Determination of Suitable Site for Solid Waste Disposal Using GIS-Based Multicriteria Analysis in Ado Odo Ota, Nigeria.

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ABSRACT

Identification of suitable sites for solid waste disposal (SWD) is crucial in newly emerging cities. The current SWD mode is manual, costly, labour intensive, time-consuming and pose varied environmental pollution and health problems. For this reason, this study was conducted to identify suitable sites and also evaluate the suitability of the existing SWD site in Ado-Odo Ota using GIS-based Multi-Criteria evaluation (MCE). Landsat Enhanced Thematic Mapper plus (LETM+) 2017 and Shuttle Radar Topographic Mission (SRTM) imagery together with soil and topographical maps of the study area were used to create slope, soil type, built-up area, water bodies, elevation, and roads network criteria. These criteria were mapped and used to create factors maps using spatial analytic tools in ArcGIS 10.4. In lieu of Federal Environmental Health Laws and local conditions, Euclidean distance, reclassification, and weighted overlay analyses were performed to generate SWD suitability map. It was revealed that out of the total area of the study area; 767.7 km² (85.7%), 47.4 km² (5.2%), and75.2km² (8.4%) are not suitable, least suitable and moderately suitable respectively while only 5.8 km² (0.7%) was highly suitable for the location of SWD sites. The super imposition of the coordinates of Kurata dumpsite indicates that it is located in the least suitable area hence, it should be relocated. The SWD site suitability analysis model of the study area serves as a guide for the approval of dumpsites by the Environmental Sanitation and the Town Planning Authority Departments in the study area, and also areas with the same geological and geographical settings. For efficient and effective waste management practice in newly emerging urban area, site suitability analysis should always be carried out.

Key words: Waste Disposal Site, GIS, Waste management, Multi-Criteria Evaluation (MCE), Landsat, Shuttle Radar

1.0 Introduction

The world population grew from 300 million in 1AD to 400 million in 1250; to 500 million in 1500, 1 billion in 1804, and 2 billion in 1927. Meanwhile, the figure rose from 2.5 billion in 1950 to 3.6 billion in 1970, 5.2billion in 1990, 5.7 billion in 1995 and at the end of 1999, the figure was already 6 billion (Population Reference Bureau, 2001). The wave continued until 2010 when the figure hit 6.9 billion and it was predicted that world population figure would reach 7.2billion, 8.0 billion, and 9.1 billion in the year 2015, 2025 and 2050 respectively (United Nations- Population Division Department, 2007). According to United Nations –World Water Development Project (UN-WWDP) (2006), half of humanity now lives in cities and, within two decades, nearly 60% of the world's population will be city dwellers. Cities are growing because of the natural increase in urban population (50%), reclassification of rural areas as urban areas (25%), and rural-to-urban migration. This growth is most rapid in the developing world, where cities gain an average of 5 million residents every month (UN-WWDP, 2006).

One particular characterization of Africa now is that it has a population close to 1.030 billion people, with 38% of these living in the cities implying high levels of concentration of population in very large cities (Adebayejo & Abolade, 2006). In Nigeria, urbanization parameters progress at a phenomenal rate without any articulated policy to stem its tide. For example, the dynamics of urbanization in Nigeria is typified by the fact that while less than 15% of the total population lived in cities of 20,000 or more populations in 1950, in 1975 that is 25 years later, this proportion has increased to 23.4% and by 2000, the proportion had increased by 43.3%, and the prognosis is that by 2025, more than half of the nation's population will live in urban centers (Mabogunje, 2007).

Given the foregoing nexus, there is the potential for urban centers to witness further exponential growth. For instance, in the year 2015, there will be about 60 megacities with a total population of more than 600 million people across the world (Waheed, 2009). This is sharply in contrast with what the figure was in the year 2000 when there were only 10 megacities with 10 million people or more on earth; the 22 cities with 5 to 10 million people or the 370 cities having 1 to 5 million people; or the 433 cities with 0.5 to 1 million people (Agbola, 2005).

As noted by Elmira, Behzad, Mazlin, Ibrahim, Halima &, Saadiah (2010) increasing population, rapid economic growth and the rise in the standard of living are indicators of urbanization but, nonetheless, the accelerate solid waste generation is a widely known consequence of urban growth (Akpu, Tanko, Nyomo & Dogo, 2017). Waste is a material discharged and discarded from each stage of daily human life activities, (Bringi, 2007) such as leaves/twinges, food remnants, paper/cartons, textile materials, bones, ash/dust/stones, dead animals, human and animal excreta, construction and demolishing debris, biomedical debris, household hardware (electrical appliances, furniture, etc) (Sha' Ato, Aboho, Oketunde, Eneji, Unazi & Agwa 2007; Babatunde, Vincent-Akpu, Woke, Atarhinyo, Aharanwa, Green & Isaac-Joe, 2013).

In Nigeria, solid waste management is characterized by inefficient collection methods, insufficient coverage of the collection system and improper disposal ,thus, solid wastes that cannot be avoided, reused, or recycled are either dumped into vacant plots, public spaces, drains, along the road, under bridges, water-channels, around houses, and conspicuous unauthorized waste-dumpsites that abound Nigerian cities (Sunmola, 2018).

Indiscriminately dumped waste not only constitute aesthetic nuisance but also made cities to lose its scenic value while residues of wastes that are discriminately burnt are washed down by runoff to wetlands. These together with ones directly dumped on wetlands, constitute a nuisance in the form of loss of scenic and aesthetic of the surroundings, pollution of surface water, and other water bodies in an area and eventual blockage of river-channels to eventually aggravate flood events (Hammer, 2003). Even the unpleasant and appalling odours that used to emanate from unauthorized dumpsites not only constitute air pollution nuisance but the latchet released from these non-scientifically approved sites are the sources of both surface and underground water pollution (Sunmola, 2018).

The aforementioned untold implications of improper solid waste management are vivid notions that urbanization as a basic precondition for development, in itself, does not guarantee development. because aside from that the pace of urban growth readily outpaces the capacity of metropolitan and planning authorities to provide basic services in many of these cities (Adebayejo & Abolade, 2006). Thus, the city is gradually and systematically decaying without any tangible programmes of rehabilitation (Waheed, 2009) while the quality of the health of urban areas kept on deteriorating. In order to attain sustainable city -the one in which the disposal of wastes does not exceed the capacity of the city's surrounding environment (Kennedy et al., 2007), urban planners and other environmental scientists now focus on lowering the negative effects of large –scale urbanization.

In the past decades, the concern of landfill site selection was convoluted and time taking. However, the advent of GIS technology has made suitable site selection systematic, technical, and manageable (Yesilnacar & Cetin, 2008). The fact that GIS has a very powerful set of functions with decisive methods for site suitability analysis as per it mightily retrieves, stores, displays, and analyses geo-information.GIS now plays an important part in multi-criteria evaluation making and suitable site modeling process (Kontos et al. 2003, Sener et al.2006 and Yadav, 2013) and generation of landfill suitability maps (Leao et al. 2004).

1.1 Statement of Research Problem

The fast-growing population, urban expansion, cum uncontrolled aggrandizement of industrialization and modernization and migration into the urban area have led to increase in the consumption of different natural and man-made composite resources and consequently resulted to a huge and excessive generation of refuse and other waste materials mainly from the households, hospitals, industries, offices, and market centers on daily basis (Yesilnacar & Cetin, 2008). Due to the growing mixture of waste characteristics and deficiency of operational application of dependable waste policies and technologies (Karadimas & Loumos,2008; Mmereki, Baldwin & Li, 2016; Zohoori & Ghani 2017), generally open waste dumps are the oldest and commonest way of disposing solid wastes in many areas in Nigeria (Nzeadibe, 2009).

In recent years, the phenomenal increase in the quantity and frequency of solid waste generated and dumped indiscriminately or managed by r other self-managed waste disposal practices that failed to guarantee cleanliness and safety in the newly emerging cities but have resulted into major untold hardships and challenges facing the inhabitants of most communities in Nigeria. This include: migration of leachate and other pollutants from waste dumps that sipped into the surface and underground waters to pollute them (Bichi, 2000; Aniah,& Utang, 2006;Sunmola, 2018) to cause poisoning, cancer, heart diseases and teratogenic abnormalities(Olaniyan, et al 2009); blockage of drains that cause disastrous flooding and loss of scenic and aesthetic value of city neighborhoods among other delirious effects of improper waste management(Sunmola, 2018).

Aside, the absence of educated manpower in city authorities cum socio-cultural, political and economic problems; poor legislation and absence of policies for accurate long-term planning, insufficient storage, limited use of technology, and insufficient knowledge of basic principles of waste management have adversely militated against the effective collection and appropriate disposal of wastes generated in developing world cities (Diaz,2011; Hettiarachchi, Meegoda & Ryu, 2018).

To the foregoing effects, poor waste management has become the topmost problem confronting cities in the developing world (Hasan, Tetsuo& Islam, 2009; Khan and Samadder 2014) and also a persistent problem in cities in Nigeria (Babalola & Busu, 2011). Mazhindu, Gumbo& Gondo, 2012). Since, solid wastes need to be properly managed, if sustainable growth is to be realized, traditionally, different effective techniques were used for disposition of the municipal solid waste in terms of solid waste management.

Though efforts have been made to promote reuse and recycling of waste worldwide (Zhikun, Menglian, Zezhou, Yanbin & Xia,2018) and also recycling, biological treatment, and thermal treatment (Kontos, Komilis &Halvadakis,2003) but the most coherent ways is dumping of wastes in suitable landfills located outside the towns or cities (Kohbanani, 2009). Regardless of the method, it is impossible to eliminate all forms of waste; a better way to handle waste is through adopting approaches that ensure its impact on the environment is minimal (Khan & Faisal, 2008) Thus, landfill, although found at the bottom of waste management hierarchy (waste reduction, reuse, recycling, composting and landfilling), is a waste disposal method in which key engineering principles are applied to spread waste into thin cells, compress it into small volumes and, finally, covering it with a soil layer (Sumathi, Natesan & Sarkar, 2008).

It has been suggested as the most reasonable means of disposing of solid waste because it is less expensive than other forms of waste treatment but an integral component of the waste management chain that has, nonetheless, created and continues to create environmental problems. Hence, requires greater attention to reduce its environmental impact (Mahini & Gholamalifard, 2006; Rahman et al., 2008) thus, selecting an adequate site for landfill is necessary to protect human and environment. As noted, a good waste disposal area has few characteristics (Chabuk, Al-Ansari, Hussain, Laure, Hazim, Knutsson, & Pusch, 2019).

Thus, the identification and selection of suitable municipal landfill involves the integration of consideration and inclusion of series of environmental factors, such as soil type, depth of groundwater, rainfall, elevation, liability to an earthquake, high flood risk zones, faults, and cracks areas, and presence of mines, (El Baba, Kayastha & De Smedt, 2015); social opposition factors such as the ‘not in my backyard’ phenomenon (NIMBY)] cum economic factors (Wang, Qin & Chen, 2009,) political opposition factors s(Gorsevski, Donevska, Mitrovski & Frizado, 2012), the impact on the surrounding residents (Homaee & Mahmodi, 2012) location of airports, historical and cultural sites (Abd-El Monsef, 2015) ,other factors, such as urban landfill traffic routes (Hosseinzadeh, 2017) , distance to groundwater, distance to surface water, ecosystem, land cover, distance to city and countryside, and land use among others.

Therefore, optimized all derived and available information to scientifically make a judicious decision about a landfill site and also design a landfill that ensure less or no negative or damaging impact on the various environmental sub-components as well as reducing the stigma associated with the residents living within and or around landfill site vicinity is paramount (Chabuk et al, 2019). In Ado Odo Ota, there is no significant and adequately positioned waste landfill site, rather generated solid waste is disposed indiscriminately often in open spaces such as roadside, riverbanks, gutters (during heavy rainfalls), most of which pile up and later block the city drainage lines. The roadside disposal not only hinders proper road accessibility but often made movement between places to be cumbersome and time-consuming due to ensuring traffic holdups and accidents from drivers claiming right of ways. The losses of aesthetic and scenic value of the neighbourhood coupled with offensive odours emanating from these heaps of wastes are other problems of indiscriminate waste disposal.

Since most of the neighbourhood is located in wetlands, well water here is directly infected with pathogens from the heap of wastes and unsafe for drinking. Therefore, the need to create an ideal waste disposal mode that will not only work to support a good sanitary environment but, will improve the scenic value of Ado Odo/Ota neighborhood.

Studies such as Sumathi, Natesan, and Sarkar (2007), Yahaya,Yahaya, Tamyes and Ismaila (2010) Zeinhom, Elhadary and Elashry (2010) and Shaker and Yan (2011) used Geographical Information System (GIS) and Multi Criteria Evaluation (MCE) to identified and selected a better alternative using Analytical hierarchy process. These studies also show that the integration of GIS and MCE was of utmost importance for effective and efficient waste management that requires a variety of geographically referenced data and a set of alternatives with a series of evaluation criteria and also aggregates the criteria maps in accordance with attribute values and the preference of the decision maker.

To this effect, this study aimed to locate and create a suitable dumpsite for solid waste disposal in Ado Odo Ota metropolis using GIS technology. The specific objectives of the study are to; identifying the existing dumpsite; determine potential location suitable and unsustainable for dumpsite and evaluate the suitability of the existing dumpsite in the study area. The determination of dumpsite is not an easy task since it involves adequate planning and design of a suitable location. GIS offers an affordable tool for spatial operation. It reduces time, cost of selection of site and provides digital database management system with user defined specification; therefore the study adopted the GIS-based Multicriteria evaluation technique to determine a suitable location for dumpsite will provide a lasting solution to indiscriminate waste disposal menace in the study area. Moreover, the identification of this suitable dumpsite will minimize environmental risk and human health problems in the study area. This study will also be useful to policy makers such as the Ogun State Urban Development Board as well as Ogun State Environmental Protection Agency (OGSEPA).

2.0 METHODOLOGY

The area under study is Ado - Odo an industrial town that lies between Latitude 6°30' – 6°46'N and Longitude 2°51' and 3°16' E on an about 1,010.4 square kilometers expanse of land with a population of 526,565 (NPC, 2006). The area lies in the subequatorial climatic zone and experiences a high temperature throughout the year. Rains are received as early as March. The study area is situated on plain land with about 16% riverine and 4% hilly regions underlain by coastal plain sand (sand and clay), alluvium (sand and silt) and Ilaro formation that is rich in kaolin, silica, sand gypsum and glass sand. The soils of the study area are poorly drained and e varies from alluvial soils, clay, and sand and silt soils. The people almost exclusively engage in farming, fishing, craft-making, trading and hunting

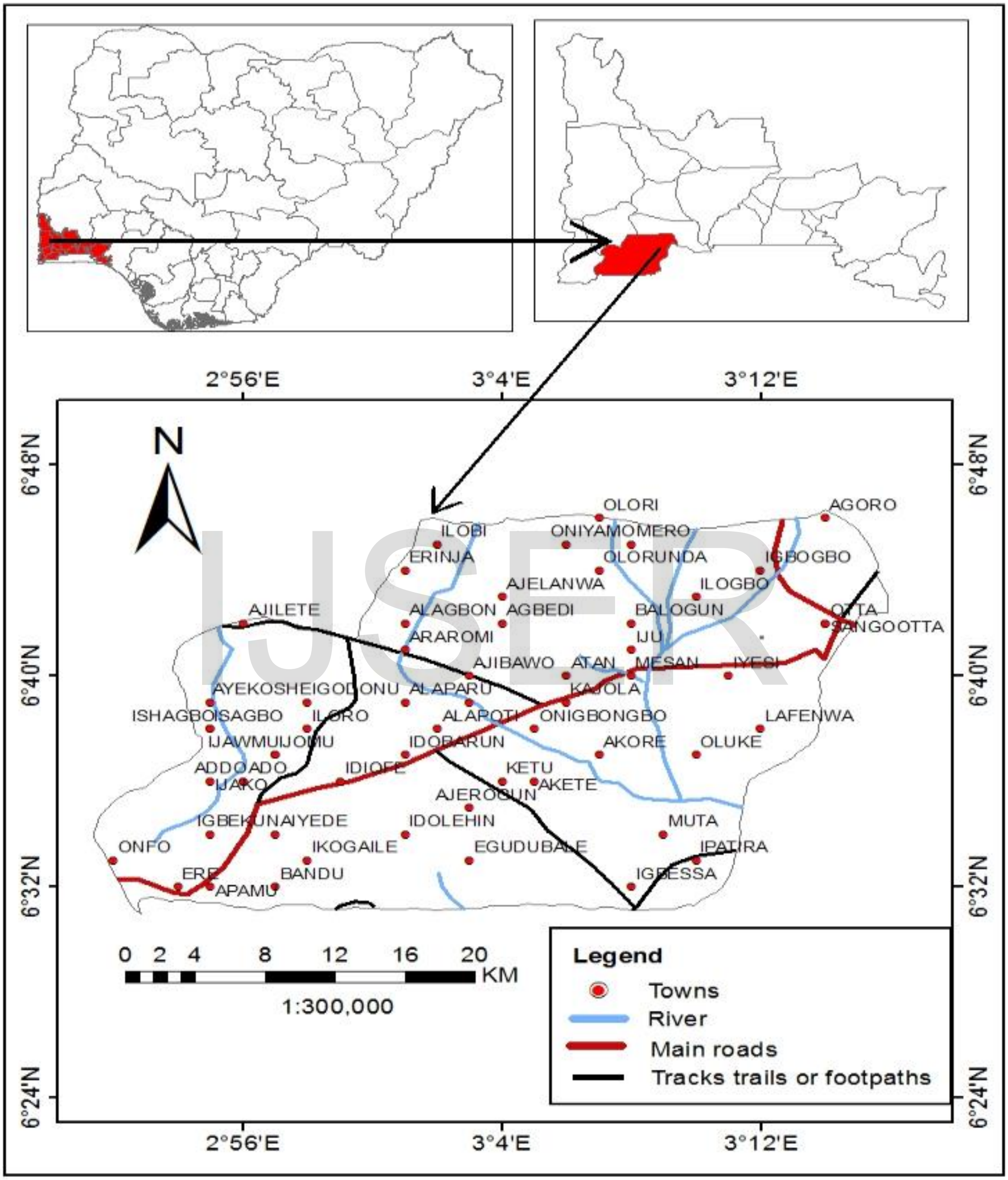

Fig.1: Map of the Study Area

2 Methodology

2.1 Description of data and sources

The study adopted field survey method and other source of data which includes; existing soil data, road network data, hydrology data, landuse data and study area shape file. All the above data were collected, manipulated and analyzed in GIS environment to be used for further analysis. The field survey involves visiting the existing dumpsite in order to take the coordinate and some land-use references for image classification as shown in Table1.

Table 1: The Adopted Data and their Attribute

S/N	Data	Source	Year	**Resolution**	**Relevance**
1	LANDSAT ETM+	USGS	2016	30m	To generate the built-up area and water body factor
2	DEM	Shuttle Radar Topographic	-	30m	To generate slope factor
3	Soil map	NBRRI	2015	Resampled to 30m	To generate soil factor
4	Road map	ArcGIS	-	Resampled to 30m	To generate road factor
5	Administrative map	ArcGIS	-	-	Extract the boundary of the study area

2.2 Data Processing and Analysis

Multi-temporal Landsat images; 2017 was processed with ENVI 5.1 and the image was enhanced for visualization purposes, the boundary of study area was extracted out of the full scene. Maximum Likelihood Classifier was used to produce different land use/land cover (LULC) maps, after which the built-up area was extracted using Arc Map 10.4. The soil data collected were entered into excels and used to create a database of soil types. Digital elevation model (DEM) of 30m resolution was imported into ArcGIS software to derive different raster layer which includes; slope, flow direction, and flow accumulation.

To determine potential location suitable and sustainable for dumpsite, the multi-criteria evaluation (MCE) and overlay operations were adopted which include: the creation of factors maps, Euclidean distance analysis, reclassification, and weighted overlay. Five criteria were used which include: Slope, built-up area, Soil, Roads, and Waterway as shown in the Workflow diagram (Figure 2). The distances are measured based on the adopted standard in this study. Each parameter considered has a different Euclidean distance (EPA Landfill Manual 2006) and these were used to determine the buffer zones and varying degrees of suitability within each layer as shown in Tables 2 and 3.

Reclassification was done so as to create a single ranked map of potential dumpsites. The values of classes between layers were compared by assigning numeric values to classes within each map layer. Measuring all value on the same numeric scale gives it equal importance in determining the most suitable locations; in this study, the numeric weight from 1-10 was chosen for all the parameters based on the criteria. The Weighted Overlay tool was applied for selection and suitability models and the weighted overlay tool only accepts integer raster as inputs. The coordinates of the existing dumpsites collected from fieldwork were imported into the ArcGIS 10.4 as a text file then converted to shape file to show the suitability of the locations of the existing dumpsites.

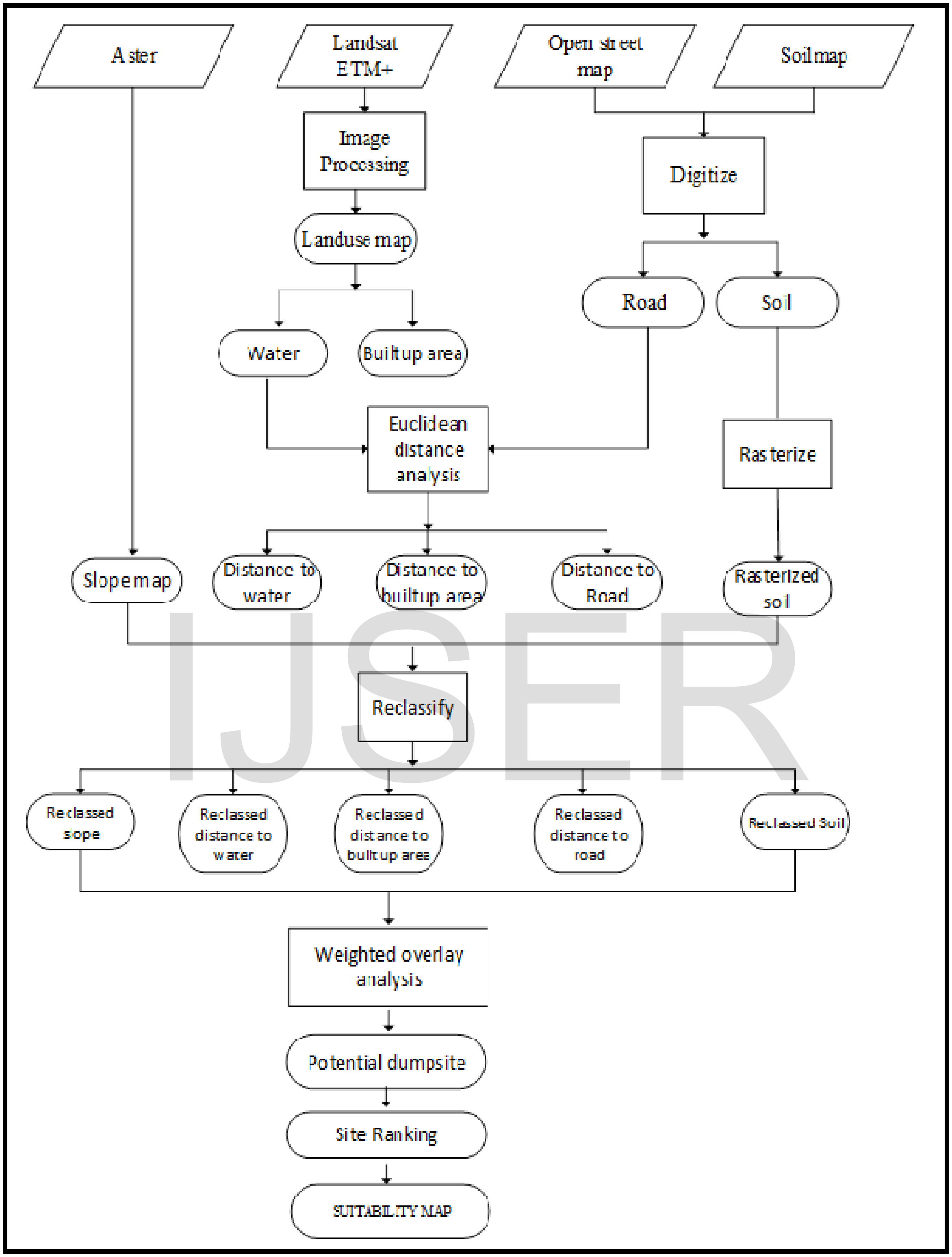

Fig. 2: Flow chart

Table 2: Constraint Criteria formulated from EPA landfill manual 2006

Criteria	Unsuitable Areas
Distance to Water Body and river	Less than 160m
Slope	Area > 15^o
Distance to Road	Less than 100m
Distance to builtup area	Less than 300m
Soil	Area with alluvial soil

Table 3: Factor Criteria formulated from EPA landfill manual 2006

CRITERIA	LEAST SUITABLE	MODERATELY SUITABLE	HIGHLY SUITABLE
Distance from the river	160m - 480m	480m - 960m	> 960
Slope	10^0 - 15^0	5^0 - 10^0	0^0 - 5^0
Distance from Road	> 2000m	1000m - 2000m	100m - 1000m
Distance from Built-up	300m - 500m	500m - 800m	> 800m
Soil		Alisols	Alisols

3.0 RESULT AND DISCUSSION

3.1 The Existing Dumpsite in the Study Area

The only existing dumpsite in the study is called Kurata. Hand-held GARMIN GPS was used to collect the coordinates of this dumpsite (Table 4).

Table 4: The coordinate points of Kurata dumpsite

Name of location	X(degree minutes)	Y(degree minutes)
Kurata dumpsite	6.69031	3.20102

Source: Authors Analysis, 2019

3.2 Creation of Criteria Maps

3.2.1 Land-use map

Figure 3 shows the result for the land use map of the study area. Four major classes were classified which include; vegetation, built-up area, bare ground, and water. 569.7km^2 (63.3%) of the land use is covered by vegetation, 227.8km^2 (25.4%) is covered by built-up area, 95.5km^2 (10.6%) is covered by bare ground while 6.5km2 (0.7%) is covered by water body respectively (Table 5).The result of the accuracy assessment of the image classified shows that the overall accuracy is 83.1% and the kappa coefficient is 0.69 The result indicates that 69% of image classification agreed with the reference data (Landis and Koch, 1977). Based on this result, the strength of agreement is thereby categorized as good.

Table 5: Distribution and spatial extent of land-use

S/N	Class Name	AreaKm^2	Area%
3	Vegetation	569.7	63.3
1	Built-up area	227.8	25.4
2	Bare ground	95.5	10.6
4	Water body	6.5	0.7
	Total	899.5	100

Source: Authors Analysis, 2019

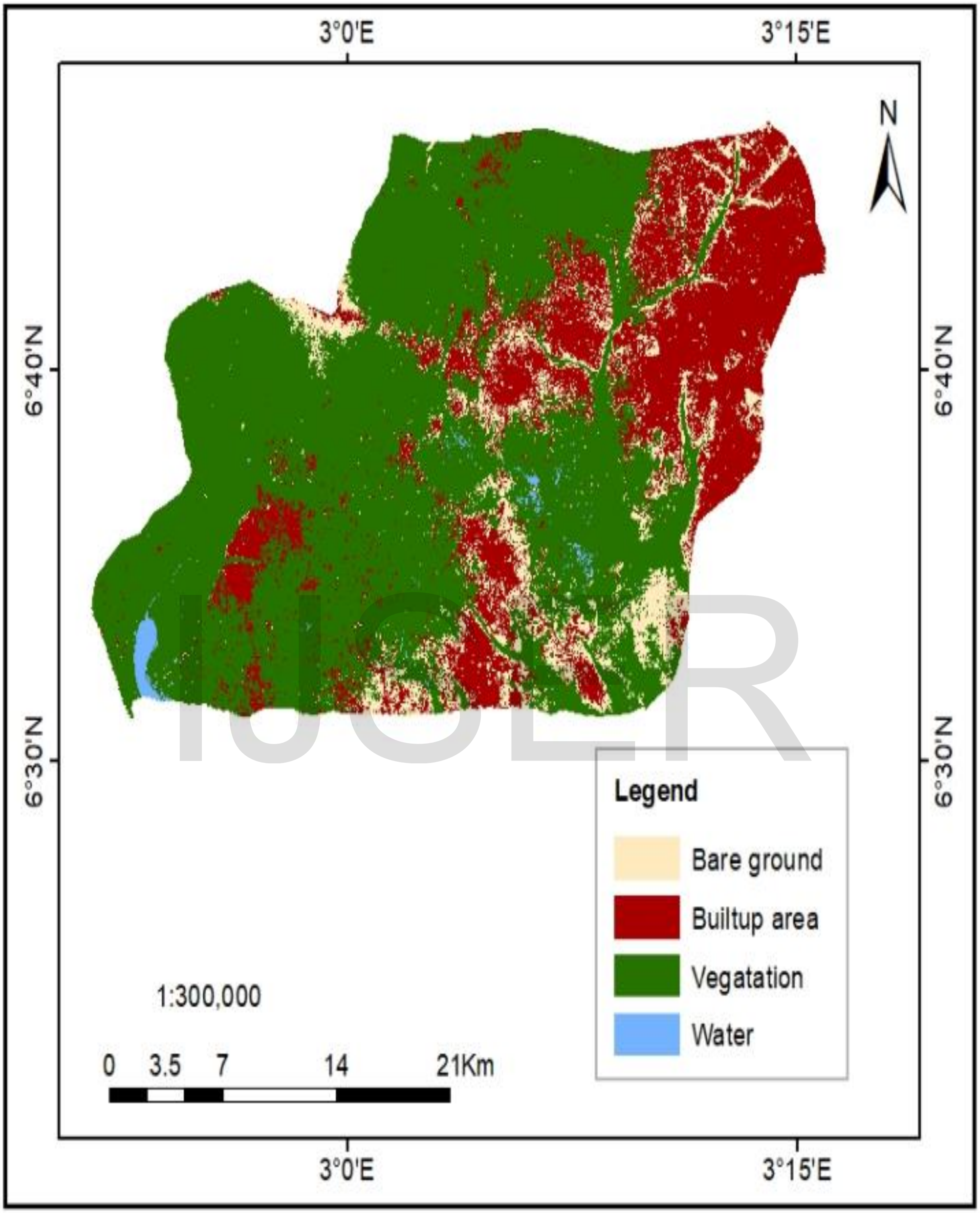

Fig.3: Land-use map

3.2.2 Soil types

Figure 4a shows the soil varieties that contain clayey sand (SC), poorly-graded sand with clay (SP-SC), loose sand (SM), and silts of high sponginess (MH) as shown in figure 4a. 516.5km^2(57.4%) of the total area is covered by clayey sand, 198.3km^2(22%) is covered by poorly-graded sand with clay, 41.9km^2(4.6%) of the total area is covered with silts of high compressibility and the remaining 142.8km^2 (16%) is covered by silt sand. Soils with high silt and clay fractions offer groundwater protection and it is economically cheaper to construct dump site. Silty sand Loose is Non-sticky/Non-Plastic; clayey sand is Sticky/Plastic whereas silt of high compressibility is extremely heavy/sticky/plastic. Figure 4b shows the soil suitability map of the study area thus, only 4.5% of the total area is suitable. Clay textured soil was most preferred for dumpsite as it is impermeable to leachate.

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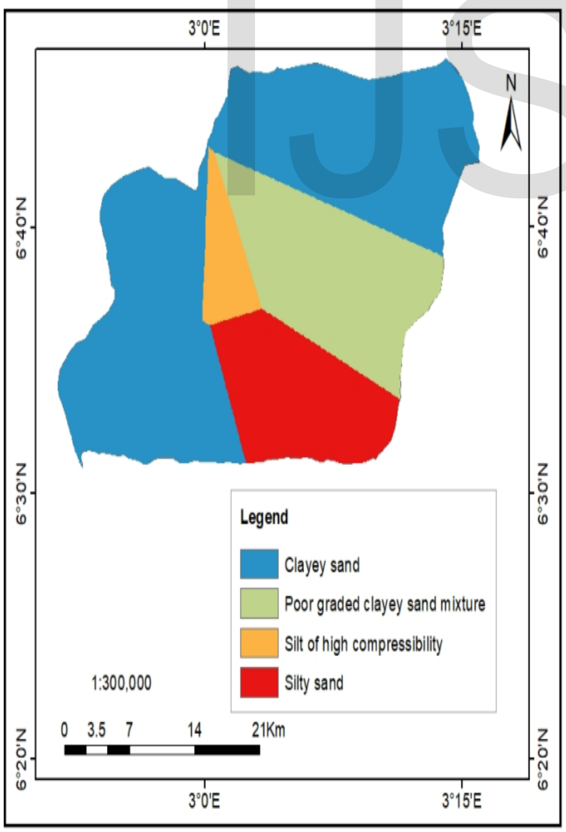

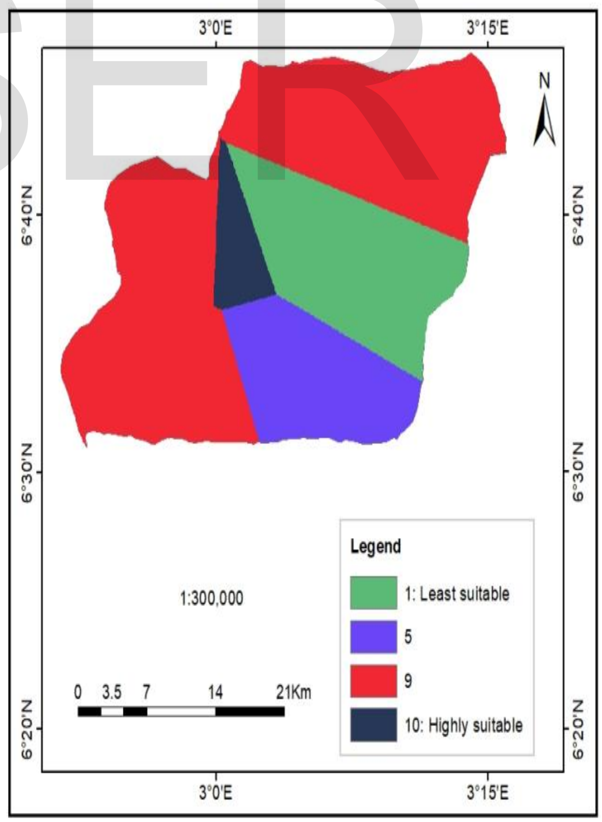

Fig.4a: Soil types **Fig.4b: Soil suitability map**

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3.2.3 Slope map

The slope of the study area ranges from 0^0 to 37.4^o. The average slope value is 3.63^o while the standard deviation is $3.0\ ^0$(Figure 5a). The slope map was reclassified based on the criteria for slope that stipulated that 0^o- $5\ ^o$ was considered highly suitable, 5^o-10^o is considered to be moderately suitable while 10^o -15^o is considered to be less suitable (Table3). Figure 5b shows the slope suitability of the study area. Lower slope areas are more suitable than high slope areas. A steep slope area is considered not suitable for constructing waste dump site. In the study area a slope of less than 5% is considered to be most suitable and this covered about covered 661.8km^2 (73.5%) of the total area of the study area. In addition, 197km^2 (22%) of the study area is moderately suitable while 31.7km^2 (3.5%) is least suitable and 9 km2 (1%) of the total area is considered not suitable (Fig.5b)

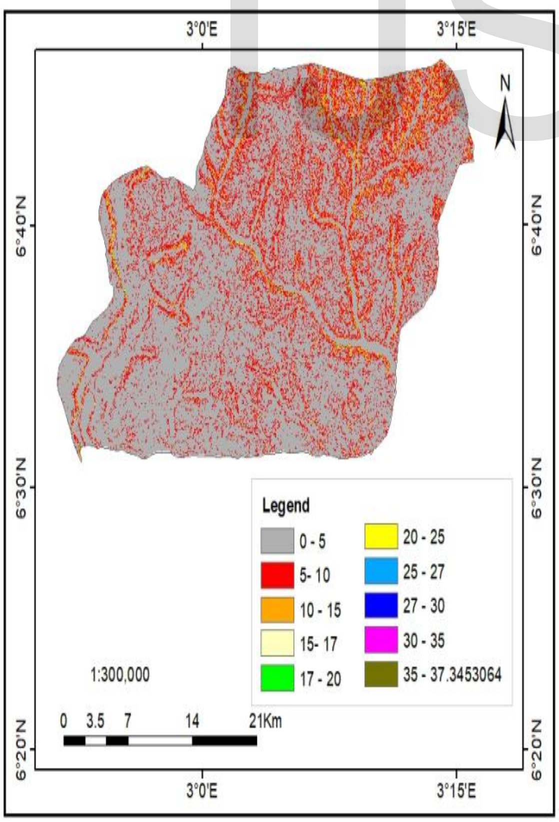


Fig.5a: The slope map

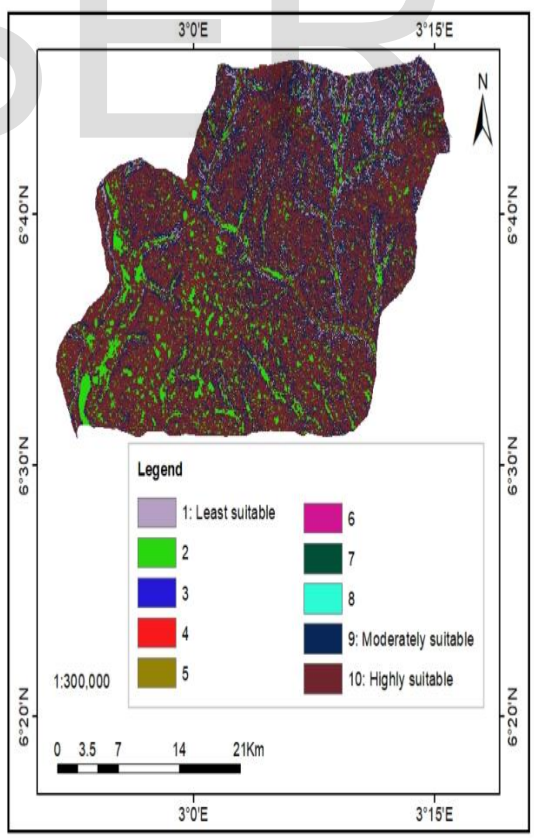
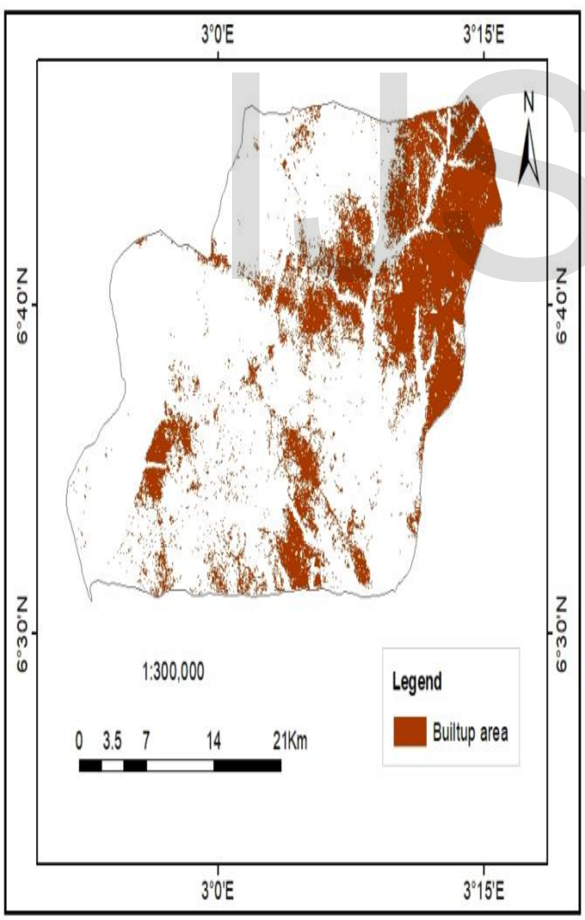


Fig.5b: The slope suitability

3.2.4 Built up area criteria

Figure 6a shows that built-up area as extracted from the land cover map of the study area. Figure6a also shows that built-up area which was covered about 25.4%of the study area. Since, the criteria stipulated that distance less than 300m is considered unsuitable, distance from 300m - 500m is least suitable, distance from 500m - 800m is moderately suitable while distance greater than 800m (> 800m) is highly suitable (Table3) thus by using Euclidean distance analysis, Figure 6b shows that 103.3km^2 (11.5%) of the total built-up area is highly suitable; 72.1km^2 (8%) of the total area is moderately suitable while 92.8km^2 (10.3%) is considered to be least suitable and 631km2 (70.2%) of the total area is considered not to be suitable.(Fig. 6b)



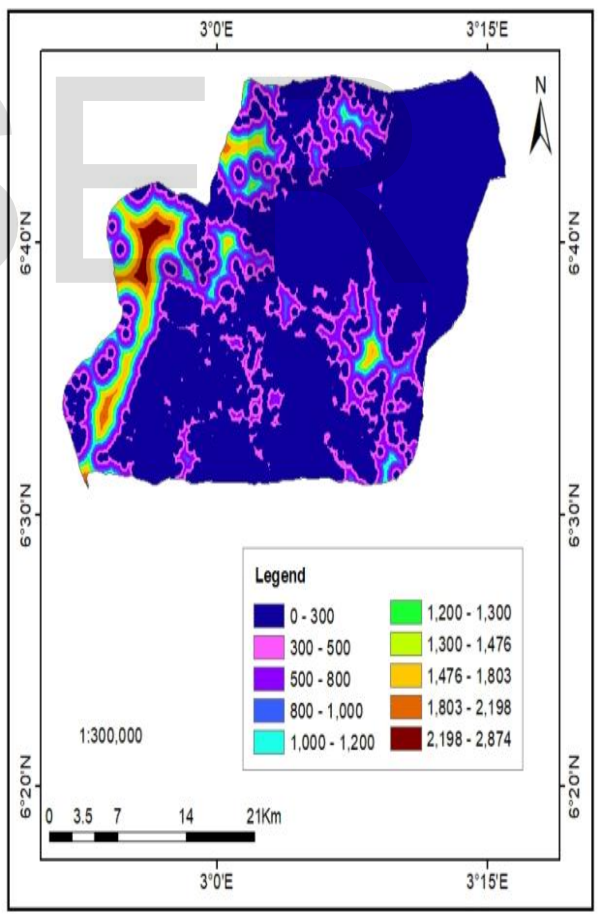
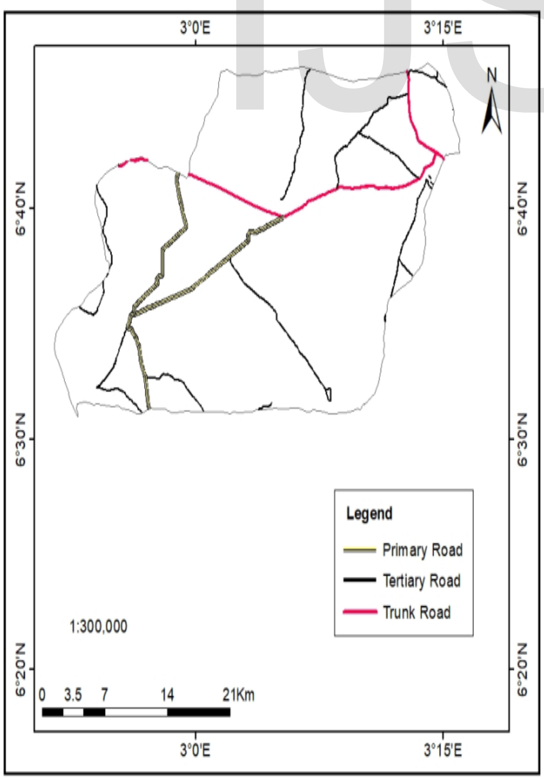


Fig.6a: The built-up area **Fig.6b: Distance from built-up area**

3.2.5 Road Map

Figure 7a shows the road network of the study area. A dumpsite must be located close to the road network for easy accessibility in order to reduce relative costs. Minimum and maximum distance from road network for this study were set after the manual that stipulated distance less than 100 metres is unsuitable for locating dumpsite while the distance between 100 and 1000 metres is highly suitable, distance from 1000m – 2000 metres is said to be moderately suitable and a distance greater than 2000 metres from the road is least suitable (Table3). Using Euclidean distance analysis it s vivid from Figure 7b that out of the total area in the study area, about 295.2km^2 (32.8%) is highly suitable; 239.5km^2 (26.6%) is moderately suitable while 323.9km^2(36%) is considered least suitable and 40.9km^2(4.6%) of the total area is considered not suitable (Fig.7)



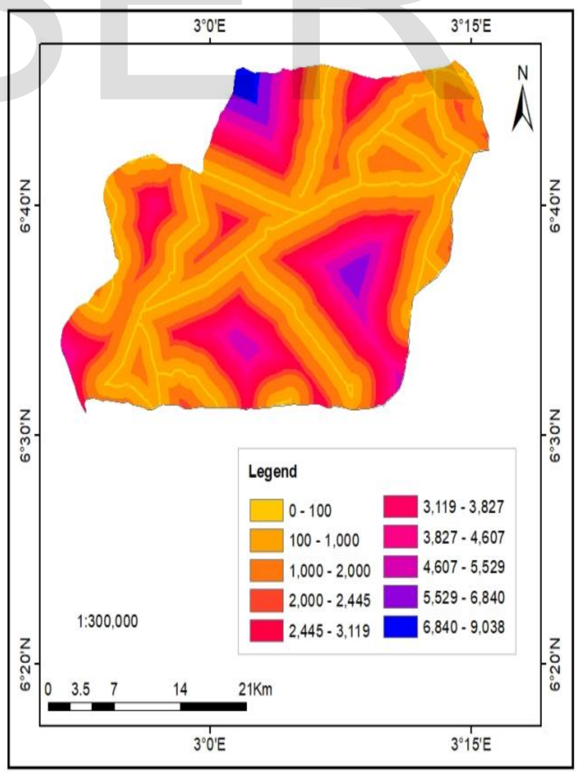
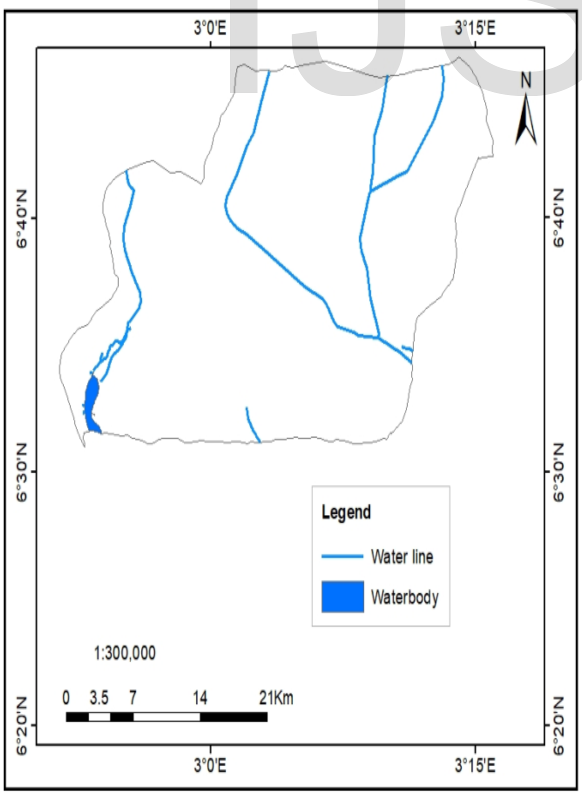


Fig.7a: The road network **Fig.7b: Distance from road network**

3.2.6 Rivers Map

The network of water bodies and rivers were extracted from land-use classes and hydrological analysis. Figure 8a, shows the position of the river and other water bodies in the study area. A dumpsite must not be located close to stream and rivers in order to avert vulnerability to ground and surface water pollution from contamination, Based on the criteria for water body and river which stipulated that distance less than 160 meters is considered unsuitable for dumpsite, 160 to 480meters is considered less suitable, 480 to 960meters is moderately suitable while distance greater than 960meters is highly suitable (Table 3). Using Euclidean distance, Figure 8b shows that with respect to distance from rivers/water bodies, 720.8km^2 (80.1%) of the total area is considered highly suitable; 90.7km^2 (10%) is moderately suitable while 55.9km^2 (6.2%) is considered least suitable and 32.1km^2 (3.7%) of the total area is considered not suitable(Figure 8b)



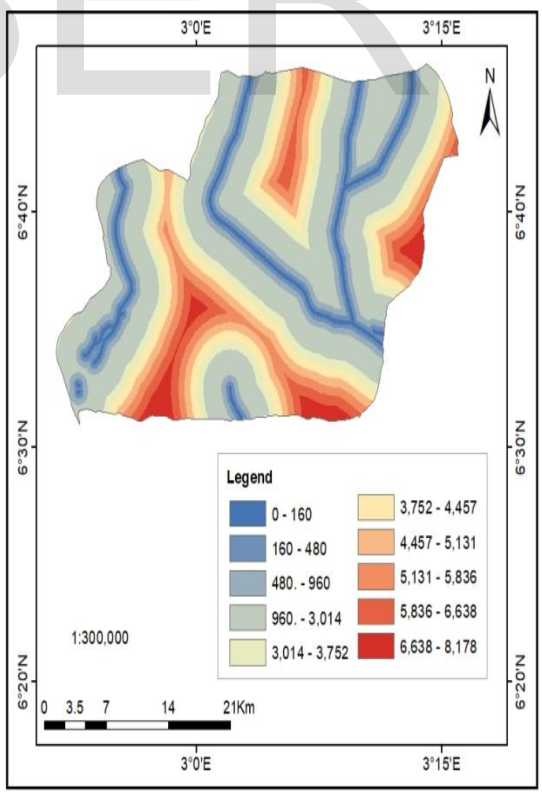


Fig.8a: Rivers map **Fig.8b: Distance from rivers**

3.3 Reclassification Results

Based on the criterion that addressed the required distance from each factor , the maps layers of distances from the road, built-up area, and rivers, soil types and slope maps were ranged from 1 to10, 1 (least suitable), and 10 (highly suitable). The results of these reclassification analyses are as shown in figures 9a, 9b, 9c, 9d, and 9e.

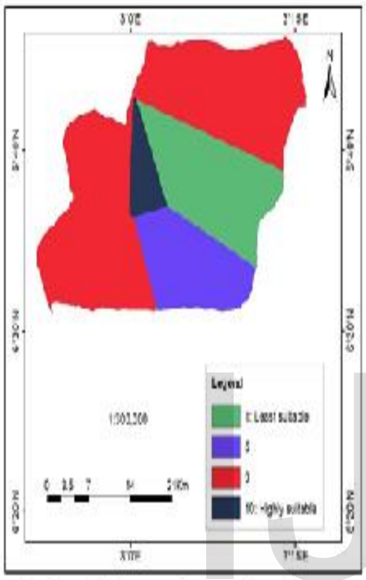


Fig.9a: The reclassed soil

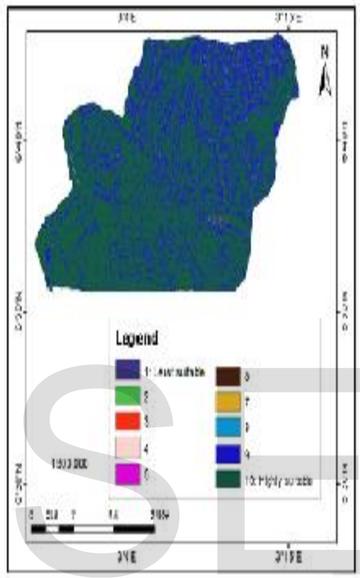


Fig.9b: The reclassed slope

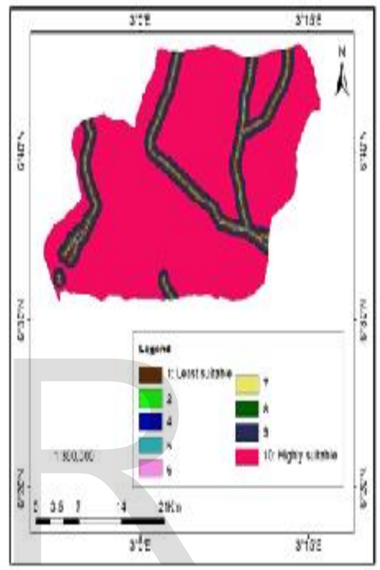


Fig.9c: The reclassed rivers

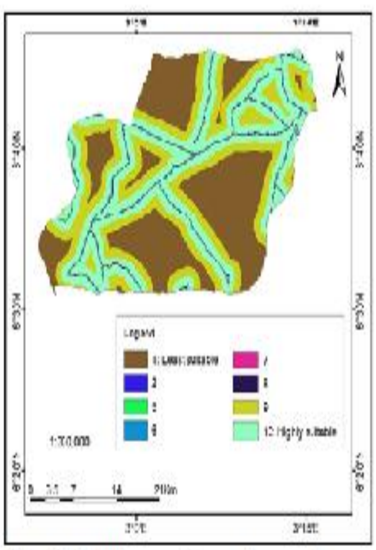


Fig.9d: The reclassed road

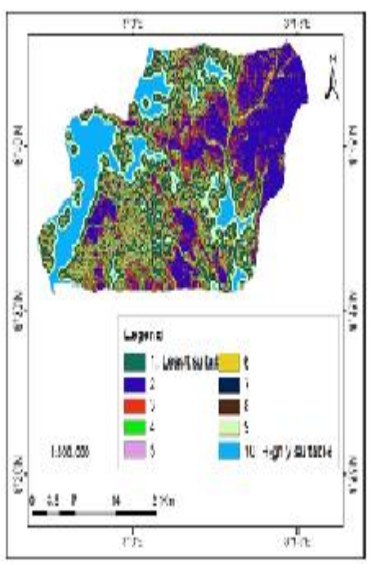


Fig.9e: The reclassed builtup

3.4 Weighted Overlay Result

Five raster layers with 30m resolution were ranked according to their importance for the development of suitability map on a scale of 1 to 10 using an evaluated scale of 1 - 9 by 1. Built-up areas were assigned an overall percentage weight of 40% as the most important variable. Slope and soil were assigned 25%, and 15% respectively. River and road were assigned equal importance of 10% each. The foregoing result was further reclassified into a scale of 1-3 for easy identification. The result revealed that767.7 km^2 (85.7%) of the total area of the study area is not suitable, 47.4 km^2 (5.2%) is least suitable, and 75.2km^2 (8.4%) is moderately suitable while only 5.8 km^2 (0.7%) is highly suitable (Figure 10).

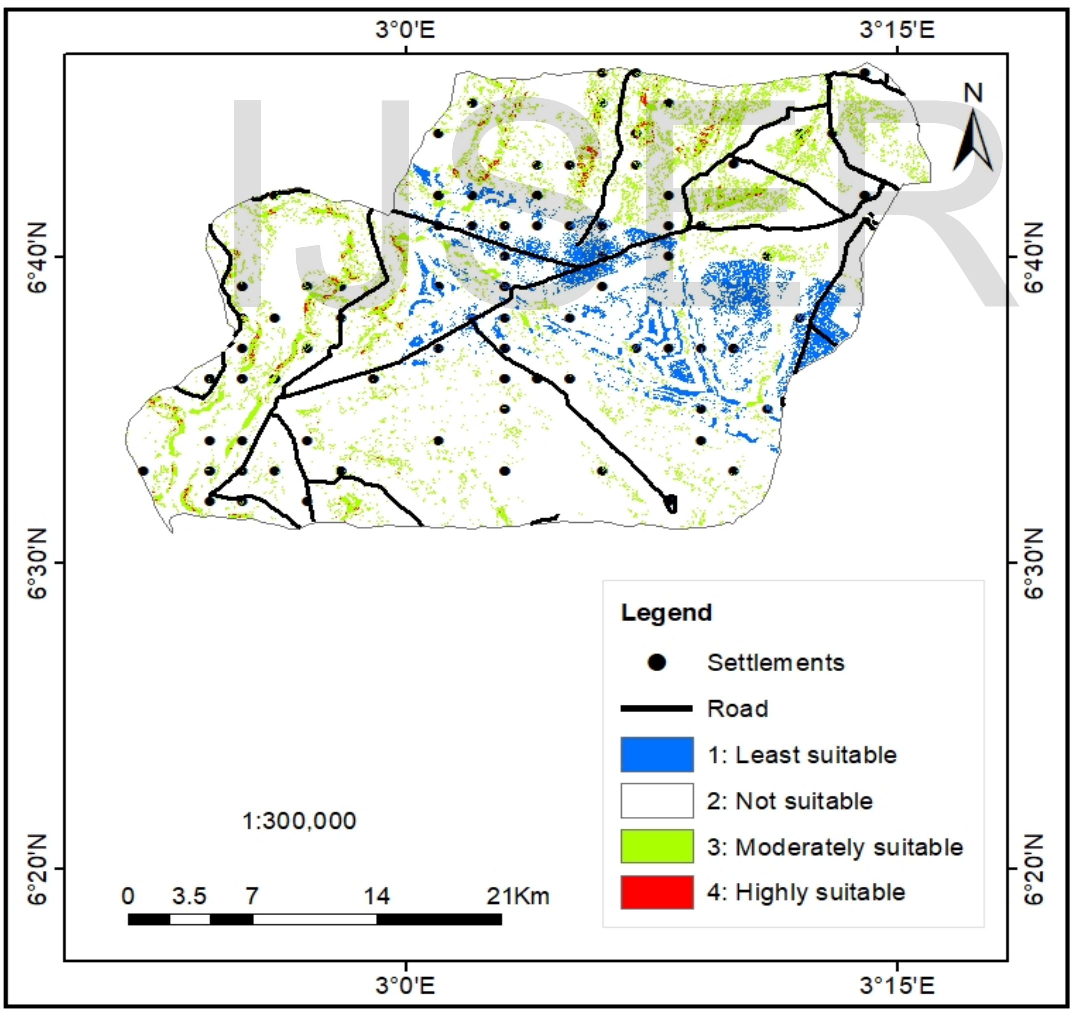


Fig.10: The Suitability Map

3.3Assessment of the Existing Kurata Solid Waste Dumpsites

Field verification exercise was conducted to determine suitability of the existing dumpsite. The shape file that shows the location of Kurata dumpsites was overlaid on the suitability map. The result reveals that Kurata dumpsite is not suitable based on the MCE (Figure 11).

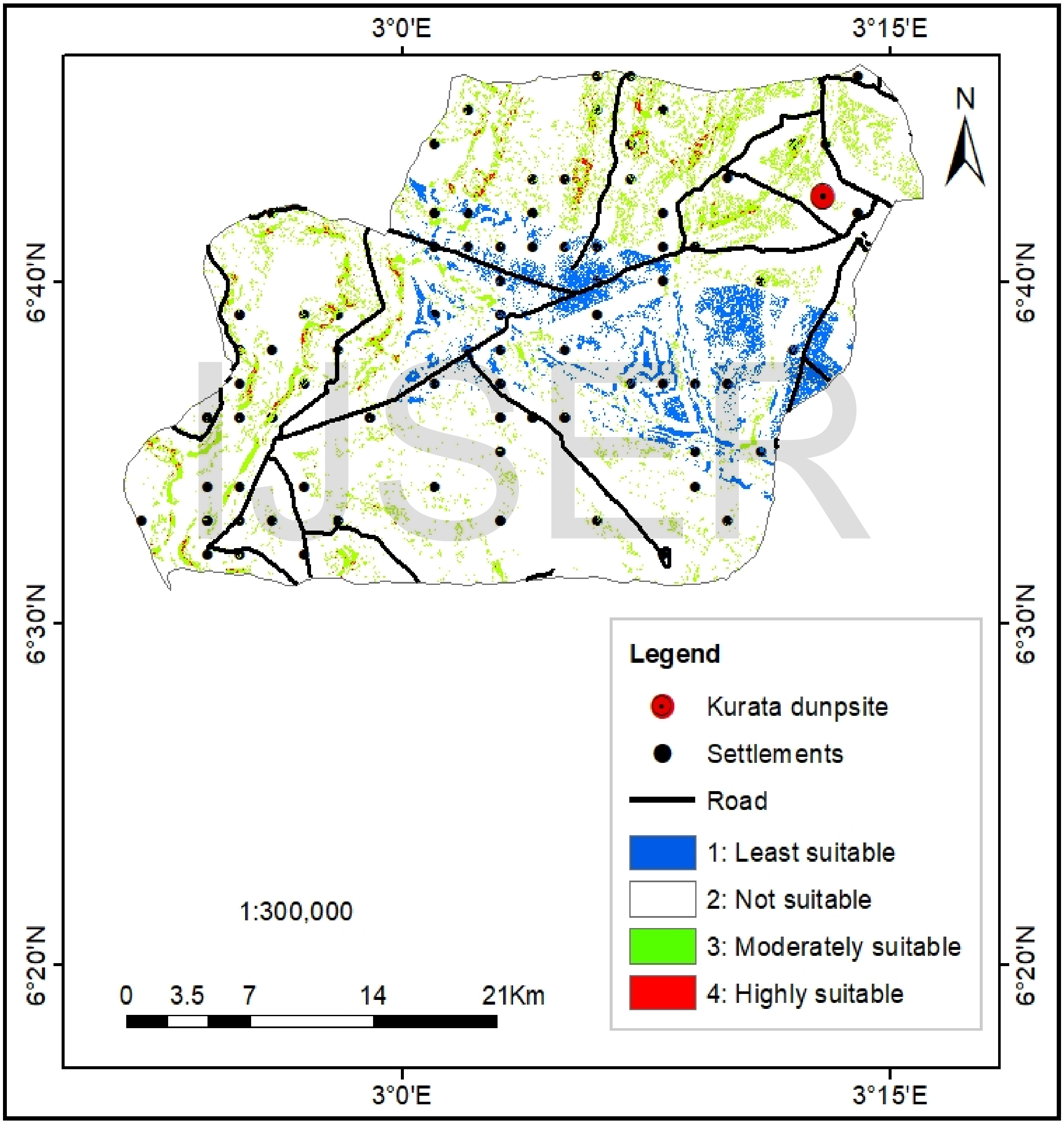


Fig.11: Suitability text Map

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

All the criteria were mapped using both remote sensing and GIS techniques. They were created as GIS layers and structured in a geo-database so as to ensure consistency of the data during spatial analysis. GIS analysis such as slope analysis, Euclidean distance analysis, reclassification, rasterization, and the weighted overlay were performed. Supervised image classification was carried out to derive the required land-use types for the analysis of the Landsat EMT+ 2016 imagery using Envi software. Slope analysis was carried out on the SRTMDEM to generate the slope of the terrain. Furthermore, Euclidean distance output raster was generated showing the measured distance from the nearest source

The result from this study revealed the effectiveness of GIS and remote sensing as a tool for dumpsite selection, the sites are easy to access and manage for disposal of solid wastes. Kurata, the existing waste dump site examined failed the suitability test and therefore considered to be located in area that is not suitable in the study area.

4.2 Recommendations

Having identified the area best for sitting dumpsites in the study area, it is hereby recommended that the Environmental Department in the Local Government Areas within the study area and the Town Planning Authority should make use of this site suitability analysis model to serve as a guide before approving dumpsite in the study area. Further study should be carried out on the identification of optimum site for locating a Solid waste dumpsite in the study area. The study suggests that the Kurata dumpsite should be relocated to a more suitable area in the study area

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