

Design and Development of GIS Database for Informational Awareness on Waste Disposal in Keffi Nigeria

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Abstract: *Refuse is one of the recent environmental problems facing developing countries. The capabilities of GIS technology can be deployed to overcome the issues pertaining to dump sites management. In this paper the emphasis is to develop a system using GIS database to monitor the activities of man toward generation and waste disposal. The ability to take care of urban esthetic is concerned urban planners to fully apply geographic information system in designing, planning, and management of geodatabase. The GIS database will help in locating suitable areas for refuse disposal and tracking people attitude toward dump site locations. Information is vital in planning processes so that people will be aware about how to relocate refuse at right time and suitable dump sites.*

Keywords: *Gis, Waste, Planning, Geodatabase, Information*

I. Introduction

It is an important area of emphasis in 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 accelerate the rate of dumping of solid waste. Waste management is the processing, collecting, transporting or disposal, managing and monitoring of wastes materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on environmental aesthetics and health. Waste management is a distinct practice from recovery of resources which focuses on delaying the rate of consumption. All wastes materials, whether they are liquid, solid, gaseous or radioactive fall within the remit of waste management. Waste management practices can differ for developed and developing countries, for rural and urban areas, and for residential or producers in manufacturing industries. Management of residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and waste from industries is usually the responsibility of the generator subject to local, national or international controls (worrell et al, 2011).

(Muhammad 2007) stated that traditionally, waste have dumped on the cheapest and least desirable land, or at the nearest convenient space usually such dumping ground are occupied or are surrounded by less fortune citizens. The dumping of wastes in area not designated as dumping grounds by the Local Authorities (LAs) is cost-free and we refer to it as 'illegal dumping'.

The collection, and ultimate disposal 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 central waste treatment plan and management facilities in most of the urban areas become difficult. The problem is more severe in the densely populated areas especially in Nigeria. 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. Most cities face the same reckless dumping of refuse along the roads side. These problems forced most communities to participate in daily or weekly sanitation or involving private sector into private partnership for the collection of huge refuse dumps.

Refuse is simply defined as a solid waste which comprises all discarded goods generated by human and animals in their environment. Solid waste management is concerned with the collection, generation, transfer, transport, processing, recovery and disposal of the solid waste. Today, solid waste management is multidisciplinary based on engineering principles, economics, urban planning and more recently, GIS (Crites et al, 1993)

Background Of The Study

Study of refuse disposal and types of solid waste together with composition and amount of refuse generated, will be a product of basic operation and functional element associated with planning and management of solid waste. This study focuses on the development of GIS database as an application to monitor and manage refuse disposal in Keffi, Local Government, Nasarawa State Nigeria. The solid wastes are categorized into residential, commercial, municipal, industrial, open Area, treatment plan and Agricultural waste (Tchobanoglous 1997). Waste is continuously becoming a problem at global and local levels. Solid wastes is derived from human and animal activities that are normally discarded as useless or unwanted. In other word, solid waste can be organic or inorganic waste materials produced by various activities of the society (Opara 2008). In order to manage solid waste efficiently and effectively in any Nigerian community, there is need to develop a national waste management database. This study would develop a GIS database on refuse disposal and identify the exact location of the dump sites. The developed system will be used in management and planning of solid waste disposal, which would eventually eliminate and eradicate the problems, associated healthy human conditions.

Problem Statement

Problem associated with the management of solid waste in today's society is complex because of the quantity and diverse nature of the waste. Vacant lands that are useful for urban development were turned to dumping sites or landfills, (George 1993). How good management and planning of waste disposal does affects the development of cities aesthetics, and what are the impacts of solid waste disposal at the local level. So far, there is no efficient system to manage solid waste disposal. Residents in the cities and towns produce large quantities of waste materials continuously which they cannot ordinarily dispose effectively or safely by themselves. The waste material accumulated from collective and individual creates menace to public health as well as the environment. The burning of the refuse creates air pollution, fire hazard, and utilizing valuable space needed for other purposes. Refuse collection or removal is paramount to the public interest, universally agreed that municipal government must make suitable arrangement for evacuation and disposal of solid waste. Although Local Government Authority has being trying to find solution to such but no efficient system exist to manage waste effectively. There is issue of inefficient management because people still practice conventional method of disposal of refuse which is not suitable in our current situation. No sufficient technology to apply or to monitor the disposal of refuse, as a result, it became problem to the societies. Lack of specific landfills for disposal courses refuse to blocked streets, sewages, drainages, roads; pollute the environment, influenced spread of diseases and course unpleasant odor. In view of the above problems, we have to find the convenient way to monitor and manage the disposal of waste as compared to the conventional methods of disposal According to (Diaz 2006), stated that solid waste has a potential to pollute our environment through air, land and water at local and global levels. One of the problems is the trends in the increase of consumption and production patterns and by continuing urbanization of the world. The problem is more acute in the developing countries of African like in Nigeria.

Aim Of Study

The aim of this study is intended toward design and development of GIS database for refuse disposal dump sites management in Keffi, Nigeria and finding possible solutions using GIS applications and analysis.

Objectives Of Study

- To design and develop a database for the refuse disposal dump sites management.
- To improve the conventional method of refuse disposal.
- To find suitable ways for managing refuse disposal.

Study Area

Keffi is a located at Lat 8°, 51 25" and Long7°, 52 40" and it has an area of 13 sq. km. Historically, Nassarawa State came into existence on the 1st of October, 1996, by the then military administration. Figure 1 shows the study area by satellite.

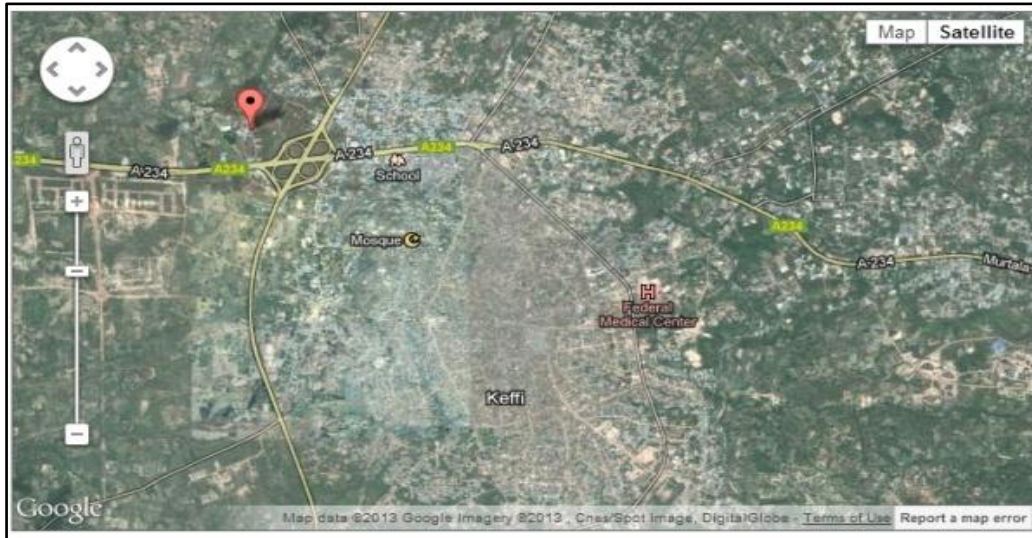


Fig1. Satellite image of the study area (Google Earth)



Fig2. Study area - Keffi (ajtmh.org)

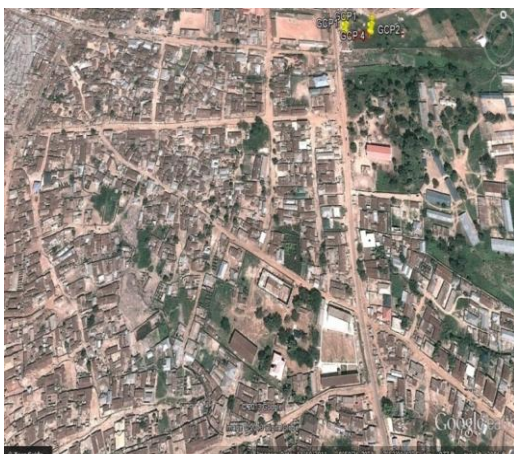


Fig3. Web map of survey area :

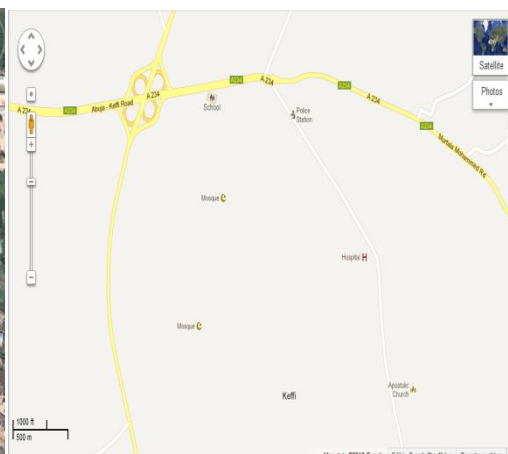


Fig 4. The study area (Keffi) source: from satellite (Google Earth) (Google Map)

II. Methodology

This study will be focused on the spatial data collected in the field. Appropriate sample size were selected, about 50 questionnaires has been administered. We intend to design and develop a database base on the response of the processed data. The GIS application will tender an improvement of conceptual, logical as well as the physical designs of geodatabase. The designs however will determine the types of applications, software for the analysis. The software to be used includes ArcGIS, SPSS, Google Earth, Google Map etc. The study will embark upon the primary data collected which will be sequentially followed to achieve the stated objectives. This study were divided into three phases

Phase-1 the conceptual design developed model or graphics and charts so that presented data will be analyzed using relational data model with appropriate GIS analysis

Phase-2 the logical design where the data collected will be presented

Phase -3 the physical design of the database

It is expected that after the analysis, the conceptual database model will enhance and improve the techniques of refuse disposal in the right dumping sites. The data in this study will be analyzed using selected statistical analysis in GIS application. The methodology used for investigation of this study is split into six stages; problem identification, planning and management, requirement and design, testing and fine tuning, manipulation and evaluation and end by making recommendation. This study is qualitative in nature, it make use of user requirement analysis (URA) in data collection.

Data Collection

Basically, two types of data have been collected: collection of data with GPS. The primary source, involved the use of User Requirement Analysis (URA) by establishing surveyed field data and use of existing map from the Nasarawa state, Keffi Local Government Authority and the photographs of the selected refuse dump sites.

Software Used

The following software will be used in this study

1. ArcGIS 10.0
2. Google Earth
3. Google map

The sample data was collected in the field from random sampling so that all the study area will be covered. Snapshot, satellite images had be analyzed by using popular GIS software AcrGIS 10.0.

Solid Waste Management Planning

This can be described as the process whereby an alternative programs and plans are developed to solve solid waste problem. The alternative programs and plans must be presented to public for decision making, selection, and adoption. the management planning of solid waste disposal are listed in steps-by step planning procedure such as

Step 1: problem Definition and Specification; the most critical stage in planning study is to find out the clear problem statement and related specifications for people to make decision about solid waste management

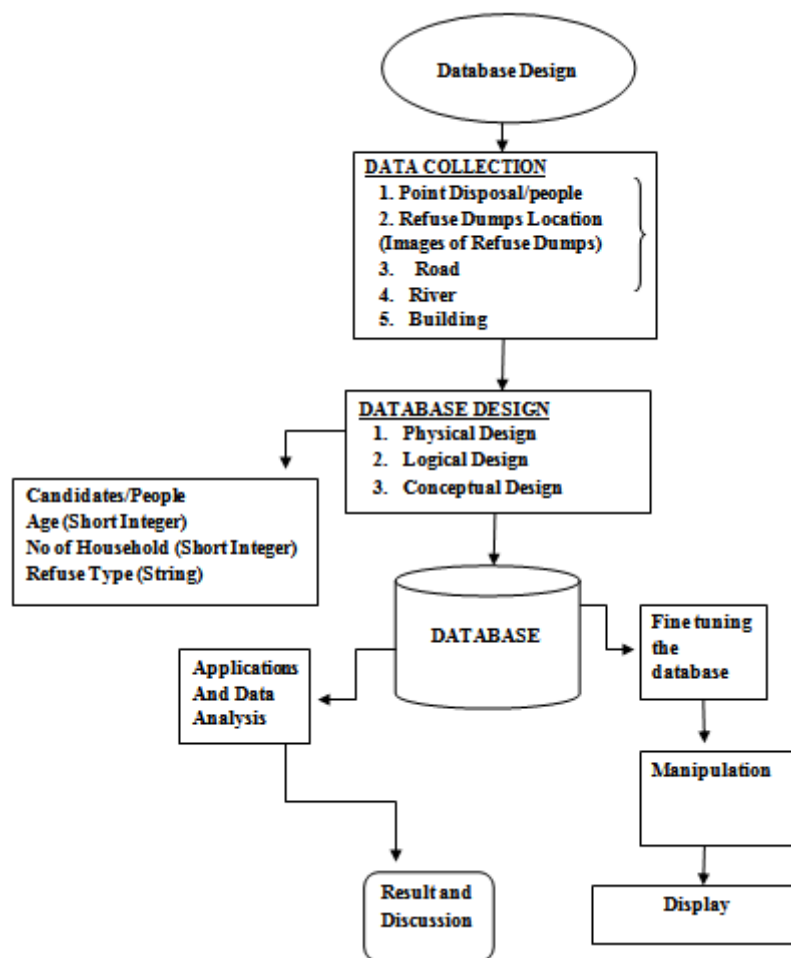
Step 2: inventory and Data Accumulation: here relevant data need to be collected to meet the problem specification. The purpose of inventoring the data is to define the existing solid waste system, so that accurate information is enough for consideration, like collecting up-to-date population data in a survey.

Step 3: Evaluation and Alternative Development: this step usually describes the evaluation and analysis of data collected in step 2. Addition information may be necessary before the program is formed.

Step 4: Program and Plan Selection: here limited number of alternative can selected to be included into planning process. The administrative control of all program is identified for evaluation purpose

Step 5: Development of Implementation Schedule: when there is a failure in planning, the expected contributory factors may include; lack of a well-defined implementation schedule to administrative and management organization

Methodology



Database Design- flow chart (2015)

III. Discussion

Waste invariably refers to lack of use or useless remain, waste is a by-product of human activities, physically, it contain the same material as are found in useful products (McDougall 2002). Health and safety have been the major concern in management of waste. Waste must be managed in such a way that it can minimize the risk to human health. The word Refuse means waste papers, waste clothing materials, food scraps, ashes animal droppings and carcasses. Other materials collected from road sides, swept or animal farm (Kumar et al 2004). Improper solid waste management leads to substantial negative environmental impacts (for example, pollution of air, soil and water, and generation of greenhouse gases from landfills), and health and safety problems (such as spread diseases by insects and rodents attracted by garbage heaps, and diseases associated with different forms of pollution). Municipal or local authorities charged with responsibility of providing municipal solid waste management services have found it difficult to tackle such problems. The difficulty has been aggravated by lack of effective legislation, inadequate funds and services, and inability of municipal authorities to provide the services efficiently. Change in lifestyles such as use of canned drinks, mobile phones, and disposable diapers, discarded papers and polythene bags increases in “consumer society”. Moreover, will pose special waste management challenges, as waste management systems in developing countries are incapacitate to match or address the lifestyle change.

Information Needs In Gis Application

Since the early 1970s, there has been a continuous growth in the regulatory reporting requirement imposed by federal regulatory agencies and by state agencies that have followed the federal lead. These regulations were imposed in response to public demand for restoring the environment and for reducing the quantity of waste generated by industrial organisation from manufacturing processes. At the same time, there has been a superimposed increase in the regulations relating to safety and health that have added to the burden on industry for dealing with these issues (William 1995). International regulation requirements have followed

U.S lead in most instances, however, in Europe there is a different relationship between industry and government, one that is not adversarial and is, conversely, based on a strategy of cooperation between the parties. This philosophy is also found in other international settings where government support of industrial development is different from that of the U.S, and has been a factor in this nation's international competitiveness in the consumer product market. Information requirement for regulatory compliance with waste management, safety and health issues, however, will become increasingly important as these countries increase their living standard. The role of Geographic Information Systems (GIS) in solid waste management is very large as many aspects of its planning and operations are highly dependent on spatial data. In general, GIS plays a key role in maintaining account data to facilitate collection operations; customer service; analyzing optimal locations for transfer stations; planning routes for vehicles transporting waste from residential, commercial and industrial customers to transfer stations and from transfer stations to landfills; locating new landfills and monitoring the landfill. GIS is a tool that not only reduces time and cost of the site selection, but also provide a digital data bank for future monitoring program of the site.

Waste Management System in Developing and Developed Countries

Because of the need to develop faster on borrowed idea and technology most developing African countries have ended up as dumping ground for hazardous and toxic waste from the developed world 'anybody can throw anything, anywhere at any time and in any quantity (Santosh 2000). According to (Solomon 2009), it is estimated that an average Nigerian generates roughly about 0.49kg of solid waste per day with commercial and household waste contributing about 90% of the total solid wastes in urban areas. The consumption of the final products has created a possibility for residual recycling, reducing and reusable of generated solid wastes in our cities, (Ray 2008). Waste management is the collection, processing, transporting, recycling or disposal of waste materials by human interactions or activities. Managing waste for non- hazardous residential and institutional waste in municipal areas is usually the responsibility of local government authorities while management of commercial and industrial waste is the responsibility of it the generator (Tchobanoglous 1993). In 1988 the Ministry of Housing And Local Government (MHLG) prepared an "Action Plant for a Beautiful and Clean Malaysia" the main objective is to have a clean and beautiful environment, a better quality of life, and congenial environment to promote tourism. It also take into consideration the open dumping of waste and poor management at disposal sites and proximity of disposal sites to residential areas.

(McDougall2003) observed composition of solid waste in selected developed countries such as In Zurich, Switzerland 1997; waste management was stable because of economic scale and continuous technological improvement. The county has a population of 360,000; total solid waste disposed in tones is 239,000. Total composted- 6%, total recycled-19%, total incinerated-56%, and total landfilled-19%.

In 1998 he also studied waste management in Seattle USA. Seattle faced a crisis due to insufficient landfills and the available ones are only two which had been closed. Therefore the waste was being sent far away. This resulted in an increase in the cost of waste management by public in Seattle's with about 82%. Seattle has total population of 533,660; total waste in tonnes 725,107 and total operating cost is about 82.1 million US Dollars in 1998. Total composted-7%, total recycled-36% and total landfilled with about 57% respectively. While in Copenhagen Demark, in 1996 the total waste generated and disposed in summary include; total population is 555,000, total waste materials in tonnes is 867,000, total composted 2%, total recycled 64%, total incinerated 27%, total landfill 4%, and special treatment has 3%

Worrell et al, 2011 described disposal of solid waste as misnomer. Our present practice amount to nothing more than hiding waste well enough so it cannot be readily found. The placement of solid waste on the land is called a dump in the USA and a tip in Great Britain (as in tipping). *The* dumping is by far the least expensive means of solid waste disposal, and thus was the original method of choice for almost all inland communities. Average affluent American throws away nearly a ton of solid waste each year. The normal methods for disposing and processing of solid waste are land disposal and incineration (Robert 1978). Planning of urban solid waste management requires continuous assessment of much complex interaction among transportation system, land use patterns, urban growth and development.

IV. Result

The spatial analysis using query from the developed database system displaying the spatial data at exactly point of refuse disposal. The yellow colored pattern in map below Fig 6 depicts the existing dumping center and the picture displayed the pictorial dumping sites.

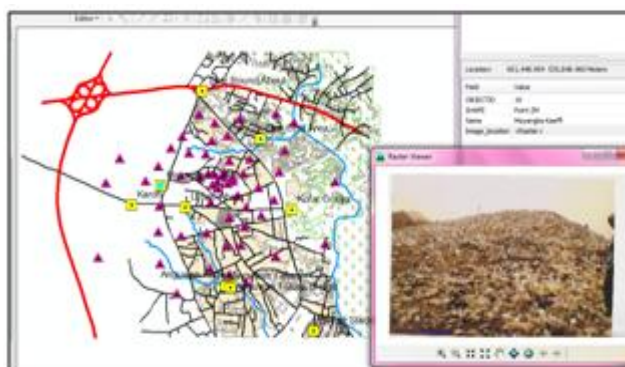


Fig 6. Result from the (ArcGIS 10.0- ArcMap)

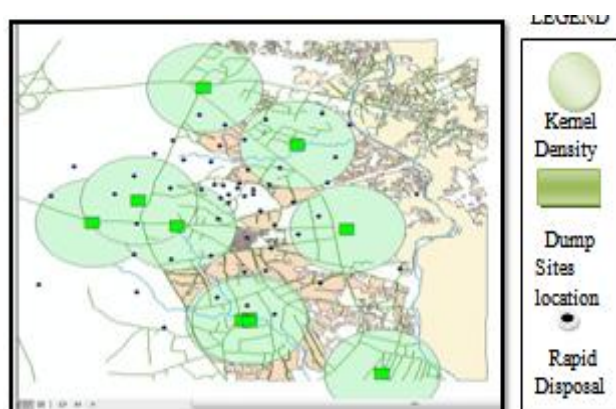


Fig 7. Kernel density of Dump sites showing affected areas of disposal

V. Conclusion

At the end of the study, a GIS database is produced. Queries will also be performed on the spatial geodatabase to obtain relevant information from it and explore its functions. All the data that are analyzed will be presented in tabular, graphics, charts, maps etc in this study. People will now understand that a system exist which make it easier to for them to monitor waste disposal if possible to find a suitable location or managing their refuse.

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