Supporting Waste Management and Sanitation at the District Level through Surveying and Mapping: Case Study in the Prestea-Huni Valley Municipality of Ghana

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Abstract

Waste disposal and sanitation problems continue to present formidable challenges to waste managers, health officials, environmentalists and town planners in developing countries. This is especially true in the urban cities of Ghana, including the mining centers, where the collection of the large volumes of waste being generated, allocation and clearing of waste containers and the management of indiscriminate waste disposal at unsafe locations are still major problems to be solved. As compared to the national figure of 40%, only about 16% of the refuse generated daily in the Prestea-Huni Valley Municipal Area are being collected by the municipal authorities, leaving a backlog of about 84% to pile up in the communities. The large volume of uncollected waste are being dumped sporadically at ecologically and hygienically unsafe, and inaccessible locations with adverse consequences on the environment, human health and socio-economic development. Even in the few areas where waste collection take place, the waste containers often stay overfilled for weeks without being emptied due to lack of funding, inaccessibility and other problems. Similar to the situation at the national level, the inadequate waste collection and sanitation services are rendered to few privileged locations, leaving large areas, particularly, slums and places inhabited by the poor out. For effective analysis of these problems and the subsequent planning of intervention efforts to improve the situation, there is the need for spatial information on the distribution of existing waste dumps and waste collection services; related access routes and the existing sanitation conditions in the communities; and where to allocate new sites or improve existing situations. One available avenue for handling these problems is the application of surveying and mapping, including the use of sanitation maps. This paper discuses aspects of the results of a survey and mapping project that was carried out to provide such supports for the Prestea-Huni Valley Municipality and how they may be applied for effective planning and improved management of the waste and sanitation problems in the area.

Keywords: Waste Management, Dumping Sites, Survey and Mapping, Sanitation, Aboso and Hunivalley

1 Introduction

Waste management problems in the mining towns of the Prestea-Huni Valley Municipal Area (PHMA) and its environs are becoming alarming and are raising the concerns of the general public, health officials, environmentalists and city officials. It is common to come across open dumpsites and piles of domestic waste, discarded electrical appliances, polythene bags, old and broken oil and gas containers, abandoned tyres, metallic scraps, rubbles from demolished or collapsed structures, etc., in most of the towns within PHMA. Most of the dumpsites are located close to food joints, playing grounds, surface water courses, roads, and undeveloped plots. The locations of such dumpsites are detrimental to a clean and safe environment and can negatively affect human and animal health as well as retard socio-economic development.

The PHMA Municipal Assembly and waste management contractors have not been able to collect and dispose off all the waste generated in the towns due to the overwhelming increases in volumes of waste, compared to the existing facilities. Compared with the national waste collection level of 40% in Ghana, the situation at PHMA is far less, leaving huge backlog of refuse to pile up within the communities (Anon, 1996; Anon, 1998; Anomanyo, 2004). Other major challenges of waste management in the municipality are lack of funds, suitable equipment for waste collection and handling and qualified personnel.

In the light of the foregoing problems, this study was undertaken to explore and demonstrate the application of Geospatial Information Technology as a tool in solving solid waste management problems in Ghana, using the Prestea-Huni Valley Municipal Area (PHMA) as study areas. Geospatial technology is being used extensively in many countries to execute analyses required in solving complex waste management problems (Kwesi, 2003; Tinmaz and Demir, 2005). The present study discusses aspects of this research that deal with the provision of sanitation maps for PHMA to show the locations and distributions of the existing waste dumps and site conditions for effective planning and collection of waste from the communities; and maintenance of proper sanitation at the dump sites. An earlier paper by the authors focused more on the Prestea Heman and Bogoso areas, but this one focuses more on the Aboso, Damang and the Hunivalley areas of PHMA.

2 Study Area

1.2 Geographical and Economic Setting

The study area comprises the mining communities in the Prestea-Huni Valley Municipality (PHMA), with emphasis on Bogoso, Prestea, Aboso, Damang and Huni valley. Fig. 2 shows the study area which is located in the Western Region of Ghana within latitudes 5° 15′ N and 5° 40′ N and longitudes 1° 40′ W and 2° 15′ W. It has an estimated land area of about 1200 km^2 (Kwesi *et al*., 2018; Anon, 2008; Anon, 2014; Mantey, 2014). The above towns are the most popular and vibrant mining centres within PHMA with Bogoso which is about 30 km north of Tarkwa, being the administrative capital. The area is accessible by both rail and road from Takoradi (through Takwa), which is about 110 km south of the area (Fig. 1). According to the 2010 Population and Housing Census, PHMA had a total population of 159, 304, with Prestia, Aboso, Huni-Valley, Bogoso, and Damang as the major urban centres. The area is one of the important mining centres in Ghana that attracts many people from other parts of the country, Africa and the world. Many of the big mining operations in Ghana are located within and around this area (Kwesi *et al*., 2018; Kusi-Ampofo and Boachie-Yiadom, 2012; Kuma and Ewusi, 2010; Anon, 2009). The economy of the study area is thus greatly influenced by mining and its allied services. It is also an important commercial and transit centre linking the western and coastal towns to other parts of Ghana, and travelers from neighboring countries (Kwesi *et al*., 2014; Hlovor, 2012). As a result of these factors many migrants move to the area for jobs and other socioeconomic activities, which in turn contributes to the rapid urbanisation and high population growth rate of about 3.0% (Anon, 2014). Related to these factors, high volumes of waste generation and disposal problems have been observed as one of the major socioeconomic consequences emerging from the study area (Kwesi *et al.*, 2018; Anon., 2014).

2.2 Topography, Geology and Climate

The study area has a topography that is generally undulating with some scarps ranging from 150 - 300 meters above sea level (Kwesi *et al.*, 2018; Mantey, 2014; Hlorvo, 2012). Small scale mining operations frequently take place along these ridges and valleys (Kwesi *et al*., 2014; Anon, 2009, Asante, 2011; Adjei *et al*., 2012; Kusi-Ampofo and Boachie-Yiadom, 2012). Geologically, the study area forms part of the Birimian and Tarkwain formations. Aquifers in the area are considered possessing dual and variable porosity and limited storage capabilities (Kwesi *et al.*, 2018; Kuma and Ewusi, 2010; Asklund and Eldvall, 2005). The area lies in the equatorial climatic zone and thus experiences ample rainfall, high humidity and fairly uniform sun shine and temperatures in the year. Mean temperature, humidity and rainfall have been around 28 °C, 80% and 1800 mm respectively (Anon, 2006; Roelef and Moamah, 2007; Kumi-Boateng, 2012; Mantey, 2014; Anon, 2014).

2.2 Waste Management

Public dumping in open spaces has been the most common waste disposal method in the study area, accounting for about 62.4%, while house to house waste collection accounts for just about 2% (Anon., 2014). The Municipal Agencies that have the mandate to manage the waste (collect, transport and dispose of waste from the communities to safe final disposal sites) and the few private contractors that have been engaged, have not been able to carry out the task satisfactorily (Kwesi *et al*, 2018; Anon., 2014). This is largely due to lack of funds, logistics and other resources. Improper or unscientific planning and allocation of the scarce resources (e. g. distribution of waste collection containers and scheduling of collection vehicles) are additional factors. The municipal Authorities collect just about 16% of the total waste generated daily, leaving a backlog of about 84% in the communities which contributes to the rising sanitation problems in the area (Kwesi *et al*., 2014; Anon., 2014). Public waste collection is also limited to few areas, usually along the commercial or ceremonial street; and most of the waste dump sites are not properly catered for, in terms of their sanitation conditions. Lack of spatial data and sanitation maps to support effective planning is a major factor contributing to these problems (Kwesi *et al*., 2019).

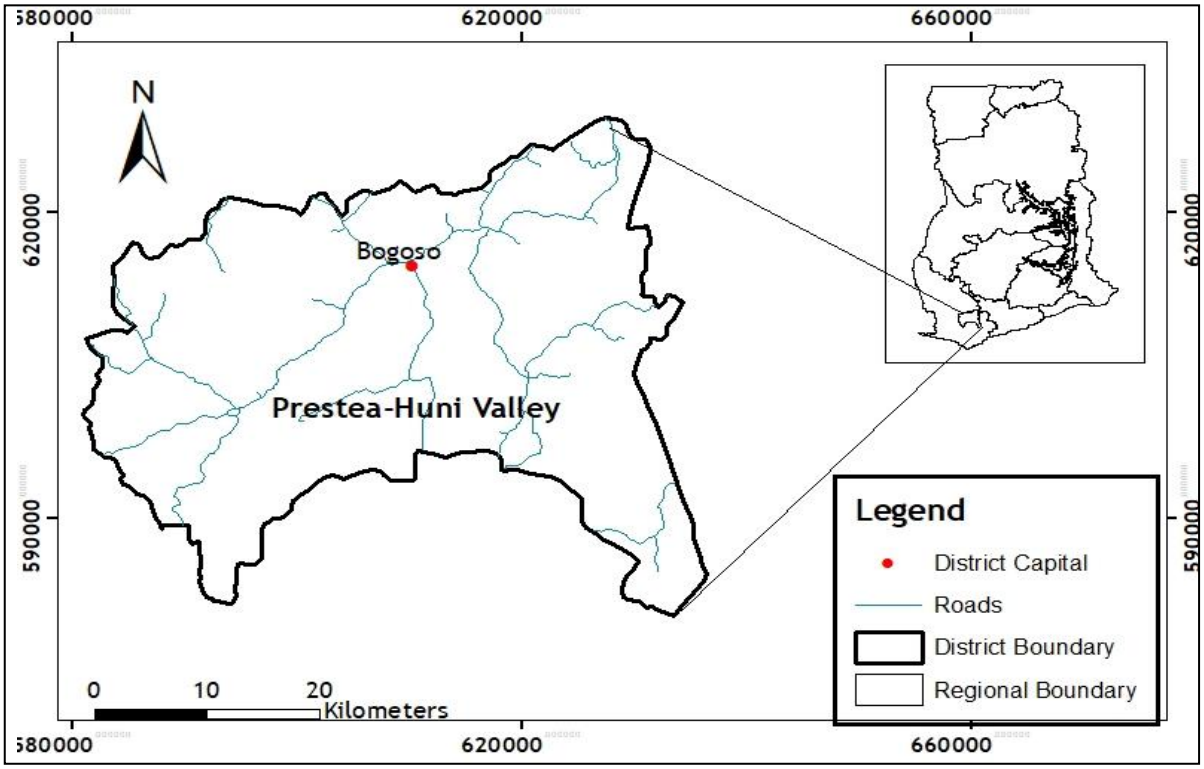

Fig. 1 Map Showing Location of Study Area (PHMA) within Ghana

Fig. 2 Example of Waste Dump Sites Situation in Study Area

3 Materials and Methods

3.1 Materials

The materials used for this work consist of base maps, attributes and point data (discussed in sections 3.2.1-3.2.4), and their associated equipment for collection, processing and storing. The data collection equipment includes Garmin hand-held GPS receivers, measuring tapes, field books and digital cameras. The Processing equipment include laptop computers and scanners. Software used were Microsoft Excel, Photoshop CS4, ArcGIS (10.4 and 10.5) and Microsoft Office Suite (2013 and 2016). The data used includes the coordinates of the waste dumps, town layout plans, topographic maps, photographs of the waste dumps and information gathered from interviews and observations about the management of waste in the study area.

3.2 Methods

The methods used include review and analysis of relevant literature and policy document; visits and examination of available records at relevant waste management offices; interviews and discussions with officials, land developers and residents near dump sites and other stakeholders; and field visits and observations at waste disposal sites. Details of the data collection and processing methods are explained below.

3.2.1 Data Collection

The data collection was planned and organised around three phases or classes, based on the main objectives of the project (producing sanitation maps for analysing the distribution of waste disposal sites, their management and environmental sanitation impacts), and the requirements of the spatial tools employed for the collection, processing and analysis. These three aspects, the point data, attribute data and base-map data phases are explained in the sections below.

3.2.2 Point Data

The point data comprises the coordinates of waste disposal sites, survey control points (pillars) and points of topographic interest for easy identification of the geographical region of the waste dumps and for cross-validation of the secondary and primary data collected. These data were measured with a Garmin handheld GPS receiver. The coordinates of the control points were necessary for assessing and controlling the accuracy of the instrument, survey work and for transformation between the GPS and the local (Ghana) coordinate systems. The topographical features picked during the field survey include road intersections and roundabout, soccer fields and railway lines that were visible on the base maps and on the ground. Table 1 shows a sample of the point data collected along with some site attributes.

3.2.3 Attribute Data

The attribute data collected during the survey include photographs of the dumping sites to capture the state of sanitation and waste management at the site and its impacts on the surrounding environment. The photos were taken with the help of digital cameras. Interviews and discussions were also conducted with the residents, landlords and community leaders living around or close to the waste dumps to get their views on the history, ownership and waste management at the sites; and how they were being affected by the situation. Among the attributes of interest were proximity of sites to sensitive environmental features, road accessibility, and nature of waste disposal and sanitation conditions at the sites. Fig. 2 shows example of the attributes observed during the survey.

3.2.4 Base Maps

The base maps used include topographical maps and town plans (physical development schemes). These were at different scales and units but contained the necessary base information for the preparation of the needed thematic maps about waste dump sites. These maps were also in analogue forms and thus required conversion into digital formats. Fig. 3 shows example of a town layout plan as a base map with some waste dump locations plotted on it.

3.2.5 Data Processing

The data collected were processed using Microsoft Office Suite (2013 and 2016) and ArcGIS (10.4 and 10.5). The field data were organized and classified into suitable groups (base maps, point data, images/photos, spatial and non-spatial attributes) for the construction of a spatial database and needed analysis in a GIS. The aspects of data collected in soft copy were transformed into appropriate formats and captured into ArcGIS environment. The hard copy aspects, including the base maps used, were converted into digital forms and captured into the GIS environment via scanning, geo-referencing, digitizing and transformation to a common coordinate system. The attributes about the waste management situations at the various disposal sites and the site photos were incorporated into the GIS database via linkages to the inbuilt attribute tables and image attachment tools in the ArcGIS software. Figure 4 shows an example of a digitized map of some part of the study area. The database was then

used to prepare and generate the desired sanitation maps and cartographic analysis.

3.2.6 Data Analysis and Presentations

The data on waste dumps were classified and analysed under the following groups:

I. *Approved verses Unapproved Dump Sites*
The approved sites refer to the communal waste dumps and waste containers that were located at sites chosen or approved by the communities and or the municipal assembly. Unapproved Sites refers to waste dumps located at sites not chosen or approved by the communities or the municipal assembly.

II. *Accessible verses Inaccessible Dump Sites*
The accessible sites were those located near roads and thus can be accessed by waste collection vehicles, while the inaccessible ones are those located at sites difficult or impossible to reach by waste collection vehicles.

Table 1 Sample of the Point and Attribute Data on Waste Dump Sites

Location/ Area	Coordinates (m)		Remarks/Attributes
	Eastern	Northern	
Bogoso, Boga Street	608973	615773	road Accessible, with collection containers services; within town, good maintenance and sanitation conditions
Bogoso,Town Council Park	608931	615331	road Accessible, no collection containers; within town, low maintenance and sanitation conditions, close to public laterine
Bogoso, Hassankrom	610160	615466	road Accessible, no collection containers; within town, poor maintenance and sanitation conditions, very close to residential houses
Prestea, Tuobodom	595095	600355	Large wastedump; road accessible, no collection containers; within town, low maintenance and sanitation conditions, close to houses
Prestea-Heman, Akromato	596180	602535	road Accessible, no collection containers; outskirt of town, poor maintenance and sanitation conditions; near to buildings
Aboso, Gyantekrom	617060	593045	Community Wastedump, no collection containers; poor maintenance and sanitation conditions
Aboso, Compound-Kesse	616557	592947	Community Wastedump with Contaner services by PHMA but stays overfilled for weeks; low maintenance and sanitation conditions
Aboso, Nzemafokrom	616232	592551	Community Wastedump, no collection and Container Services, poor maintenance and sanitation conditions
Damang, Market Area	625951	609379	road Accessible, no collection containers; near main market within town, fair maintenance and sanitation conditions
Damang, Ntiakokrom	625439	609890	road Accessible, no collection containers; within town, low maintenance and sanitation conditions
Huni Valley, Fante New Town	619524	605071	road Accessible, no collection containers; outskirt of town, poor maintenance and sanitation conditions
Huni Valley, Bosomtwe Jhs	620559	604169	road Accessible, no collection containers; near to school, low maintenance and sanitation conditions

III. *Collected verses Uncollected Dump Sites*
The 'collected' sites were those where waste collection services to final disposal sites were provided on regular basis while those without these services were classified as 'uncollected'

IV. *Public verses Private Waste Dumps*
The public waste dumps refer to those that come or fall under the responsibility of the District Assembly to manage while those created and controlled or owned by private individuals and bodies such as the mining and financial companies are private waste dumps.

V. 'Managed' verses 'Unmanaged' Waste Dumps
The 'managed' waste dumps consist of those having the attributes of waste being located at safe or approved sites, kept properly in waste containers, collected regularly to final disposal sites, surroundings properly kept to maintain good sanitation conditions, site accessible by road and well enclosed or fenced to reduce public eye-saw. Those missing more than three of these conditions were classified as 'not managed' (or poorly managed). These include those located at environmentally unsafe locations and are usually left unattended to (such as in marshes, valleys and in close proximity to dwellings)

VI. Data Symbolization and Presentation
The fifth classification of the waste dumps into *'managed' and 'unmanaged'* groups were used for the symbolization and mapping purposes. The other classes were placed in the attribute tables for other site analysis other than for symbolisation and presentation on the maps.

VII Graphical Analysis and Assessment For easy comparison and evaluations, bar graphs and pie charts were derived from the data compiled to help assess the waste disposal and sanitation conditions at some of the sites within the study area. For these graphs, the waste dumpsites were further sub-classified into *good, fair, poor and very poor* under some of the main classes above, depending on the degree of (i) ease of road accessibility; (ii) location suitability or safety; (iii) sanitation conditions at site, and (iv) site management or control measures.

4 Results and Discussion

4.1 Generation of Sanitation Maps

Figure 3a and 3b respectively show some of the sanitation maps generated for parts of the study area in locations within and outside existing town planning schemes. The maps were produced at a scale comparable with those of the town layout plans used as a base map. The dump sites were modelled as 'point' data and thus appear smaller than their real sizes at the scale indicated. They are therefore exaggerated but their true relative positions have been preserved. The symbology of the waste dumps reflects the two main categories of 'managed' and 'unmanaged' sites into which the data was grouped. The legends on the maps indicate the symbol for each category.

4.2 Distribution of Dump Sites and Waste Collection Services

Inferring from the maps generated, it could be observed that the approved sites provided by the Assemblies were not adequate to serve most of the communities as shown by large portions of the maps having no proper dumping sites (Fig. 3a and Fig. 3b). Also most of the dumpsites were the 'unmanaged' types where there were little or no control measures (like supervised dumping, pushing and compaction, fumigation, site screening and drainage control) to curb negative practices and impacts. Another observation was that sanitary spaces left in the layout maps had been used for dwellings and other purposes, and new communities had sprung up that did not have spaces for locating public waste collection containers or adequate access routes for waste collection vehicles. The various classes of the disposal sites, their proportions and locations can be seen on or inferred from the sanitation maps and the associated attribute Tables (Fig. 3a, Fig. 3b and Table 1). These can be used to analyse the spatial distributions of waste disposal, waste collection services and the sanitation situations at the various dumping sites and aid in the planning of subsequent intervention actions that may be necessary.

4.2 Assessment of Dumpsite Conditions and Management

This was based on site observations, interviews and discussions with residents and the graphs generated from the data gathered for the studies. Examples of the graphs generated for the assessment analysis to add visual emphasis to the field information are presented at Fig. 4. Together with the maps, tables and field photographs, they facilitate easy comprehension and reliabilities of the observations and deduction made from the study. From these graphs and field observations and interviews, the following were some of the deduction drawn:

Waste Disposal Practices and Sanitation Conditions: Most of the dumpsites exhibited

unsightly scenes, bad odors, flies, mosquitoes and other disease vectors, and leachates from the waste dumps into the environment (Fig. 2). Some of the waste dumps were inaccessible by roads, making waste collection difficult or impossible at such sites (Fig. 4. Open dumping and burning which pollutes the environment were thus the main management methods observed (Fig. 2). Such waste dumps were mostly maintained by the communities and individuals and not the Assembly (Fig. 4).

Site Suitability and Access: A number of the waste dumps were located at areas that were inappropriate for human and ecological health and safety, inaccessible by road for waste collection and difficult to control any negative impacts emanating from the waste (Fig. 2 and Fig. 4). Such sites were recommended to be closed and replaced with safer alternatives. Some were located at sites that were accessible and were serving large communities but had no waste collection and management support from the municipal Assembly (Table 1 and Fig. 4).

Fig. 3a Example of the Waste dump Distribution Maps (on Layout Plans) of PHMA

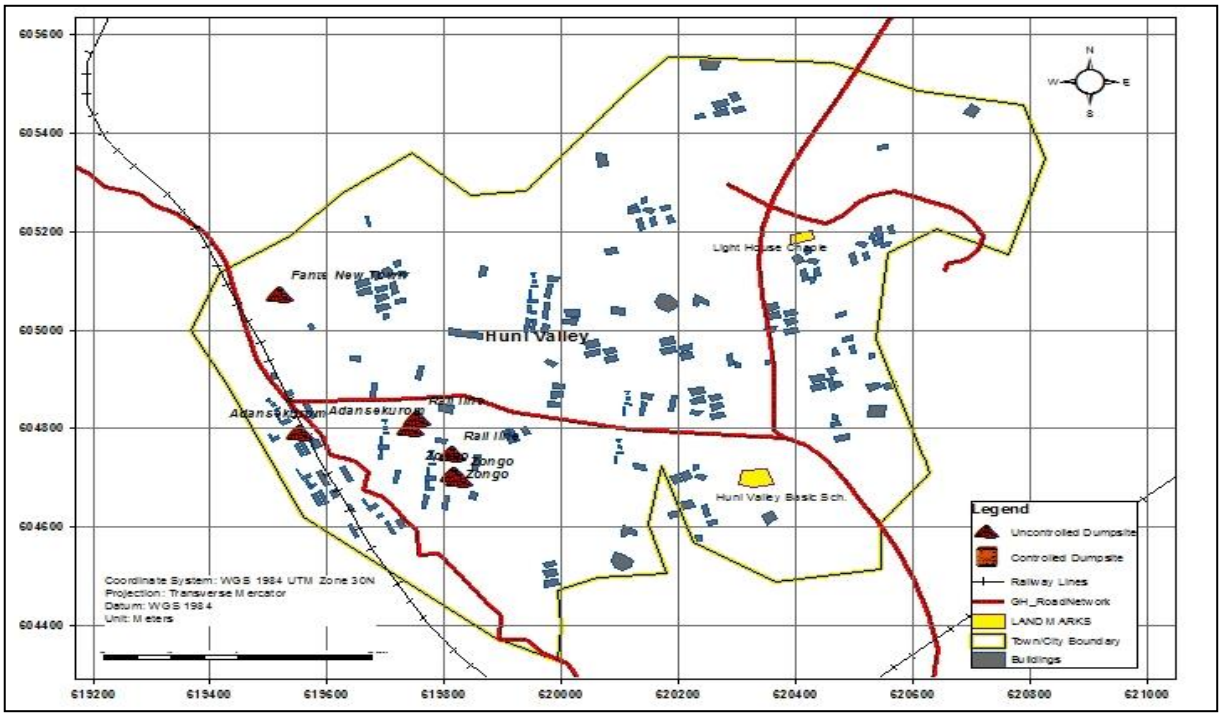

Fig. 3b Example of Waste Dumps Distribution Maps in Areas with No Planning Schemes (PHMA)

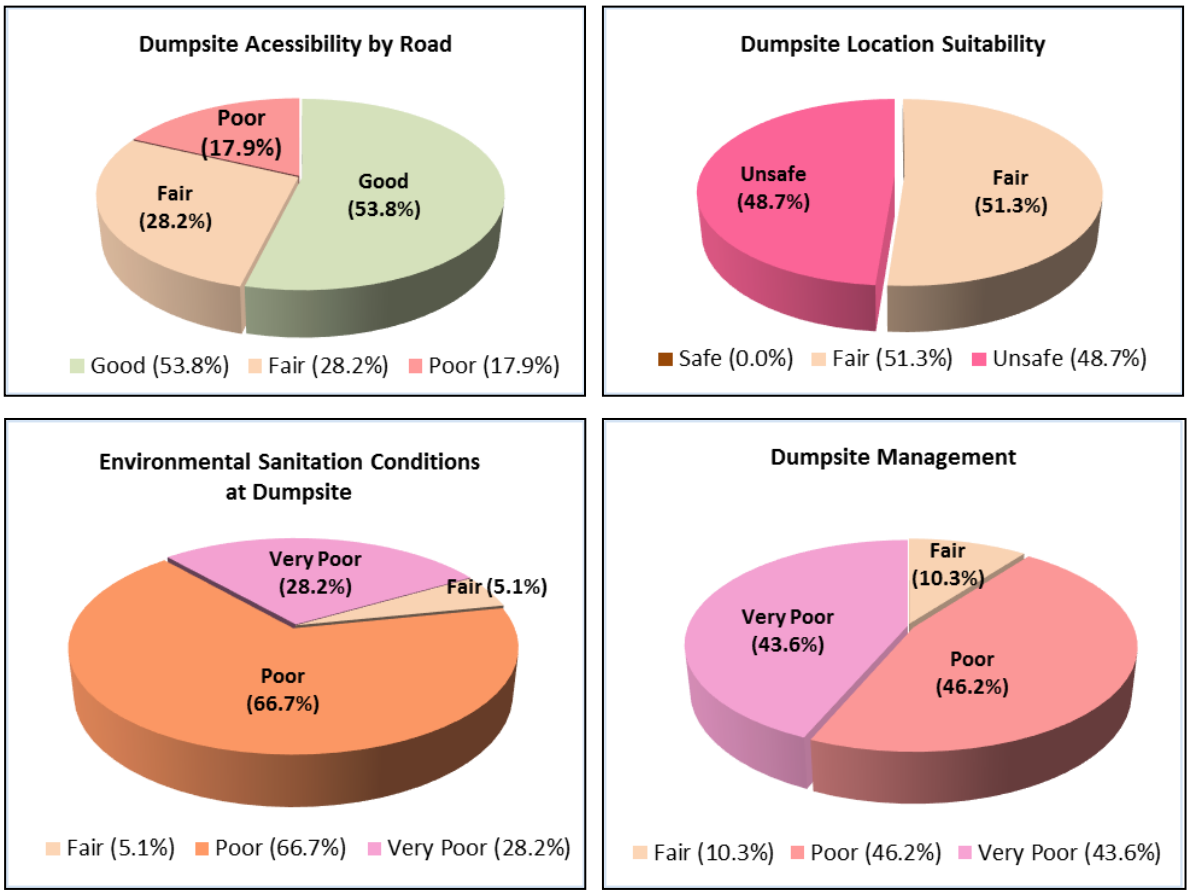

Fig. 4 Waste Disposal Assessment at Some Communities in Study Area

Waste Collection and Management Support

As can be inferred from Fig.2, Fig.3a, Fig.3b, Fig. 4a, Fig. 4b and Table 1, waste collection and management support from the Municipal Assembly was very low. Only few places were getting some support. Most communities are left to manage the situation on their own and this has contributed to the bad waste disposal practices and conditions. Some communities complained of being ignored by the authorities in the provision of sanitation services and necessary remedial actions in their locations despite repeated requests. Some indicated that the large waste dumps in some of the communities resulted from the failure of the authorities to provide support and enforce waste disposal at appropriate locations and failure to provide regular waste collection and maintenance services at the few sites that were supported.

5 Conclusions and Recommendations

The provision of sanitation maps and spatial database on the locations and distributions of disposal sites and facilities is one of the key roles that survey and mapping can play in improving waste management and sanitation at the local (district) level. With these provisions, unsafe and poorly managed sites and disposal practices can easily be brought to the attention of authorities for appropriate actions to be taken. Sites, facilities and communities needing urgent care but overlooked by the Assemblies, can easily be flagged for attention. The spatial database from the survey and mapping exercise can also be used for effective cost-benefit analysis in the choice of appropriate intervention methods such as maintaining or closing old dumping sites and allocating new ones, extending waste collection services to remote or inaccessible areas, and the routing of waste transportation. The paper therefore recommends the integration of survey and mapping and sanitation maps into the existing waste management system to support effective data collection and analysis efforts to improve the planning and distribution of waste management services and intervention efforts.

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