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USE OF GIS IN STUDY OF SUITABILITY REFUSE DUMP SITES PLACES IN KEFFI METROPOLITAN NASARAWA STATE, NIGERIA

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Abstract: There are cases of outbreak of diseases through water contamination, pollution and unpleasant odour due to the closeness of the disposal sites to residential. This and much more had affected the urban aesthetics that most local authorities have ignored the effects of municipal solid waste disposal. This study aims to verify the suitability of refuse dump site locations and to provide solution to where the new locations of the 10 dump sites will be located. Ten existing refuse dump site locations are considered by using suitability criteria such as roads, rivers, vegetation and residential areas. Various analyses are performed such as the kernel density, Euclidean distance and buffer analysis using spatial analyst in ArcGIS 10.0. The result from GIS analysis had shown that all the present existing ten refuse dump sites in Keffi are not suitable for dumping sites.
Keywords: Refuse, GIS, Dump site and Solid waste.

1.0 Introduction

It is an important area of emphasis on the provision of environmental qualities to dispose waste properly and if possible to find ways of changing the waste into useful materials. Management of waste, both liquid and solid, has become a critical environmental concern particularly in the urban population of Nigeria. The increase in the rate of consumption and rise in per capita income accelerates the rate of dumping of solid waste. All waste materials, whether they are hazardous or non-hazardous fall within the remit of waste management. Waste management practices can differ for developing and developed countries, for rural and urban area, and for large scale or producers in manufacturing industries. Management of residential and institutional waste in metropolitan areas is usually the responsibility of local authorities, while management for non-hazardous commercial and waste from the industries is usually the responsibility of the generator subject to local, national or international controls (Vesilind *et al.,* 2002; Agamuthu, 1997; Begum et al).

The collection, and ultimate disposition of household and commercial waste, is one of the fundamental local government services, essential to maintaining a clean and disease free society. Urban areas are littered with garbage as a result. To find suitable land for disposal, or

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central waste treatment plan and management facilities in most of the urban areas become difficult. The problem is most severe in the densely populated areas especially in Nigeria. The increase in resource consumption pattern has had an unintended and negative impact on the urban environment- generation of waste far beyond the capacities of urban government and other agencies.These problems forced the most communities to participate in daily or weekly sanitation or involving private sector into private partnership for the collection of huge refuse dumps. In the view of the above statement, there are so many techniques that have been applied to overcome dumping of waste and of the latest technology to use as a tool is known as Geographic Information System.

The solid wastes are categorized into residential, commercial, municipal, industrial, open Area, treatment plan and Agricultural waste In other word, solid waste can be organic or inorganic waste materials produced by various activities of the club.In order to determine the suitability of refuse dump sites, efficiently and effectively in any Nigerian community, there is need to develop a national waste disposal database. This study would develop a GIS database on refuse disposal and to identify the exact location of the dump sites. The developed system will be utilized in the management and planning for solid waste disposal, which would eventually eliminate and eradicate the problems, associated healthy human conditions (Tchobanoglous, 1993; Bamgbose, 2009).

1.1 Municipal Solid Waste

A municipal solid waste management system needs solid management techniques where the present of a sanitary landfill is important. The versatility of landfills increase in the rate of population growth, and the dump sites also increase in number. This turns the situation very difficult and challenging issue, especially GIS to make decisions using multi-criteria analysis to select the optimal dumping sites (Yesilnacar *et al.,* 2012). Solid waste management is a complex process that requires the cooperation of the Local Authorities and the participation of the private partnership and other disciplines. In this juncture, the use of technology, and many innovative solutions is greatly paramount in association with the disposal, generation, handling, storage, collection, transfer, transportation, processing and recycling of waste have been advanced to address this problem. All of these processes perhaps innovative or classical have followed the existing legal regulatory and social guidelines that protect the public health and the environment. For the disposal process to be responsive to the public attitudes the disciples that must be considered in administration, financial, legal, architectural, planning

and engineering functions must be incorporated. At the beginning of the 1990s, most municipal refuse is disposed of by tipping at the so-called landfill site. However, this option is traced with growing political and economic difficulties land till has been criticized as a viable disposed option because it produces toxic lactates which can contaminate waste supplies and also produces combustible landfill gas from the anaerobic decomposition of putrefied waste. There gases, once they have entered the atmosphere, act as greenhouse agents, and one kilogram of methane is believed to be up to 60 more powerful than carbon dioxide in its contribution to global warming and constitutes some 16 percent of greenhouse gases. Therefore, landfills continue to be the useful center for refuse disposal, depending on the location, about 90 percent of solid waste generated in all over the world is recently disposed in landfills (Gendebien *et al.,* 1992). Landfilling is probably the cheapest way to treat waste. Therefore, up to 80% of the world practice open dumping. For this reason, special attention should be paid to this final disposal option, mainly in developing countries. In continents such as Africa, 95% of all social waste is dumped or landfilling. There is no landfill in Chennai city that make it possible to find suitable land for solid waste disposal in India. Mostly the use of fussy logic is applied to such situation (Suresh and Usha, 2008).

2.0 Problem Statement

Vacant lands that are useful for urban development were turned into dumping sites or landfills. The concentration of human settlement has the ability to produce large amount of waste (Zerbock, 2003).How refuse dump sites and planning of waste disposal have affected the development of cities aesthetics, and what are the impacts of the dump sites locations at the local level. So far, there is no efficient system to manage the existing refuse dumps in Keffi, Nigeria. Residents in the area are attacked by diseases and unhealthy conditions. Large quantities of waste materials are being disposed and burnt without collection thereby creating pollution and environmental uncertainties. Solid waste has a potential to pollute our environment through the air, land and water at local and global levels. So,we have to find the convenient way to monitor and manage the disposal of waste as compared to the conventional methods of disposal.

The objectives of this studyare to: locate the locations of the existing dump sites, identify related issues pertaining to the proximity of the dump site locations, create a GIS database relating to the dump sites and analyse the suitability of the dump site locations using GIS analysis.

2.1 Study Area

Keffi is a located at Lat 8˚, 51' 25˝ N and Long 7˚, 52' 40˝ E and it has an area of 13 km^2. Historically, Nassarawa State came into existence on the 1st of October, 1996, by the then military government. Figure 1.1 shows Keffi town in within the state.

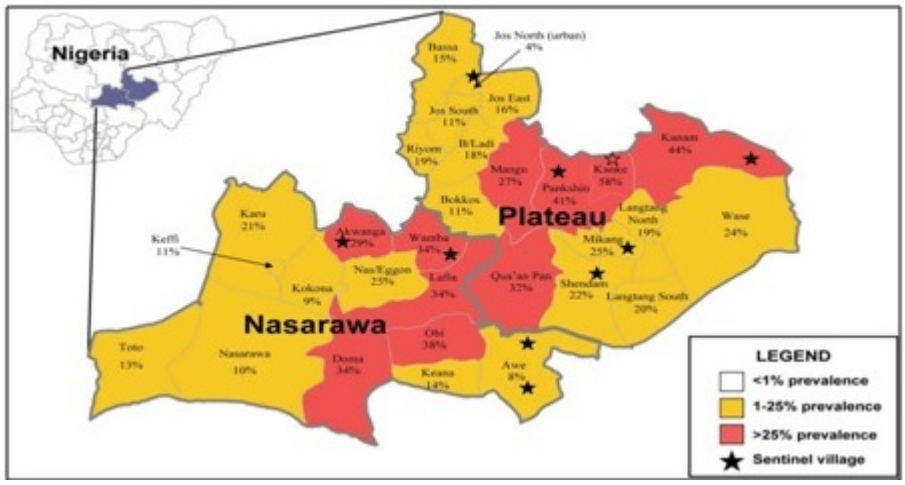


Figure 1.1: Nasarawa state and the study area (source: ajtmh.org)

3.0 Methodology

Data collection is a procedure established to develop and define the required data types and the qualities and quantities of data gathered. The refuse dump site data are collected and georeferenced as a spatial data. The non spatial data include the types of refuse disposed, number of households, number of people in a household, the weight of the waste disposed, are all required for developing the database. Figure 3.1 illustrates the flow chart used in this study, whereas Figure 3.2 shows the model builder of the project.

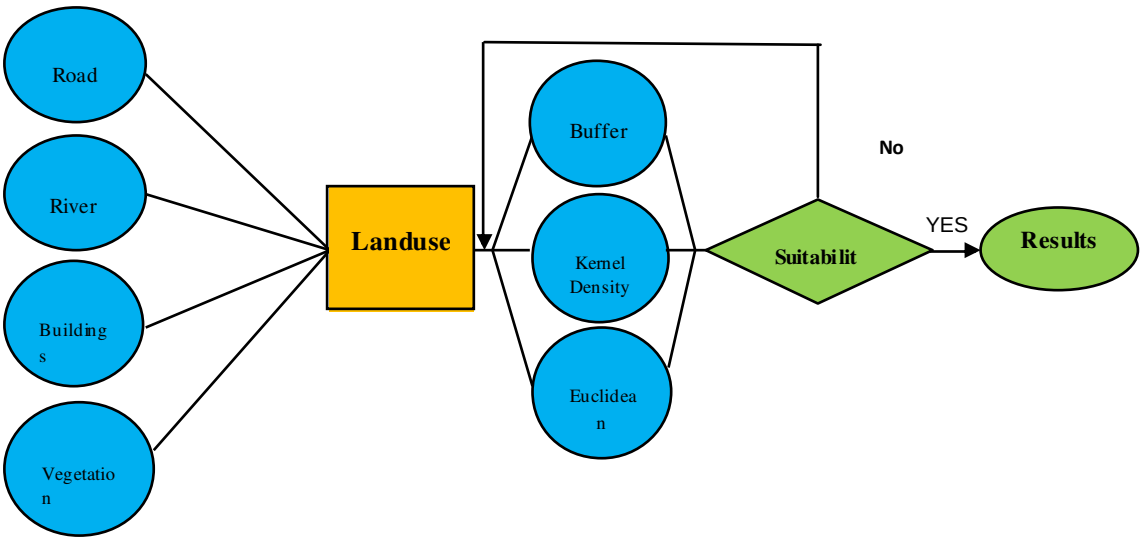


Figure 3.2: The model builder of the Project

3.1 Data Collection

The field data of the 10 refuse dumps are of two types; that is primary and secondary data as shown in Table 3.1. About 10 selected dump sites were chosen from the study area with their accurate coordinates. It is paramount to consider the dump site locations, as distributed over the space, by this we can visualize its problems with the environment as well as design appropriate analyses for all the refuse dump sites. While for the attribute data, we used the database and some statistical techniques. Careful planning and design, using the required analyses for the dump sites is important so that residential disposal have been monitored.

Table 3.1: Data used in this study

Data Type	Data	Source
Primary	From candidates Questionnaire	People around Keffi
Secondary	**Vector**: Road, River, Building, Vegetation, refuse dump location, and candidates	Digitizing and visualisation from Google earth and geocode and georefrencing from address and questioner
	Raster: 1) Google Earth Image 2) Photograph of the refuse dump locations	Georefrencing by taking GCP at Google earth

3.2. Primary and Secondary sources of data

The primary source, involved the use of User Requirement Analysis (URA) by establishing and administering questionnaires. About 55 questionnaire sample was surveyed in the field for this study.The secondary data involved use of existing map of the Nasarawa State, Keffi Local Government Authority (vector and raster data) and the photographs of the selected refuse dump sites. Figure 3.3 shows the refuse disposed rampantly on the road and riverside.

3.3 Method of Research

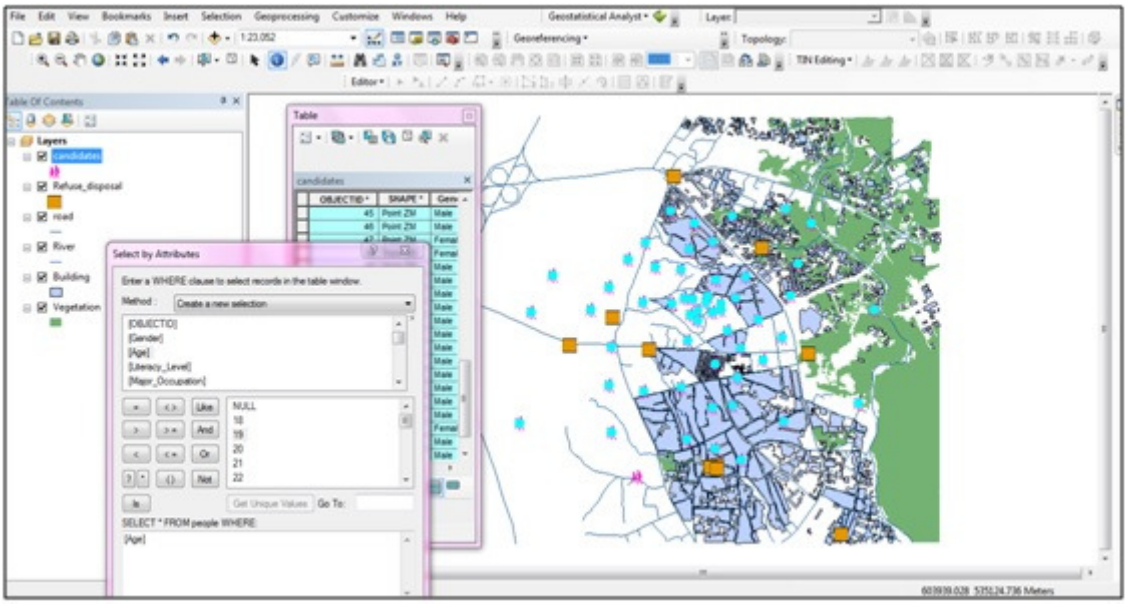
The method of the research in this study is quantitative in nature. In the early stage of this study, understanding on overall of research is important to ensure the needs requirement, problems, objectives, aim, and data collecting. Based on this study, we utilize the GIS applications to solve the problems of dump site locations in Keffi Nigeria.

3.4. Data Preparation

This study contributes of high and huge data sets in term of accuracy, storage, and others. A variety of methods used for collecting data likes, interview in Keffi local government health care department and zonal inspectorate. Private organizations such as the private partnership participation NGOs all in Keffi and in order to gather the data, much more information related to this study was conducted.

3.4.1 Spatial Analysis

Spatial analysis in this study was conducted using GIS which has the capabilities on handling spatial data especially geographical data. In this study,



The Figure 3.3 is an example of GIS capabilities.

ArcGIS 10 is used to conduct the spatial analysis likes, clipping, Euclidean distance, kernel density, intersecting and buffering to produce the outcome or results in form map and other output. The developmental data are important in providing spatial and non spatial. It both displays the output and relate to what can be done especially in decision making.

3.4.2 Database Development

A database is a medium for storing and managing the spatial data and its attributes. This is important in developing a geographic information system. Generally, before capturing the answers, we must do data collecting first and store it to make it manageable.The database has high capabilities to store and secure the data organize well.The purpose to acquire a database is for ensuring the information is not redundantly and as a result the storage required is less.

In this study, there are 3 types of database designs, which are conceptual, logical and physical designs.

Table 3.2: Data types as stored in Database

Entity Name	Attributes	Description	Data Type
Road	ID Length Type	Layer contains the major and minor road	Object id Double Text (string)
River	Id Length	Show the length of the river	Object id Double
People/candidates	Id Name Age Gender	Based on geocode the address of the questionnaire	Object id String Short Integer String
Refuse dump site	Id Name Raster	Field identification (snap image) and visualization of the Google earth image for location	Object id String
Vegetation	Id Type Area	The type and location of vegetation in the area at Keffi	Object id String Double
Building	Id Type	Contain the residential area, hospital, mosque and its	Object id String

3.4.3 Physical Design

Physical design refers to the implementation of the database to secondary memory and explains the structure of storage, data access method, in order to achieve effective data and communicate it directly with the Database Management System (DBMS) that will be used.

3.4.4 Data Requirements

Developing database is to create the structured data storage systems that simplify the process of accessing towards the data and support the study. Based on Figure 3.7, the database was developed by using ArcGIS 10 "ArcCatalog". It can be determined from the resulting database is arranged in a personal geodatabase and divided according to Dataset Features

categories such as Land Use, Topography, raster as well as digital elevation model.The model followed by personal geodatabase then feature datasets and lastly is feature class.

3.4.5 Data Processing

The data obtained was stored in a DBMS and should be revised according to various criteria such as data type, coordinate reference systems, scale, topology, and other attributes. The information received in digital form is reviewed to assure that no errors, redundancy or duplication occurs.

4.1 Analysis of Existing Refuse Dump Sites Locations in Keffi

From the Figure 4.1, we can see that almost all 10 refuse dump sites are close to the vegetation area, residential area, river area, and the road.The Table 4.1 and 4.2 issues presented with statistics as answered by the candidates on the questionnaires. Tables 4.2 and 4.3 are shown the statistical analysis using SPSS by calculating mean, media and standard deviation from the household population.

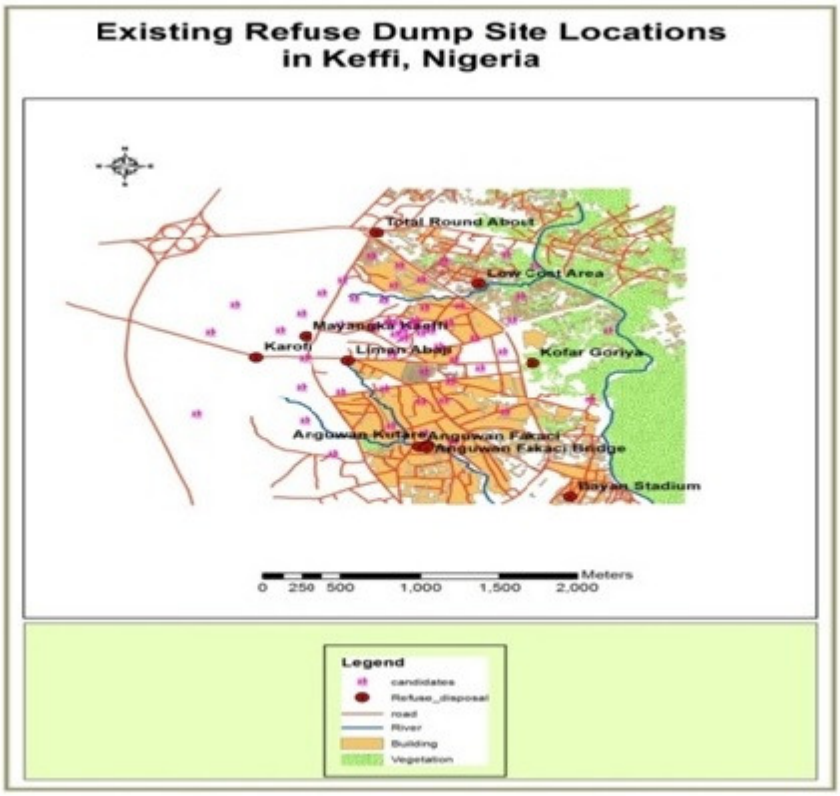


Figure 4.1: Present existing refuse dump site locations in Keffi

Table 4.1: Statistics analysis from the questionnaire

Statistics									
		GENDER	AGE	LITERACY LEVEL	MAJOR OCCUPATION	HOUSEHOLD SIZE	REFUSE DISPOSAL TYPE	HOW REFUSE ARE GENERATED	TYPES OF REFUSE DISPOSED
N	Valid	55	55	55	55	55	55	55	55
	Missing	0	0	0	0	0	0	0	0
Mean		1.20	1.58	2.98	1.75	2.25	1.55	1.85	2.75
Median		1.00	1.00	3.00	2.00	2.00	1.00	2.00	3.00
Mode		1	1	3	2	2	1	2	2
Std. Deviation		.404	.762	.490	.726	1.265	.603	.591	1.308
Skewness		1.542	1.405	1.909	1.942	1.035	.608	.036	.545
Std. Error of Skewness		.322	.322	.322	.322	.322	.322	.322	.322
Sum		66	87	164	96	124	85	102	151
Percentiles	25	1.00	1.00	3.00	1.00	1.00	1.00	1.00	2.00
	50	1.00	1.00	3.00	2.00	2.00	1.00	2.00	3.00
	75	1.00	2.00	3.00	2.00	3.00	2.00	2.00	3.00

Table 4.2: Statistics analysis from the questionnaire

Statistics									
		MATERIAL SELECTION FROM REFUSE BEFORE DISPOSAL	METHODS OF REFUSE DISPOSAL	WEIGHT OF REFUSE DISPOSED PER WEEK	IS RECYCLING GOOD?	FREQUENCY OF REFUSE DISPOSAL/GENERATION	FREQUENCY OF SANITATION	USE OF G.I.S IN RECYCLING	REFUSE DISPOSAL MANAGEMENT TYPE
N	Valid	55	55	55	55	55	55	55	55
	Missing	0	0	0	0	0	0	0	0
Mean		1.76	2.80	1.89	1.15	1.27	2.53	2.89	1.85
Median		2.00	4.00	2.00	1.00	1.00	3.00	3.00	2.00
Mode		2	4	1	1	1	3	3	2
Std. Deviation		.637	1.393	.832	.448	.449	.742	.762	.405
Skewness		.243	-.353	.411	3.228	1.049	-.945	-.333	-1.154
Std. Error of Skewness		.322	.322	.322	.322	.322	.322	.322	.322
Sum		97	154	104	63	70	139	159	102
Percentiles	25	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00
	50	2.00	4.00	2.00	1.00	1.00	3.00	3.00	2.00
	75	2.00	4.00	3.00	1.00	2.00	3.00	3.00	2.00

4.2 Analysis using the Households Population

In the family, population size is used here to calculate the weight of food waste from each household within the study area in Keffi. The Table 4.3 describes the percentages of people or family size that disposes refuse in the dump sites. As it can be seen from the table, about 22 respondents out of 55 have a family size ranging from 6 to 10 people in a house with 40% followed by 1-5 to 30.9%, 11-15 to 12.7%, 16-20 to 5.5%, and households with family size above 21 people has 10.9% respectively.

Table 4.3: Percentages of household sizes

HOUSEHOLD SIZE					
	Range	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	17	30.9	30.9	30.9
	6-10	22	40.0	40.0	70.9
	11-15	7	12.7	12.7	83.6
	16-20	3	5.5	5.5	89.1
	21 ABOVE	6	10.9	10.9	100.0
	Total	55	100.0	100.0	

The graphical presentation of household size in Keffi with the highest value of 40%, and lowest with 6%. Figure 4.2 shows that 22 repondence have agreed that the their dependence ranges between 6-10 per households, 1-5 persons with 17 respodence, 11,15 persons with 7 respondence, 16 -20 persons with 3 respondence and above 21 persons with only 6 respondence.

Also, Table 4.4decribes the frequency of refuse disposal in Keffi, with 40 respondent said that they are disposing refuse in the dump site with about 72.7% while those that disposed refuse weekly in the dump sites are 15 respondents with total of 27.3% respectively.

Table 4.4: Frequency of refuse disposal

FREQUENCY OF REFUSE DISPOSAL IN KEFFI					
	Range	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DAILY	40	72.7	72.7	72.7
	WEEKLY	15	27.3	27.3	100
	Total	55	100	100	

The graphical presentation with the daily and weekly refuse disposal, daily people disposed refuse with 73% while 27% disposes weekly. From this chart we can see that refuse disposal in Keffi is a daily affair with the heighest percentage being disposed daily. Figure 4.4 illustrates that people mostly disposed waste on daily basis in Keffi.

The rapid disposal of refuse in Keffi as decribed by the Table 4.5 has been analyzed about 50 gm weight of refuse is being disposed per week with 38.2% and those that disposed 1 kg to 4 kg has 36.4%. And then about 23.6% disposed upto 5 kg daily. Only 1.8% have no response.

Table 4.5: Weight of weekly refuse disposal in Keffi

WEIGHT OF REFUSE DISPOSED PER WEEK					
	Range	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	50g	21	38.2	38.2	38.2
	1kg - 4kg	20	36.4	36.4	74.5
	5kg - above	13	23.6	23.6	98.2
	NO RESPONSE	1	1.8	1.8	100
	Total	55	100	100	

The Figure 4.5 shows that people mostly disposed refuse which weighted 50 gm per person per week, this perhap is due to the nature of the study area, it is not industrial area where manufacturing is taking place, but most of the refuse generated is commercially and residentail solid wastes.

The Table 4.6decribed the varouis method used in disposing refuse, most of the method employed in the study area is taking the waste to refuse dump site with 49.1%, followed by burning with 32.7%, then recycling with 9.1% and 7.3% of the waste disposed is burried.

Table 4.6: Different methods of refuse disposal in Keffi

METHODS OF REFUSE DISPOSAL					
	Range	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BURNING	18	32.7	32.7	32.7
	BURYING	4	7.3	7.3	40
	RECYCLING	5	9.1	9.1	49.1
	REFUSE DUMP	27	49.1	49.1	98.2
	NO RESPONSE	1	1.8	1.8	100
	Total	55	100	100	

From the illutration in Figure 4.6it can be estimated that the highest method adopted by people of Keffi, most of their waste are taking direct to refuse dump and that is more reason why all the refuse dump site are filled-up with greater impactson environment, socially, economically and health wise.

The next analysis is the types of refuse being disposed, if we look at the compsition of solid waste disposal in developing countries it look similar to these diplayed on the Table 4.7 The highest percent of refuse type being disposed is polythene or plastic bags with 32.7%, followed by garbage with 29.1%, papers with 16.4%, and other refuse constitute 18.2%.

Table 4.7: Types of refuse disposed in Keffi

TYPES OF REFUSE DISPOSED					
	Range	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	PAPERS	9	16.4	16.4	16.4
	POLYTHENE	18	32.7	32.7	49.1
	GARBAGE	16	29.1	29.1	78.2
	RUBBER	2	3.6	3.6	81.8
	OTHERS	10	18.2	18.2	100
	Total	55	100	100	

The analysis had shown that most of the disposed refuse types consists of polythenes and garbages as displayed graphically in the Figure 4.7.

Most of the refuse generated in Keffi are rise by the family with 63.6%, if we compare it with the people in the household, the single generation is individual with 25.5% and followed by the neighborhood with 10.9 % as shown in Table 4.8.

Table 4.8: Generation of refuse in Keffi

HOW REFUSE ARE GENERATED					
	Range	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ALONE	14	25.5	25.5	25.5
	FAMILY	35	63.6	63.6	89.1
	NEIGHBORHOOD	6	10.9	10.9	100
	Total	55	100	100	

4.3 Analysis of Results from the Developed Database

The rest of the analysis is done using GIS applications. The objectives for this study is to find the result in identifying the dump sites, database, new suitable dump site locations and the issues related to existing dump site location.

4.3.1 Density of Refuse Dumps

A kernel density surface, showing the number of refuse dumps per unit area as illustrated in Figure 4.10, this was done using the density toolbox. Kernel density calculates the magnitude per unit area from point features using a kernel function to fit a smoothly tapered surface to each point. The surface value is highest at the location of the point and decreases with increasing distance from the point, reaching zero at a search radius distance from the point. A radius of 0.5km was used. The extract values to points tool under the extraction toolbox in the spatial analyst extension was used to extract the density values of community centroids and recorded into the attributes of the community feature class.

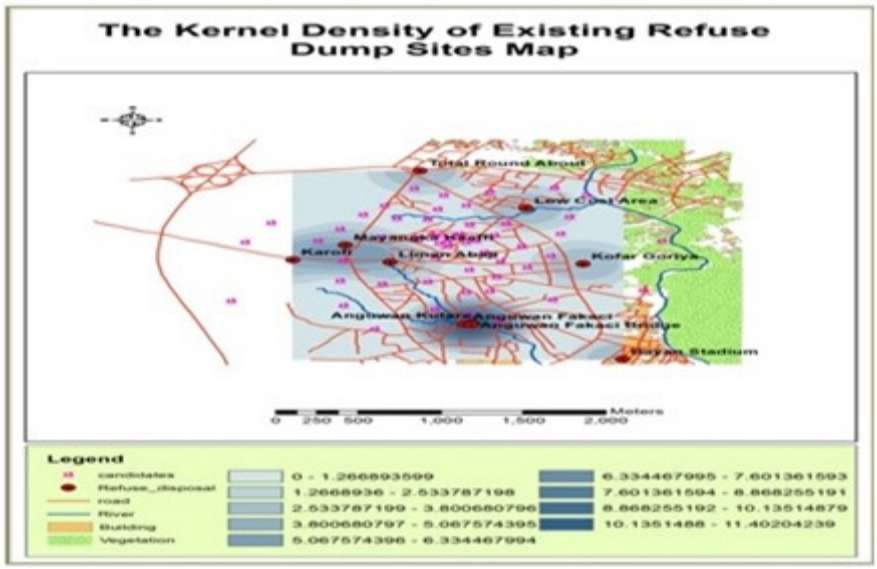


Figure 4.10: Low and high density of the refuse dump site locations

4.3.2 Proximity to Refuse Dump Sites

Using Spatial Analyst extension and the Distance toolbox, Euclidean distance surface was generated in ArcMap, with refuse dumps layer selected as input feature source. This calculates for each cell, the Euclidean distance to the closet source. In this study, a search radius of 0.5km was used. Figure 4.11 and Table 4.10 shows the approximate distance that affects each landuse.

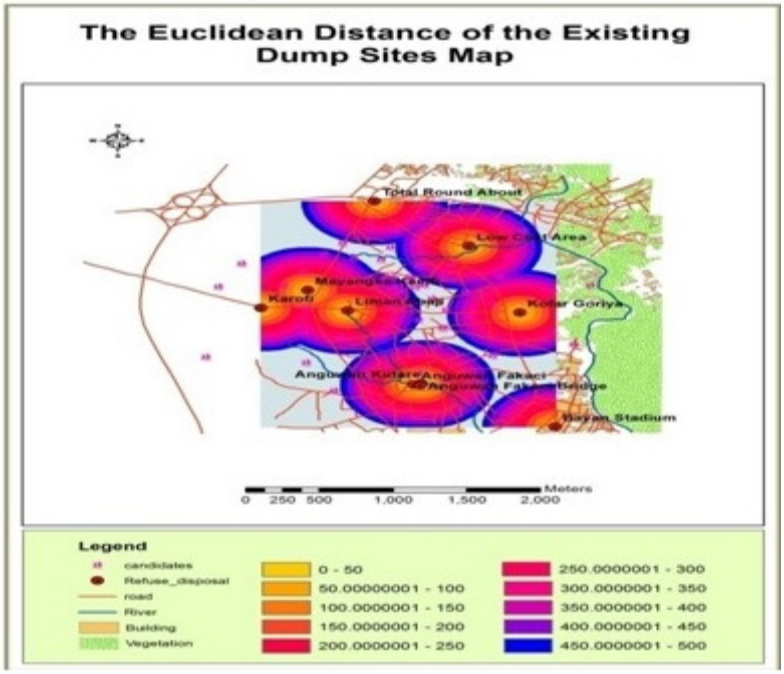


Figure 4.11: Distance of dump sites locations its affects on residential health

Table 4.10: Distance of the major landuse in the study area

Type of Landuse	Total length and area (m)	Location effected (m)	% location effected (radius <300 m>
Road	71004.02	42710.17	60%
River	8483.39	4467.01	52%
Vegetation	18709.72	4446.59	23%
Building	25334.72	20397.48	80%

Health issues also it effects the resident due to the distance (300 m) with highest percentage of 80%. Most of refuse dumps sites are located closed to the river or water resources used for domestic human usage such as drinking, cooking, washing, cleaning, and for and bathing. Examples, the prevalent diseases includes typhoid, cholera, malaria, dysentery, lung cancer and respiratory infections and other related diseases with destruction of ecosystems.

5.0 Conclusion

There are a lot of benefits derived from the careful study of waste, especially in the developing countries because it made us realize the importance of keeping our environment clean and clear from the dirt. Environmental sustainability is an all round concern to meet the necessity of modern technology such as GIS to integrate the spatial data into use.This work portrays the complexity in determining the possible solutions to make people cognizant of the effects of living near to the refuse dump sites.

The application of GIS in selection of suitability and appropriate location of refuse dump sites in Keffi has brought number of lessons; the capability of GIS has displayed results showing all the trends in the geodatabase. Another advantage is the capability of handling bulky data in a repository both spatial and non spatial data. GIS has tools that provide alternative operations especially the role of spatial analyst tools.

There also needs to prioritize for the involvement of the NGOs to help in investment through cooperating bodies in the state to handle refuse disposal issues since government alone cannot solve the existing problems. It is the communal mode of operation for everyone to insure cleanliness.

The use of GIS has proven very effective in analysing the suitability of refuse dump site location in Keffi. In reality, there is need to investigate the situation physically so that the true picture of the analysis can be imaged in the area.The location parameters, the new sites for refuse dump and people involved.

6.0 Recommendation

The major challenge facing developing countries especially Nigeria is lack of maintenance culture, whereby people do not consider that our environment needs to be safe and free from diseases. The nonchalant attitude is there that people mostly wait for the government to solve all their needs and problems.

However there is a need to sensitize public on public hygiene and on how to dispose refuse from their household to refuse dump sites in a proper manner. The health inspectors are responsible to manage such situation under ministry of health. The house to house inspection can help in checkmating the reckless disposal. The use of GIS techniques and analysis are so important in determining the suitability index.

There is also need for further expansion in the area of research and development to take into cognizance the ever increasing population and manpower development so that the needs

assessment will be projected to satisfy the general public. Since we just focused on the selection of suitable dump sites with certain parameters, a global view on this issue probably will be better highlighted for future research such as expand the study area, increase or add other parameters, efficient management of waste disposal, combined techniques and many more.

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