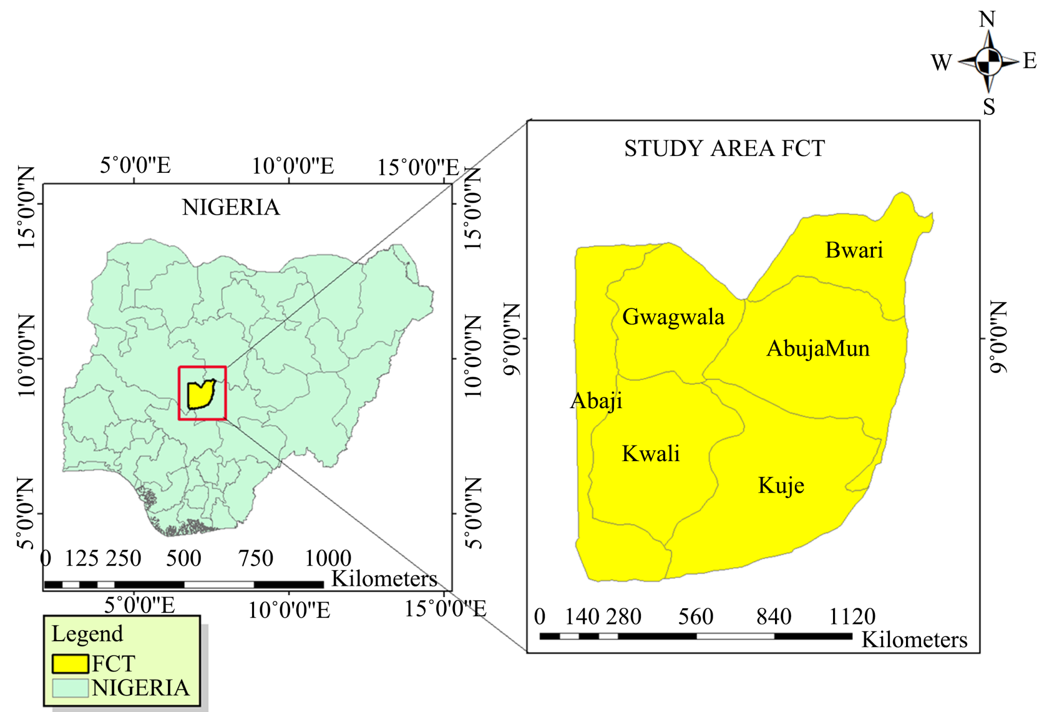


Figure 1. Study area map.

2.3. Data Analysis

Multicriteria analysis was used to evaluate and compare the various factors to make informed decisions. This method was useful in decision-making which involves complex, multi-dimensional factors. The map of selected environmental factors such as topographic factors (elevation, slope and water body), vegetation index and climatic factors (temperature and rainfall) was developed, such that, weight was assigned to each factors as seen in Pair wise comparison matrix table (Table 1) map of each of these environmental factors was also derived through the Spatial Analyst extension of the ArcGIS 10.3. Thus, the factors were overlaid to generate schistosomiasis risk map.

2.4. Flow Chart Showing Methodology

Environmental factors (LST, DEM, LULC, NDVI, Water body and Rainfall) were reclassified using ArcGIS software and a multicriteria analysis was done based on factors hierarchy and assigned weighted. (Figure 2)

3. Results and Discussion

The euclidean distance from the water bodies is depicted in Figure 3. It is a widely used statistic in spatial analysis and is crucial for comprehending how human populations and water bodies interact in this study.

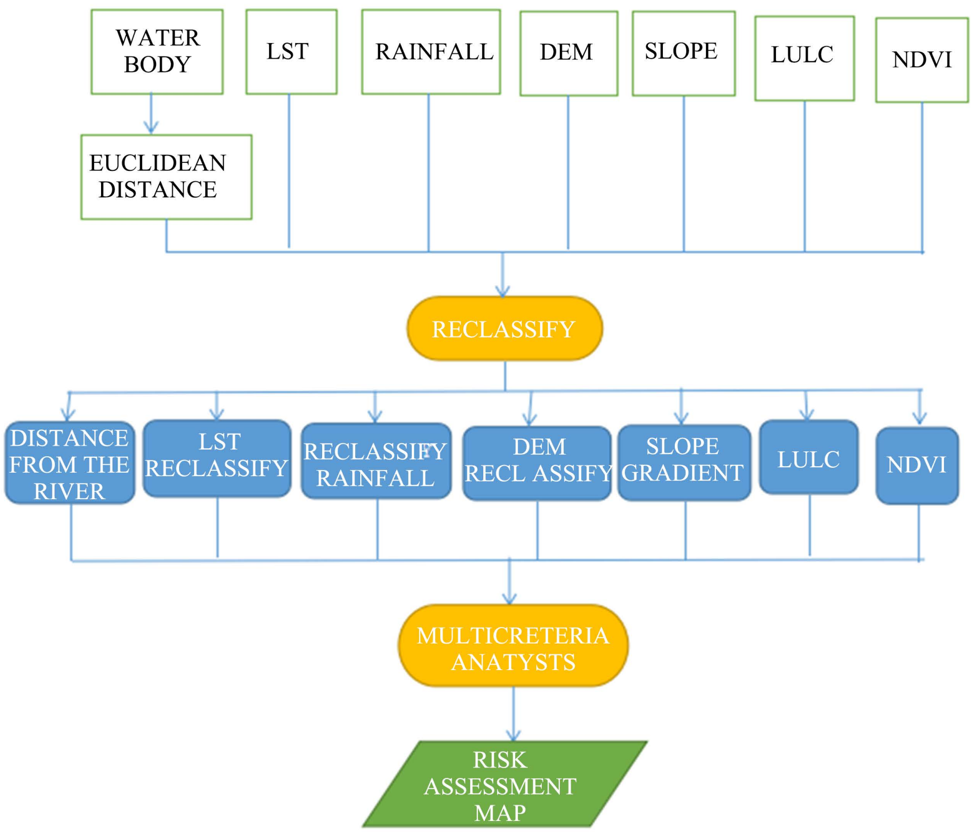


Figure 2. Flow chart of research method.

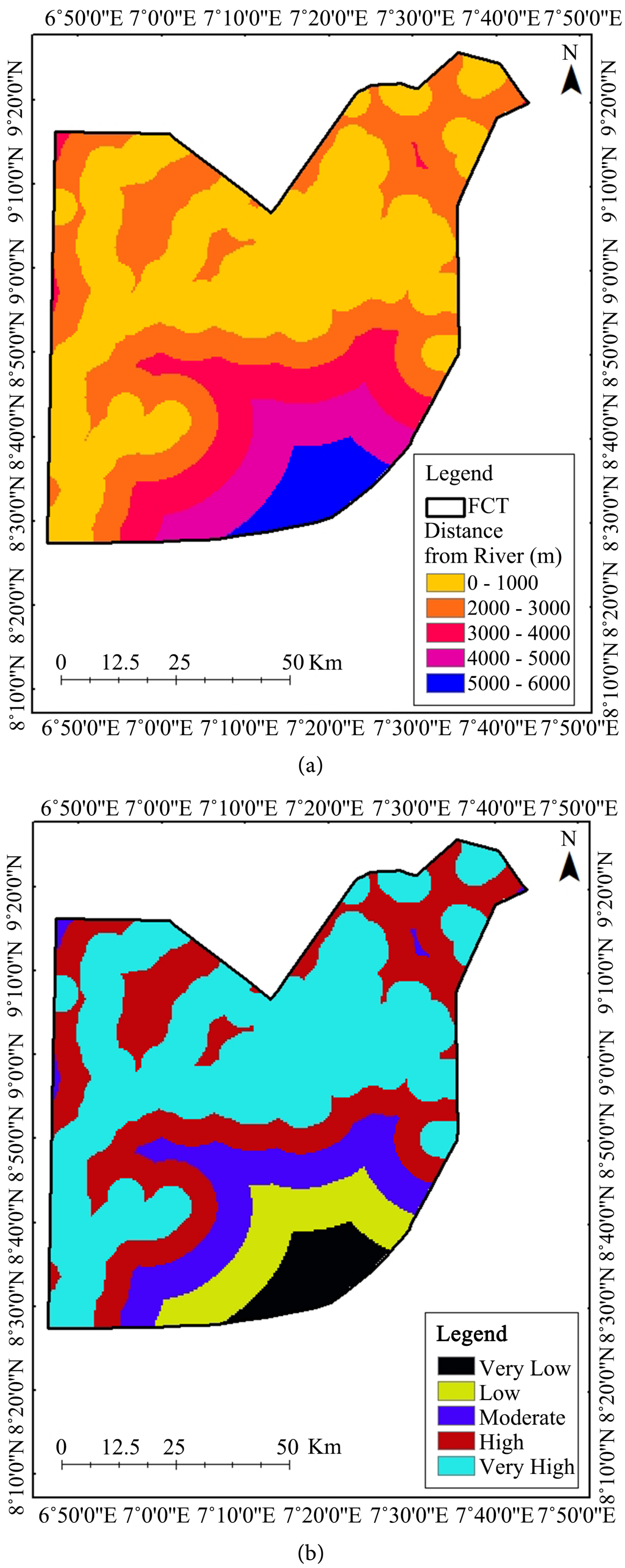


Figure 3. (a): Euclidean distance from water; (b): Reclassify euclidean distance from water.

3.1. Land Surface Temperature (LST)

The Land Surface Temperature (LST) in Abuja showed considerable differences between the various types of land cover, with built-up regions showing higher temperatures than vegetated areas. The city also has a significant heat effect, with LST in urban areas being higher than in neighboring rural areas as shown in **Figure 4**. Land cover features, such as the proportion of built-up areas and vegetation, are significant factors influencing the intensity of the urban heat impact in Abuja. This agrees with the works of [14] [15].

3.2. Rain Fall

With two separate rainy seasons—the primary rainy season (April to July) and the secondary rainy season (September to October)—Abuja has a bimodal rainfall pattern. The majority of the yearly precipitation fell during the main rainy season, which featured frequent torrential downpours and significant rainfall intensities. Significant variations in rainfall patterns may be seen throughout the city in **Figure 5** below. This study confirmed the findings of [16] [17] [18] by identifying a north-south gradient in rainfall distribution, with higher amounts of rainfall observed in the southern regions of Abuja.

3.3. Digital Elevation Model (DEM)

The DEM data was gotten from Global DEM datasets; the Shuttle Radar Topography Mission (SRTM) and utilized in combination with other geospatial datasets to perform slope analysis. The results in **Figure 6** shows very high elevation towards the eastern part of Abuja with reduction as you move to the west in agreement with [19] [20].

3.4. Slope

The assessment of slope in Abuja relies on the availability of Digital Elevation Model (DEM) data, which represents the elevation of the terrain at discrete points and provide the necessary information to calculate slope values accurately. The research utilized DEM data to derive slope values and model schistosomiasis risk area of the region. (**Figure 7**)

3.5. Land Use Land Cover (LULC)

The land use and land cover of Abuja have undergone significant changes over the years due to rapid urbanization and development. The result here assists in identifying settlement close to water bodies which are vulnerable to schistosomiasis due to water body contact. (**Figure 8**)

3.6. Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is a commonly used remote sensing tool to assess the health and abundance of vegetation in an area. NDVI is calculated using satellite imagery, and it provides valuable information about

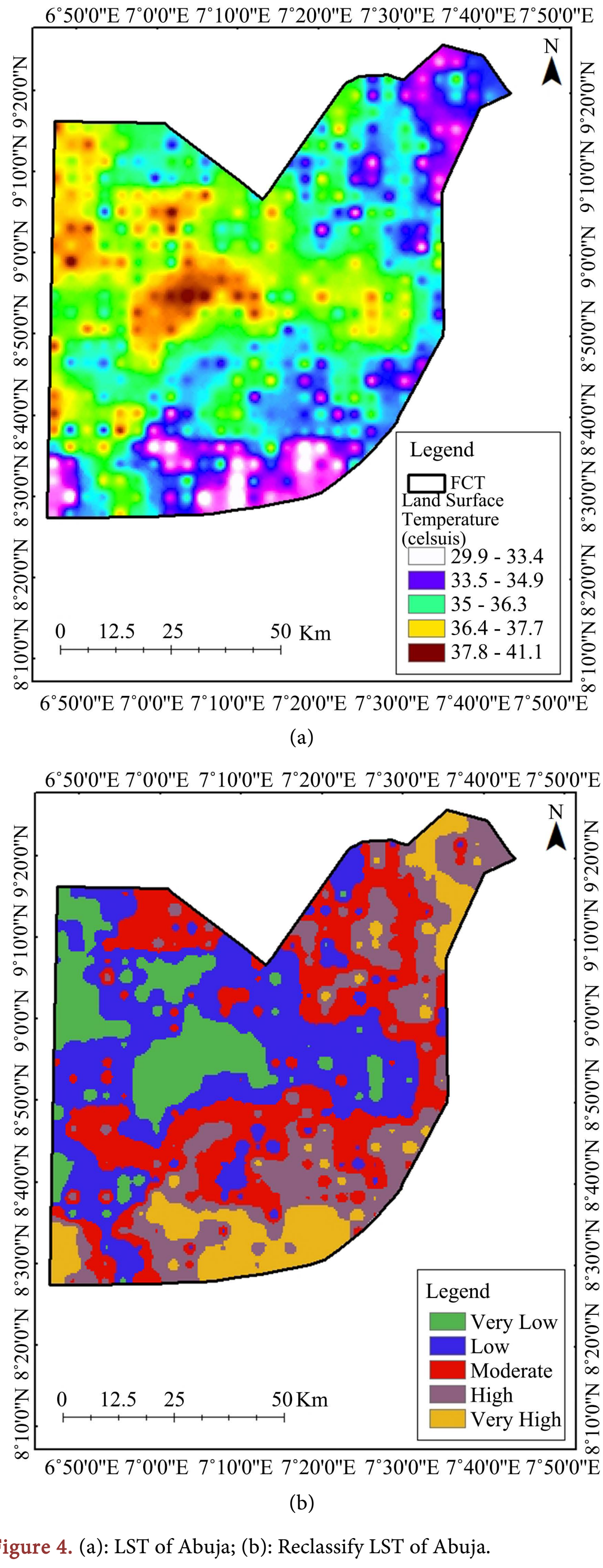
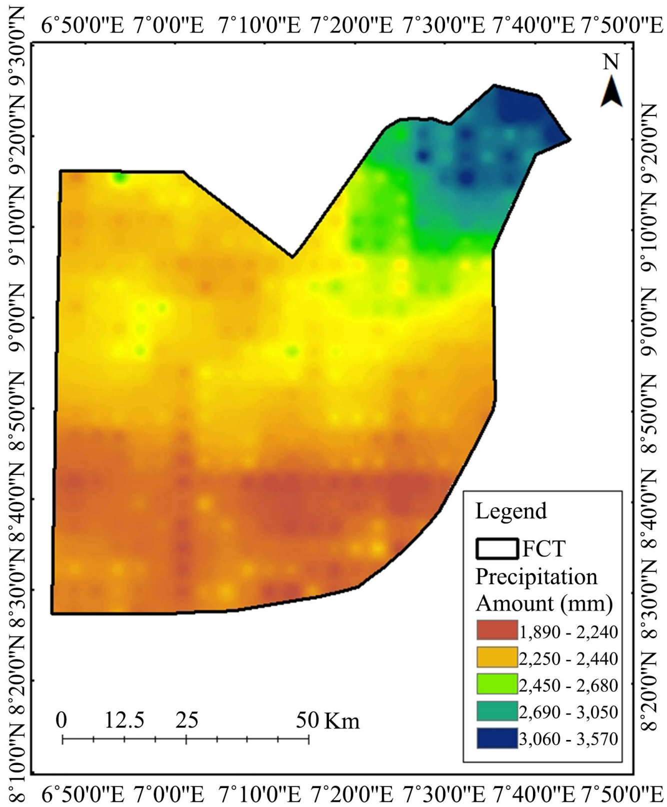
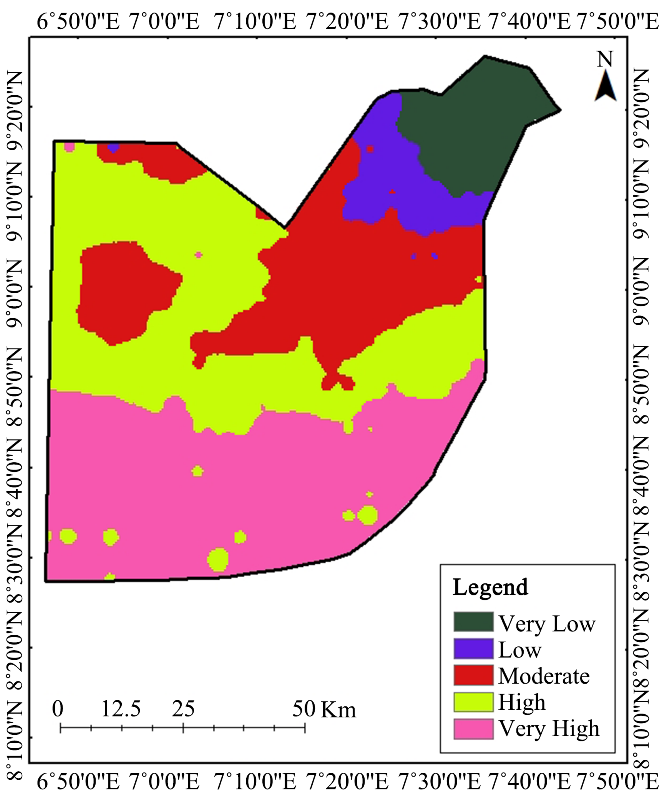


Figure 4. (a): LST of Abuja; (b): Reclassify LST of Abuja.



(a)



(b)

Figure 5. (a): Abuja precipitation; (b): Reclassify precipitation.

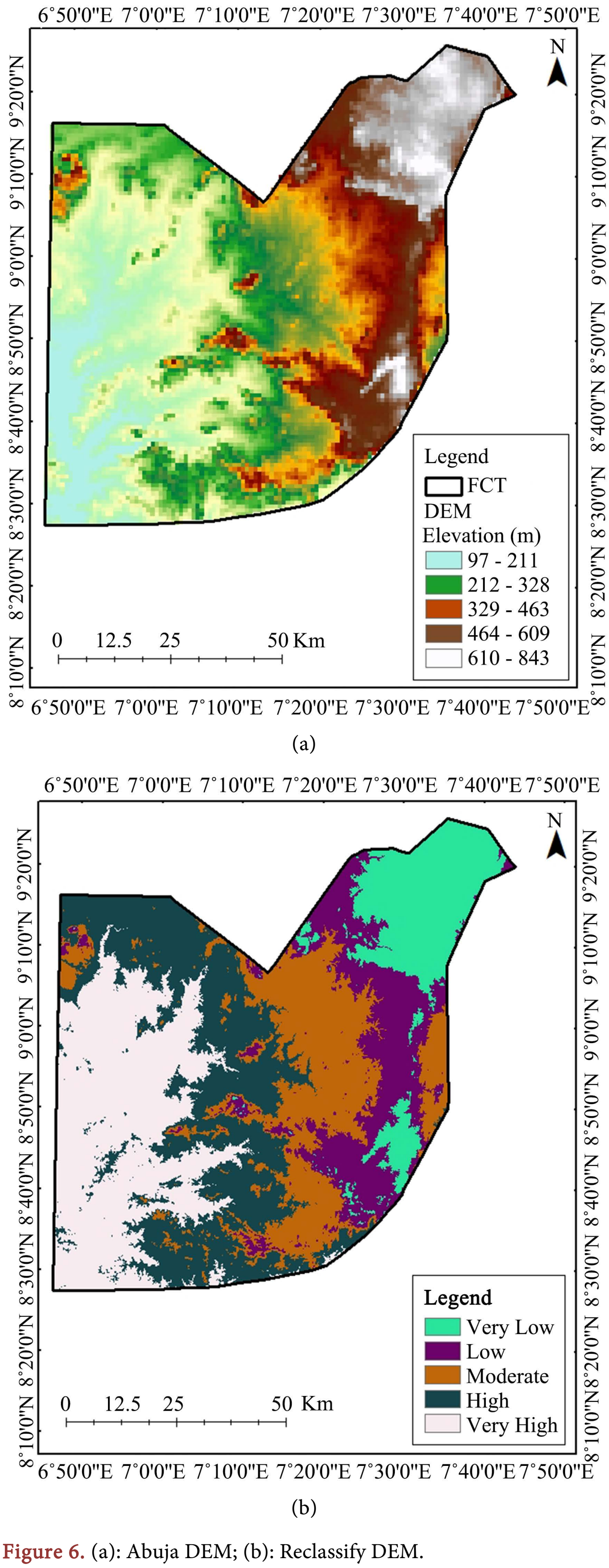
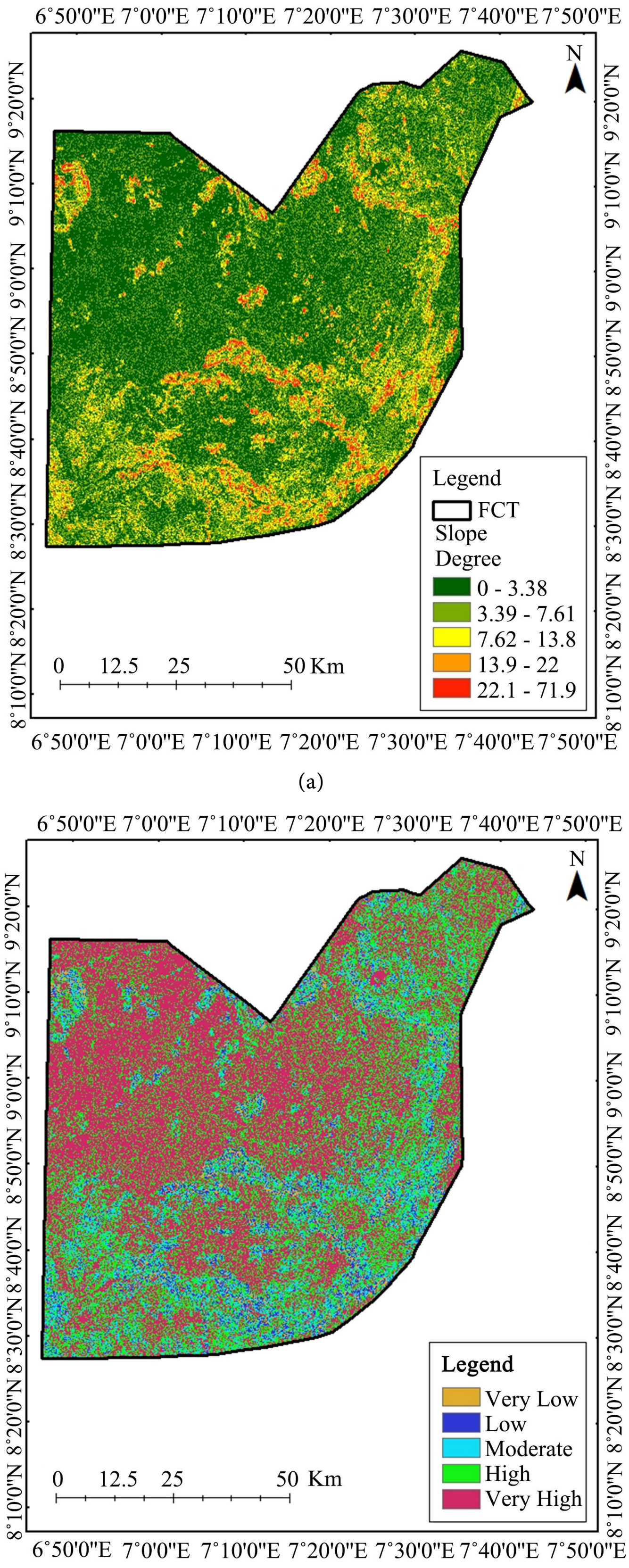


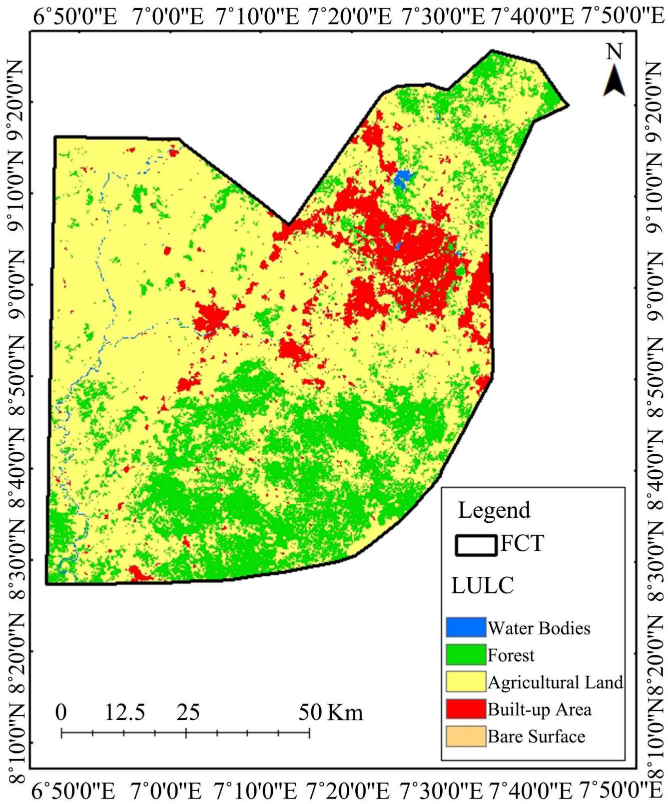
Figure 6. (a): Abuja DEM; (b): Reclassify DEM.



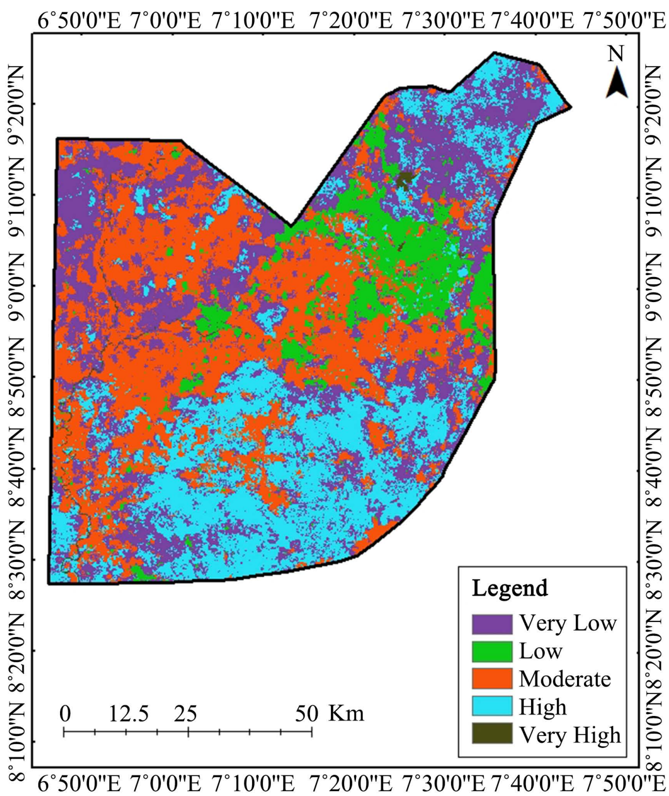
(a)

(b)

Figure 7. (a): FCT Slope; (b): Reclassify FCT Slope.



(a)



(b)

Figure 8. (a): Abuja LULC; (b): Reclassify Abuja LULC.

vegetation density and health. The result shows the green spaces and vegetation cover of Abuja at the time of research. (**Figure 9**)

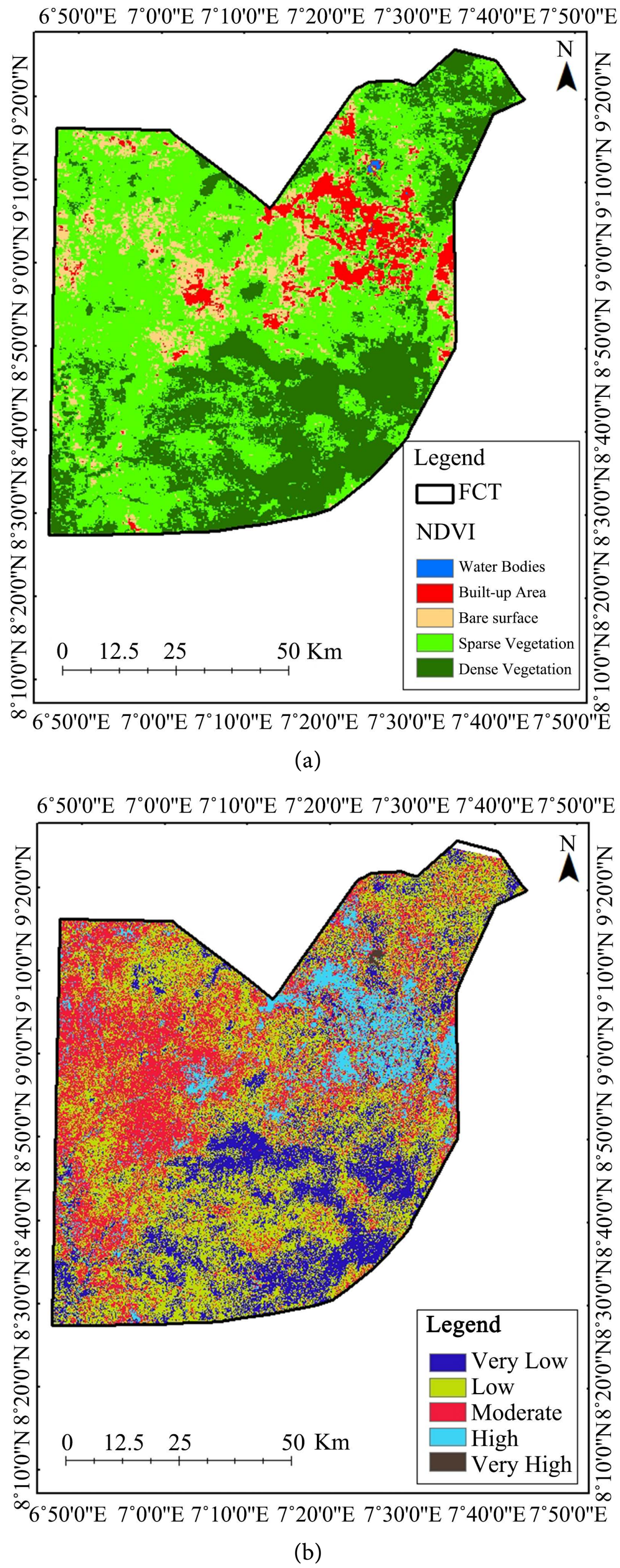


Figure 9. (a): Abuja NDVI; (b): Reclassify NDVI.

3.7. Schistosomiasis Risk Areas in Abuja

Environmental factors that influence schistosomiasis transmission include distance to snail habitats, building dams, land cover, especially elevation, rainfall, seasonal land surface temperature (LST), and the presence of flooded agricultural land. The high prevalence of schistosomiasis in children is related to distance to such as snail habitat, the building of dams, living close to streams, springs, pools or ponds and there is a negative association of slope with Schistosomiasis infection [21] [22]. **Figure 10** shows that most of the settlement (built tops) falls within high and very high risk area which implies their closeness to water bodies. Areas covered by high and very high risk zones sum up to 40% of the total area covered. The villages in Abuja have the highest percentage 88.76% that falls within high and very high risk zones (**Table 2** and **Figure 11**) confirming the fact that schistosomias is a disease of the poor and mostly rural.

Table 2. Area covered by schistosomiasis risk areas in Abuja.

S/N	Potential risk zones	Area Km^2	%
1	Very Low	870.15	11.5
2	Low	1577.42	20.86
3	Moderate	2076.23	27.45
4	High	2250.2	29.75
5	Very High	789.41	10.44
	Total	7563.413	100

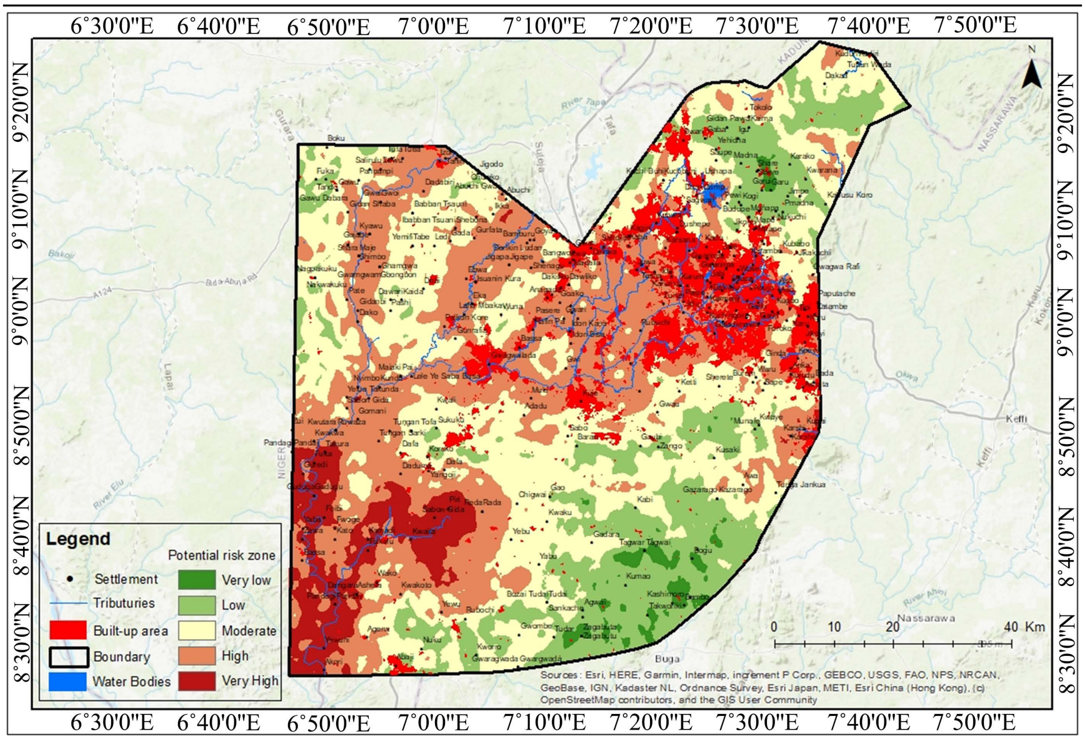


Figure 10. Map showing shcistosomiasis risk area in Abuja.

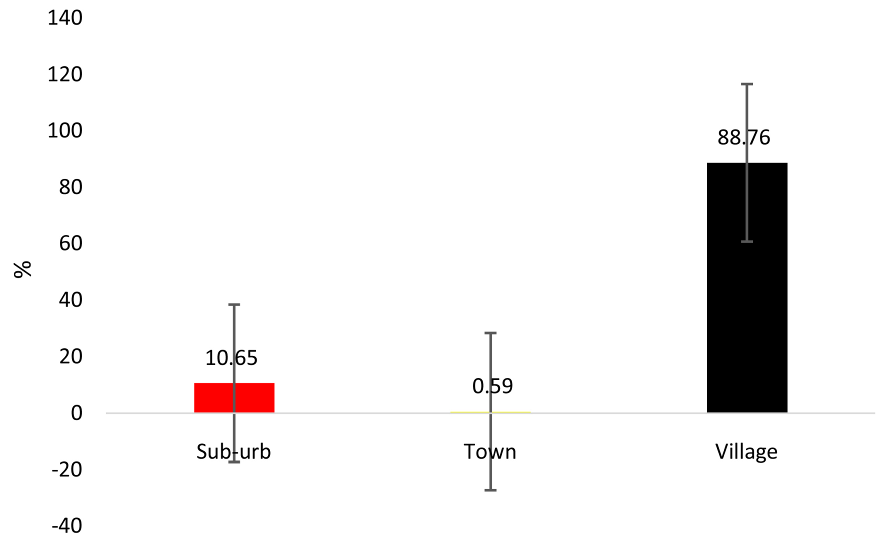


Figure 11. Statistics chart of communities in schistosomiasis transmission risk zone.

4. Conclusion

This study utilizes geospatial technology to map schistosomiasis risk zones in Abuja in order to assess the vulnerability of the area and reduce the incidence of the disease through appropriate medical interventions. Environmental changes are primarily responsible for the proliferation of disease vectors and micro-organisms, including schistosomiasis. Geospatial analysis, using various factors such as distance to water, rainfall, temperature, DEM, slope, land use land cover, and NDVI, was employed to model schistosomiasis risk zones in Abuja. The results indicate that 40% of the total area in Abuja is classified as high or very high risk zones, with the majority of affected areas being villages. This poses a significant challenge to achieving the World Health Organization's goal of eliminating schistosomiasis. However, this goal can still be attained through effective health education, influencing the behavior of at-risk populations, and promoting improved sanitation and infrastructure to minimize contact with surface water.

Conflicts of Interest

The authors declare no conflicts of interest.

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