SPATIAL LOCATION OF SOLID WASTE DUMPSITES AND COLLECTION SCHEDULING USING THE GEOGRAPHIC INFORMATION SYSTEMS IN BAUCHI METROPOLIS, NIGERIA

Dr. Jonathan Ali Ogwuche

Dept of Geography, Benue State University, Makurdi, Nigeria

Abstract

This study examines the application of Geographic Information Systems in determining the spatial location of solid waste dump sites and collection scheduling in Bauchi metropolis. The study used the field survey and survey research design to acquire spatial and non-spatial data respectively. The spatial data were obtained using a Quickbird image and map of Bauchi State, as well as GPS, and ESRI ArcGIS 9.2 software. The non-spatial data on household size, waste generation and disposal were obtained from the interview of 38 households sampled in the area. The study obtained data on household solid waste generation, disposal as well as collection schedule, and identified hotspots of solid waste dumpsites in the area. The study revealed that the average household size is 9, daily solid waste generated per household is 6.11kg, and per person is 0.80kg. While 40% of the solid wastes generated are managed by BASEPA, 30% are indiscriminately dumped in unauthorized spots in the area. The map of the area showing the spatial location of the identified hot spots of the dumpsites was produced. The study recommends the employment of the integrated solid waste management system that requires geospatial information if sustainable solid waste management in urban areas is to be achieved.

Keywords: Geospatial data**,** Environmental sustainability, Geographical Information Systems, Integrated solid waste management system

Introduction

Solid waste is a global phenomenon that has attracted global concerns. The generation and management of urban areas due to high density of residential areas due to high density of residential areas, urbanization, industrialization and the inefficiency of the collection systems

(Yusuf, 2010). The 7th goal of the Millennium Development Goal is to ensure environmental sustainability. The pursuit of environmental sustainability is an essential part of human well-being (UNEP, 2004). According to the World Health Organization (1997), improved solid waste management is an important aspect of environmental sustainability which offers opportunities for income generation, health improvements and reduced land vulnerability.

It is a well known fact that the geographical setting of a place, as well as the socioeconomic characteristics of households influence the scale and nature of human activities and structures within that environment, and in turn influence the types of waste produced (Yusuf, 2010). In Nigeria 25 million tonnes of municipal solid waste are generated annually, where 60% of the wastes are organic and only 8% are recovered for reuse (Ogwueleka 2009). Also, the institutions appointed to manage these wastes have failed in this regard, especially as the wastes are generated at the rate beyond their capacity to handle (Onibokun and Kumuyi, 1996). High population growth rates and increasing socioeconomic activities have resulted in the generation of enormous amounts of solid waste, posing a serious threat to environmental quality and human health.

In Nigeria like most developing countries, wastes are commonly dumped in open dumps, uncontrolled landfills where a waste collection service is organized or burnt in any available open space within the neighborhood of residential areas.((Ogwueleka, 2009). In the same vein Achenyo (2009) said that this menace has now become an essential part of the Nigerian landscape as seen along the roadside, market places, undeveloped plots and on every street. This concern has attracted this research to identify the hot spots for these indiscriminate dumping of solid wastes and organize a schedule for their evacuation from households in Bauchi metropolis.

The study area

Bauchi State lies between latitude 09^{o} 52^{I} and 09^{o} 86^{I} North of the Equator and longitude 10^{o} 45^{I} and 10^{o} 45^{I} East of the Prime Meridian (Fig. 1). The study area is located in the heart (center) of Bauchi metropolis. Bauchi city is formerly called Yakoba, and is located on the northeastern edge of the Jos plateau. Bauchi state was derived from Bauchi town. Bauchi town is named after Baushe, who was a brave hunter during his time. Baushe was the first settler in Bauchi before the arrival of Mallam Yakubu the first Bauchi ruler. Bauchi, according to early Hausa translators means “no animal ever escaped the trap and arrow of a hunter”. It covers a total land area of 3,687 square kilometers, and a population of 493,810, according to the 2006 population census. It is the most populous part of the state, as it serves as the seat of the state government. This increase in population, coupled with the socioeconomic activities in the metropolis has implications for solid waste generation, disposal and management in the area.

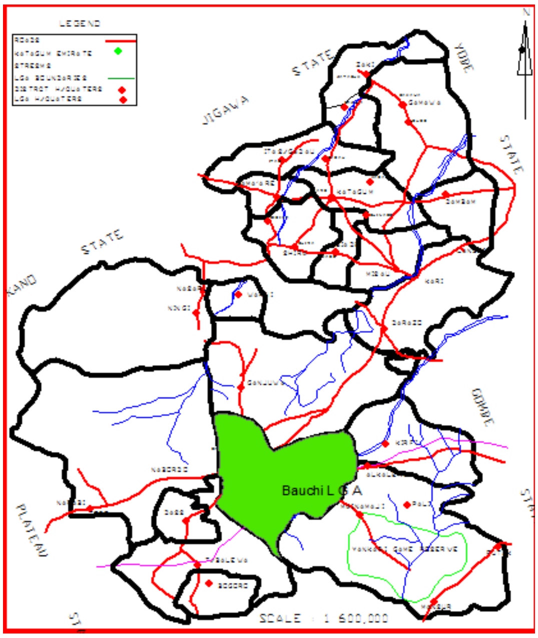


Fig.1: Map of Bauchi State highlights the study area

In Bauchi metropolis, like most cities in Nigeria, wastes are mostly burnt or dumped in open spaces, usually infringing on the right of ways (ROW) of infrastructures such as roads, market places, undeveloped plots of land, neighborhood of residential buildings. This can be attested to from the sight of the spatial pattern of waste dumpsites captured within the study area as shown in the figure below

Fig.1 Specimen photographs of hot spot of waste dumpsites within Bauchi metropolis

Plate1 Photographs of hot spot of waste dumpsites within Bauchi metropolis

Research Materials and Methods

The following materials were used for this paper – Quickbird Image of Bauchi State, and Map of Bauchi State showing the road network. Also, the following softwares were used – ESRI ArcGIS 9.2, and Microsoft Excel 2003.

The study adopted the field survey and survey research design for the acquisition of spatial and non-spatial data respectively. The spatial data were acquired using Garmin 75XL handheld GPS receiver and the on-screen digitizing tool of ArcGIS 9.2 software version, whereas the non-spatial data were obtained from interviews.

The study population consisted of all the households in Bauchi metropolis. A sample size of 38 households, selected systematically from 3 residential areas of the city. This size was considered sufficient because of the homogeneity of the phenomenon under investigation.

The interview addressed issues of house address and household size. A 50kg sack was distributed to all the selected households to store their solid waste and weighed daily for a week (7 days). The following data/information were obtained:

i) The average quantity of solid waste generated daily per household was obtained using $\sum w/ 7$, where $\sum w$ is the sum of all the daily weights.

ii) The average daily solid waste generated per person was computed using $\sum w/HS$, where HS is the household size.

iii) The schedule ie days of solid waste collection from each household was obtained using WB/WG, where WB is the weight of waste bin, and WG is the average waste generated. The value obtained indicates the day of waste collection from each household.

The calculations are shown below:

i. The amount of daily waste generated per each household computed in column 4 were arrived at using this formula**:**

$$\text{Daily W.G/Household} = \frac{summation of each household weighted waste sampled}{No. of days weighed}$$

$Summation of daily waste generated by all households sampled$= 232.14kg

ii. The average daily waste generated per person was computed from column 2 and 4:

$Summation of daily waste generated by all households sampled$= 232.14kg

$Summation of the population\ size\ of all household sampled$=315 persons

Average daily W.G /person $=\frac{Summation daily waste generated by all households sampled}{Summation\ of\ population\ size\ of all households sampled}$

∴Average daily W.G /person $=\frac{232.14}{315}$ = 0.74kg/day/person

iii.The day of waste collection from each household was computed in column 6, using the same size of waste bin (50kg) for all the households sampled:

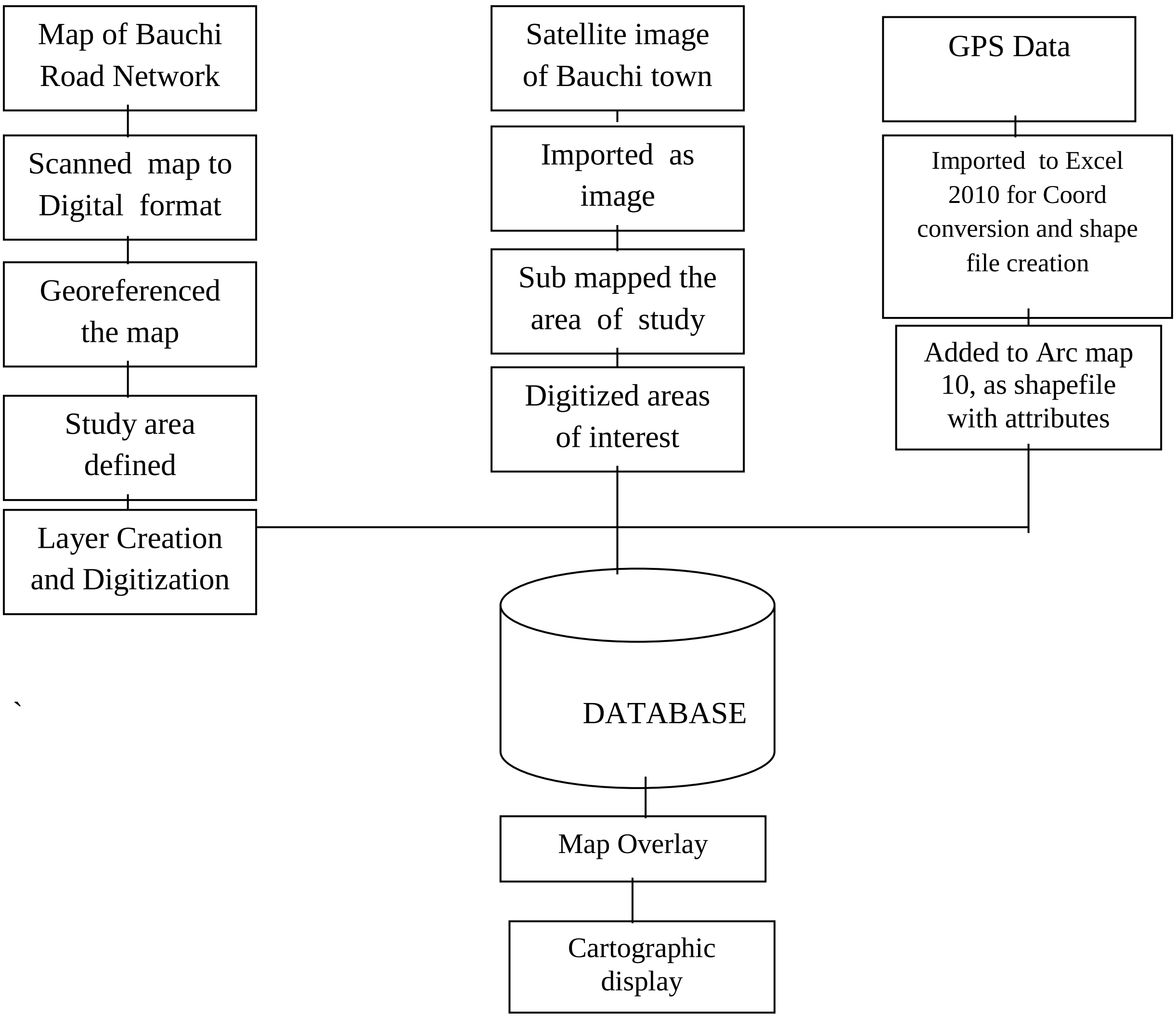
Day of waste collection per household$=\frac{size of bin}{average\ waste\ generated/house}$

For instance, the day of waste collection from house A1 is $=\frac{50}{5.66}$ = 8.8 =9

This implies that the waste of household A1 is due for collection at the interval of 9 days.

iv) The Cartographic Model shows the stages of operation from the beginning of the production of the cartographic display on figure 2 below:

Fig. 2 Cartographic Model



Results

i) **Data on Solid Waste Generation and Collection Schedule for the Households**.

Table 2 shows the result of daily solid waste generated per household, average solid waste generated per person per household, and the schedule for the days of waste collection. This schedule is very vital as it indicates areas of daily need in deploying personnel and evacuating solid wastes from neighborhoods.

Table 2: Determination of Daily Average Waste Generated /Person in the Area

1 S/N	2 House No	3 Family Sizeze	4 Daily W.G/House	5 Average W.G/Person/H	6 Day of waste collection
	A1	7	5.66	0.81	9
2	A2	6	6.13	1.02	8
3	A3	7	5.99	0.86	8
4	A6	1	2.19	2.19	23
5	A7	4	5.07	1.27	10
6	A8	7	4.32	0.62	12
7	A10	10	5.58	0.56	9
8	A11	6	5.54	0.92	9
9	A13	15	5.92	0.39	8
10	A15	8	6.6	0.83	8
11	A17	8	6.35	0.79	8
12	A18	7	5.62	0.80	9
13	A19	12	5.58	0.47	9
14	A21	10	5.49	0.55	9
15	A24	6	8.71	1.45	6
16	A26	7	6.33	0.90	8
17	A28	9	6.03	0.67	8
18	A30	15	7.01	0.47	7
19	B6	10	6.42	0.64	8
20	B7	9	4.00	0.44	13
21	B8	5	2.21	0.44	23
22	B9	9	2.81	0.31	18
23	B12	11	7.58	0.69	7
24	B13	9	10.75	1.19	5
25	B14	8	5.54	0.69	9
26	B16	7	5.08	0.73	10
27	B18	6	5.58	0.93	9
28	B30	3	3.67	1.22	14
29	B31	7	3.29	0.47	15
30	B34	7	6.71	0.96	7
31	B39	13	14.21	1.09	4
32	B40	5	2.46	0.49	20
33	C4	8	4.67	0.58	11
34	C5	6	5.42	0.90	9
35	C10	9	8.33	0.93	6
36	C15	18	17.83	0.99	3
37	C17	13	8.08	0.62	6
38	C18	7	3.38	0.48	15
---	**TOTAL**	315	232.14	30.36	---
	AVERAGE	**9 Persons**	**6.11Kg**	**0.80Kg**	

ii) Waste Disposal Methods in the Area

Fig. 3 shows the 4 main solid waste disposal methods in Bauchi metropolis, and shown in a pie chart.

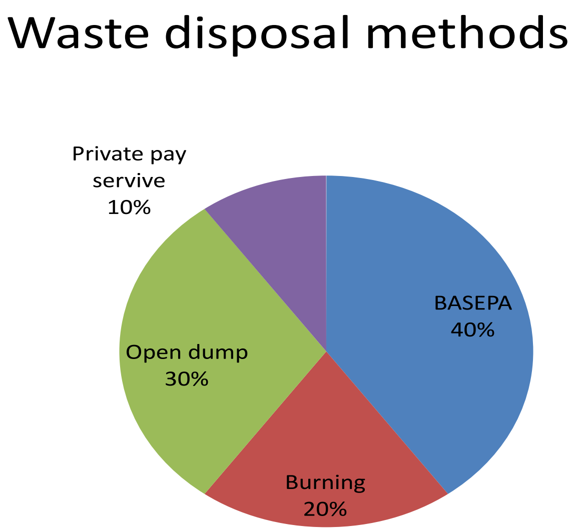


Fig.3: Pie Chart showing methods of waste disposal in the study area

The pie chart above shows that the organized disposal method by Bauchi Environmental Protection Agency (BASEPA) is far below the disposal methods of burning and open dumping, which are highly dangerous to the environment. Burning produces a dangerous gas called ‘doxin’ while the open dump serves as habitation for rats, snakes and other dangerous reptiles and animals in addition to the emission of offensive odour to the air. The open dumping of solid waste is a common practice there, moreso as there are virtually few designated sites for BASEPA collection. The practice is also indiscriminately carried out at various locations in the municipality, as shown in fig.3.

iii) Identified Solid Waste Dumpsites in the Area

Fig. 3 shows the identified hot spots of solid waste dump sites in Bauchi metropolis.

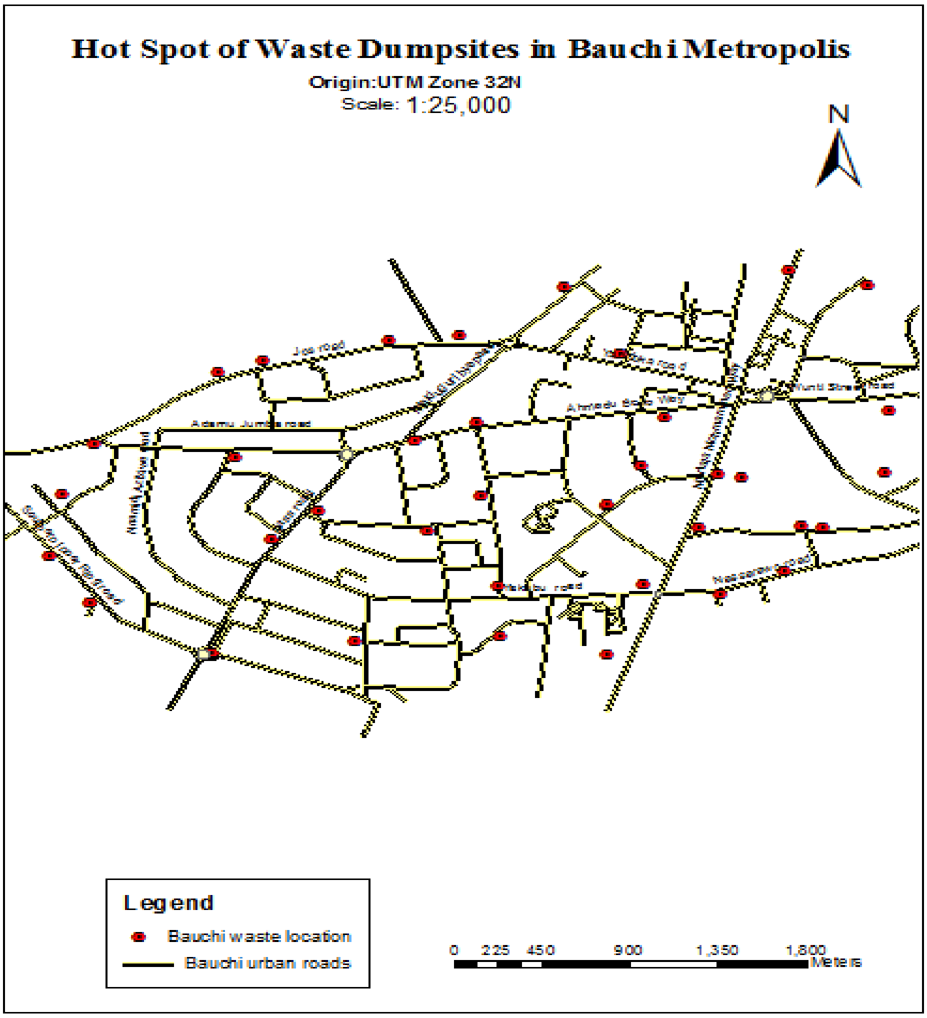


Fig.3: Map showing hot spot of waste dumpsites in Bauchi metropolis

These dumpsites are located haphazardly without considering factors such as centrality, adequacy of space, other neighbouring land-uses, etc.

Conclusion

The nature and quantity of solid waste generated in Nigerian urban areas, especially in Bauchi metropolis, is increasing at an alarming rate far above the capability of the waste collection system of BASEPA. Management of huge volumes of garbage and solid waste is very difficult, and has led to increasing environmental health burdens. The task of waste management becomes more complex as the population increases. The overwhelming ability of GIS in handling large volume of geospatial data necessitates its preference to the use of traditional method of waste management.

This study has succeeded in obtaining data on households' solid waste generation and collection schedule, waste disposal methods and identification of solid waste dumpsites in the area. The study has shown the efficiency of GIS technology in waste management in a complex urban setting, heightened by the forces of urbanization, increase in population, and increasing socio-economic activities.

Recommendations

From the result of this study, the integrated solid waste management is recommended if sustainable solid waste management in urban areas is to be achieved. The integrated solid waste management concept implies the integration of social, economic, environmental and institutional dimensions into the whole solid waste management process. To facilitate this requires the acquisition, processing, storage and presentation of geospatial information, which is the technical heart of the Geographic Information Systems. The use of this technology in solid waste management is highly emphasized by Rahman *et al* (2011).

References:

Achenyo, I (2009). Climate Change and Power Supply Solution. LFGE/MSWE Project Development in Nigeria. A White paper on Greenovative Chain.

Ogwueleka, T. C. (2009). Municipal Solid Waste Characteristics and Management in Nigeria. *Iranian Journal of Environmental Health, Science and Engineering*. Vol 6 No 3 pp.173-180.

Onibokun A. G. and Kumuyi A. J. (1996) Urban Poverty in Nigeria: Towards Sustainable Strategies for its Alleviation. Centre for African Settlement Studies and Development, Ibadan, Nigeria.

Rahman, Atiqur *et al*.(2011). Assessment of Urban Environmental Issues using Remote sensing and GIS techniques: An Integral approach: A case study of Delhi India.

United Nations Environmental Programme (UNEP) (2004) Human Well-being, Poverty and Ecosystem services: Exploring the Links, Nairobi, Kenya

World Health Organization (WHO) (1997) Sustainable Development: Five Years after the Earth Summit, Geneva.

Yusuf F. A. (2010) Solid Waste Generation and Management in Akwanga Town, Nasarawa State, Nigeria. M.Sc Dissertation, Department of Geography, Benue State University, Makurdi, Nigeria.