Assessment of Waste Management and Sanitation Services at Local (Municipal) Levels— Case Study in the Mining Communities of Tarkwa, Ghana.

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Abstract

One of the major waste management and sanitation challenges facing developing countries is achieving the universal goals of replacing unacceptable disposal practices (such as open dumping and burning at unsafe sites) with internationally acceptable methods (such as engineered landfilling and recycling) and climbing up on the waste management ladder for improvement. A number of intervention efforts towards achieving this have not yielded the needed results at the local levels and these have been attributed to sustainability problems regarding funding, technological and political support. However, prevailing local conditions can have significant influence on success or otherwise of intervention efforts and methods.

There is therefore the need to periodically assess intervention efforts and methods against prevailing local conditions to ascertain modifications that may be necessary to help achieve intended objectives. This paper discusses the methods and results of an example of such assessment and the lessons that can be learnt from it, using a case study approach at the mining areas of Tarkwa, Ghana. Field surveying and mapping, interviews, and documentary analysis were employed to gather relevant data for the study. The data was processed and analysed using GIS, statistics and graphs to provide sanitation maps and other useful information on the distribution of dumping sites, waste collection and disposal, environmental sanitation services, the inter- relationships among these factors, and how these influence interventions efforts in the area. Local land tenure system, spatial distribution of existing disposal sites, uneven distribution of facilities and services, nimby and other negative attitudes by land holders and residence are among the major factors found to be influencing waste management efforts in the area. The paper recommends that the effects of these and other local factors on waste management efforts should be assessed to ascertain necessary modifications prior to or during their implementation, using spatial-based methods as demonstrated in this study.

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1 Introduction

Waste management problems in Ghana, and in particular at the municipal levels, continue to be alarming despite intervention measures put in place to deal with the situation. 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 and metallic scraps, rubbles from demolished or collapsed structures, etc., in most of the towns and cities. Most of these dumpsites are at unsafe locations (close to food selling points, playing grounds, near surface water courses, roads, undeveloped plots, etc.) with negative consequences to the environment, human health and socio-economic development.

The Municipal Assembly and the waste management contractors have not been able to discharge the duty of collecting and disposing of all the waste generated in the cities and towns due largely to the overwhelming increases in the volumes of waste as compared to the existing facilities. The Assembly collect just about 40% of the total refuse generated daily, 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. A number of national and local targets set forth in the early 2000s to be achieved within a decade have not been materialized despite resources committed to that.

In the light of the foregoing needs, a research was undertaken to explore and demonstrate the application of Geospatial Information Technology as useful tools in analyzing and evaluating the prevailing waste management situation against some of the targets set, and assessing local factors that may contribute to the failures or successes achieved. A case study approach was adopted, using the Tarkwa-Nsuaem Municipal Area (TNMA) as study area. This technology is being used extensively in many countries to perform necessary geospatial analyses required in solving complex waste management problems (Kwesi, 2003; Tinmaz and Demir, 2005). The present paper discusses aspects of this research that deal with the use of sanitation maps to show the locations and distributions of waste disposal sites and management efforts in dealing with the problems.

2 Study Area

1.2 Geographical and Economic Setting

The study area is Tarkwa and its surroundings. Tarkwa is the administrative capital of the Tarkwa-Nsuaem Municipal Area (TNMA) which is located in the Western Region of Ghana

between latitudes 4o 50′ N and 5o 25′ N and longitudes 1o 45′ W and 2o 15′ W (Fig. 2). TNMA has an area of about 950 km^2 and a population of about 90, 477 (Anon., 2014). Tarkwa is a famous mining centre that attracts many people from other parts of the country, Africa and the world. Many of the big mining operations in the country are located in and around Tarkwa (Kusi-Ampofo and Boachie-Yiadom, 2012; Kuma and Ewusi, 2010; Anon, 2009). The economy of the area thus revolves around 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 Cote d'Ivoire to Burkina Faso (Hlovor, 2012; Kwesi, *et al,* 2014). These factors draw many people to the city daily to look for jobs and do business. Some of these people settle, giving rise to rapid urbanisation with a high population growth rate of about 3.0%. One direct social impact of this is the huge volumes of waste generation that is beyond the resources and capabilities of the Municipal Assembly to handle effectively (Kwesi, *et al*, 2014; Anon., 2014).

2.2 Topography and Geology

The topography of the study area is generally undulating with some scarps ranging from 150 - 300 meters above sea level (Mantey, 2014; Hlorvo, 2012). Small scale mining operations frequently take place along these ridges and valleys (Anon, 2009, Asante, 2011; Adjei et al., 2012; Kusi-Ampofo and Boachie-Yiadom, 2012). Geologically, the area forms part of the Birimian and Tarkwain formations. Aquifers in the area are considered possessing dual and variable porosity and limited storage capabilities (Kuma and Ewusi, 2010; Asklund and Eldvall, 2005).

2.2 Waste Management

The Municipal Assembly that has the mandate to manage the waste (collect, transport and dispose of waste from the city to safe final disposal sites) and the few private contractors that have been engaged for that, have not been able to carry out the task satisfactorily (Kwesi, *et al*, 2014; 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 Assembly collects only about 40% of the total waste generated daily, leaving about 60% to pile up in the communities (Kwesi, *et al*, 2014; Anon., 2014). This is also limited to few areas, usually along the commercial or ceremonial streets and the communities of the elite few. There are no sanitation maps that show the locations of waste dumps within the communities and this has left most of the waste dumps unattended to. While some communities have two or more waste containers and enjoy waste collection services from the assembly, others have none.

3 Materials and Methods

3.1 Materials

The materials used for this work consist of survey and waste management data sets and equipment. The field equipment includes Garmin hand-held GPS receivers, measuring tapes, field books and digital cameras. Software used were Microsoft Excel, Photoshop CS4, ArcGIS and Microsoft Word. 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 waste dump sites and other stakeholders, as well as field visits and observations at waste disposal sites. Comparative evaluations were also made between the observed data (existing situation) and the waste management targets set for the decade. 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, 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 secondly and primary data collected. This 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 examples 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.

3.2.5 Data Processing

The data collected were processed using Microsoft Office Suite and ArcGIS. The field data were organized and classified into suitable groups (based 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. The database was then used to prepare and generate the desired sanitation maps and spatial analysis. The comparative evaluations by tables and graphs were done with the help of Microsoft Office.

3.2.6 Data Analysis and Presentations

Distribution Maps and Analysis

The data on waste dumps were classified and analysed under the following groups for the distribution mapping and analysis purposes:

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 refer to waste dumps located at sites not chosen or approved by the communities or the municipal authorities for waste management.

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

III. *Collected verses Uncollected Dump Sites*
The ‘collected’ sites were those at which waste collection services 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 general public and the District Assembly to manage while the private ones are those created and controlled or owned by private individuals and bodies such as the mining and financial companies.

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 three or more of these conditions were classified as not 'managed' (properly). These include those located at environmentally unsafe locations and are usually left unattended to (such as in marches, 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.

Evaluation Analysis

Regarding the evaluative analysis, tables and graphs were used to present and compare the observed data against the set values or goals for the period of observation (2005-2015). In some cases the observations at the study area were compared with those of at national to assess the performance made. Factors observed as contributing to the performance were then highlighted and discussed. The factors used for the evaluation were mainly based on the National and Local waste management goals or targets set for the 2005-2015. Among these factors were:

(a) Waste collection coverage in terms of extent (in percentage of households or population). This was to be increased to 50% and beyond by 2015.

(b) Even and fair distribution of waste management and sanitation services to both rich and poor areas in the community. This was to be improved significantly by 2015

(c) Phasing out unsafe waste disposal sites and practices by 2015

(d) Provision of engineered landfill and other improved disposal sites and facilities.

4 Results and Discussion

4.1 Generation of Sanitation Maps and Graphs.

Fig. 3 shows an example of the sanitation maps generated for parts of Tarkwa. The maps were produced at a scale comparable with those of the town layout plans used as a base map. The damp 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 reflect 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.

Fig. 4, and Fig. 5 show examples of the graphs generated for the comparative and evaluation analysis to add visual emphasis to the tabular information. Together with the maps, tables and field photographs, they provided greater consistencies and reliabilities on the observations and deduction made from the study.

4.2 Distribution of Dump Sites and Waste Management Services

From the maps, it could be noticed that most of the waste dumps were left unmanaged. The approved sites provided by the Assembly were not enough to serve some of the communities as shown by large portions of the maps having no proper dumping sites (Fig. 3). This shows that waste management objectives (a) and (b) above are far from realization. Another observation was that new communities had sprung up that did not have spaces for locating public waste collection containers or adequate access routes for waste collection vehicles. These were among the local factor hampering the municipal authorities' efforts to improve conditions and achieving the targets set for 2005-2015 (evaluation factor (a), above).

However, other waste dumps were located at safe sites that were accessible and were serving many people but had no management support from the municipal Assembly.

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). This observation clearly indicates that the local authorities and the country as a whole are far realizing goals (c) and (d) above regarding phasing out unsafe disposal sites and practices.

The various types of waste disposal sites and practices, their locations, proportions and distributions can be seen on or inferred from the sanitation maps and the associated attribute Tables and graphs (Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Table 1). These can be used to assess the waste management situation and draw the attention of the appropriate authorities for necessary remedial actions as demonstrated in this study.

4.3 Observations from Sites and Interviews

From the site observation and the interviews and discussions with residents, the main problems cited include:

- Unsightly scenes of the dumps, bad odors, flies, mosquitoes and other disease vectors, and leachates from the waste dumps into the environment. Some of the waste dumps were inaccessible by roads, making waste collection difficult or impossible at such sites. Open burning which pollutes the environment was thus the main management methods reported and observed. Such practices were observed at all the dump types maintained by the communities, individuals and the Municipal Assembly (Fig .). This again indicates how far goal (c) is from achievement.

- Some communities complained of being ignored by the authorities in the provision of sanitations services and necessary remedial actions in their locations despite repeated request. Large waste dumps in some of the communities resulted from failure of the authorities to provide and enforce disposal facilities at appropriate locations or failure to provide regular waste collection and maintenance services at the sites. This also indicates that a lot still needs to be done in order to head towards achieving goal (b) above.

4.4 Quantitative Assessment

Fig. 4 and Fig. 5 show examples of the quantitative assessment of the waste management situation as against the target goals set for the 2005 to 2015. From the graphs it could be seen that all the goals set could and have still not been achieved. The study area is doing just about 15% of waste collection as against the national and regional figures of about 40% and 30% respectively. The distribution of this low waste collection coverage is also very uneven, concentrated at the commercial areas (Fig. 3). The levels of inaccessible dumping sites, unsafe dumping locations, poor site sanitation and open community dumping and burning are very high, respectively averaging about 40%, 37%, 25% and 60% from the graphs (Fig 5). No engineered landfill sites were available, despite efforts by the Municipal Authorities to acquire land for the purpose. “Nimby” attitude by existing mining companies which control a large percentage of the available land is cited as a major contributing factor to this.

5 Conclusions and Recommendations

This study has demonstrated some of the important roles that mapping and spatial analysis can play in assessing waste management and sanitation activities at the local (municipal) level to ascertain whether intended goals are being met or not and what local factors may be contributing to that. In the current study, local land tenure and "nimby" attitude by land holders, lack of sanitation maps and spatial analysis in the distribution of sanitation services, lack of adequate support to local communities in phasing out inappropriate sites and practices, and increasing urbanization and pressure on land are noted as some of the contributing local factors hampering the achievements of waste management goals. The paper therefore recommends the integration of such local factors and survey, mapping and spatial analysis into the existing waste management system to support effective data collection and analysis efforts to improve the planning, distribution and evaluation of waste management services and intervention efforts.

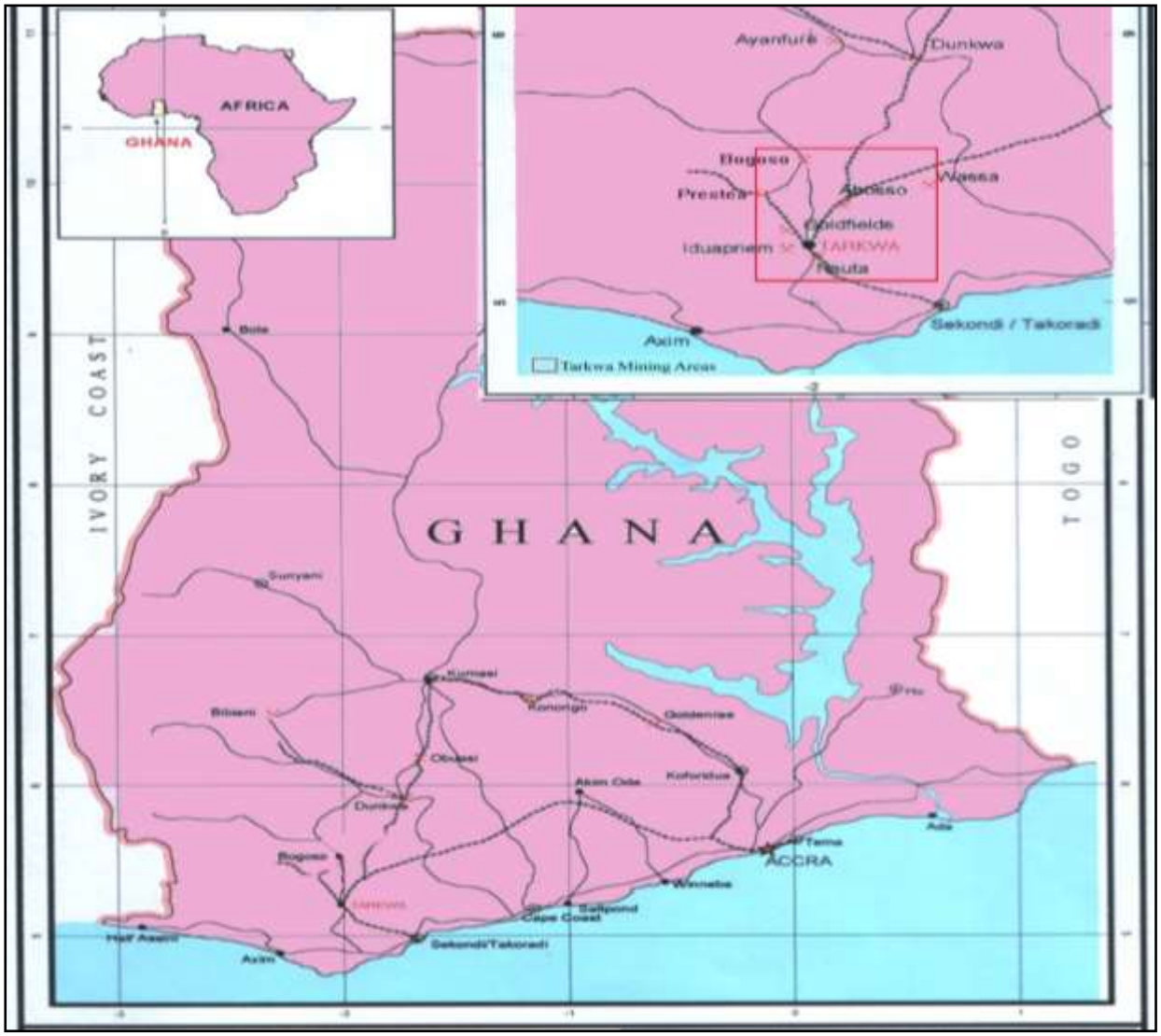

Fig 1 Map Showing the Study Area

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

Location/ Area	Coordinates (m)		Remarks/Attributes
	Eastern	Northern	
Kamponase	610845	585524	Large waste dump. Inaccessible by road. Active but not well managed.
Main Station	611282	586406	Wastes are kept in containers. Easy road accessibility. Overspills.
UMaT Area	610447	585932	Wastes are kept in waste bins. Accessible by road. Managed well.
Nsuta	613173	583349	Waste are kept in containers in an enclosed platform. Well managed.
Low Cost	611298	585119	Community waste dump. Not managed and not accessible by road
Akyinpim	610337	581608	Survey Control Pillar (SGW1205 3A)) for Accuracy Check
Bogoso Junction	613195	589516	Both Survey Control Point and Road Junction for location identification

Fig. 2 Example of Waste Management Practices in Study Area

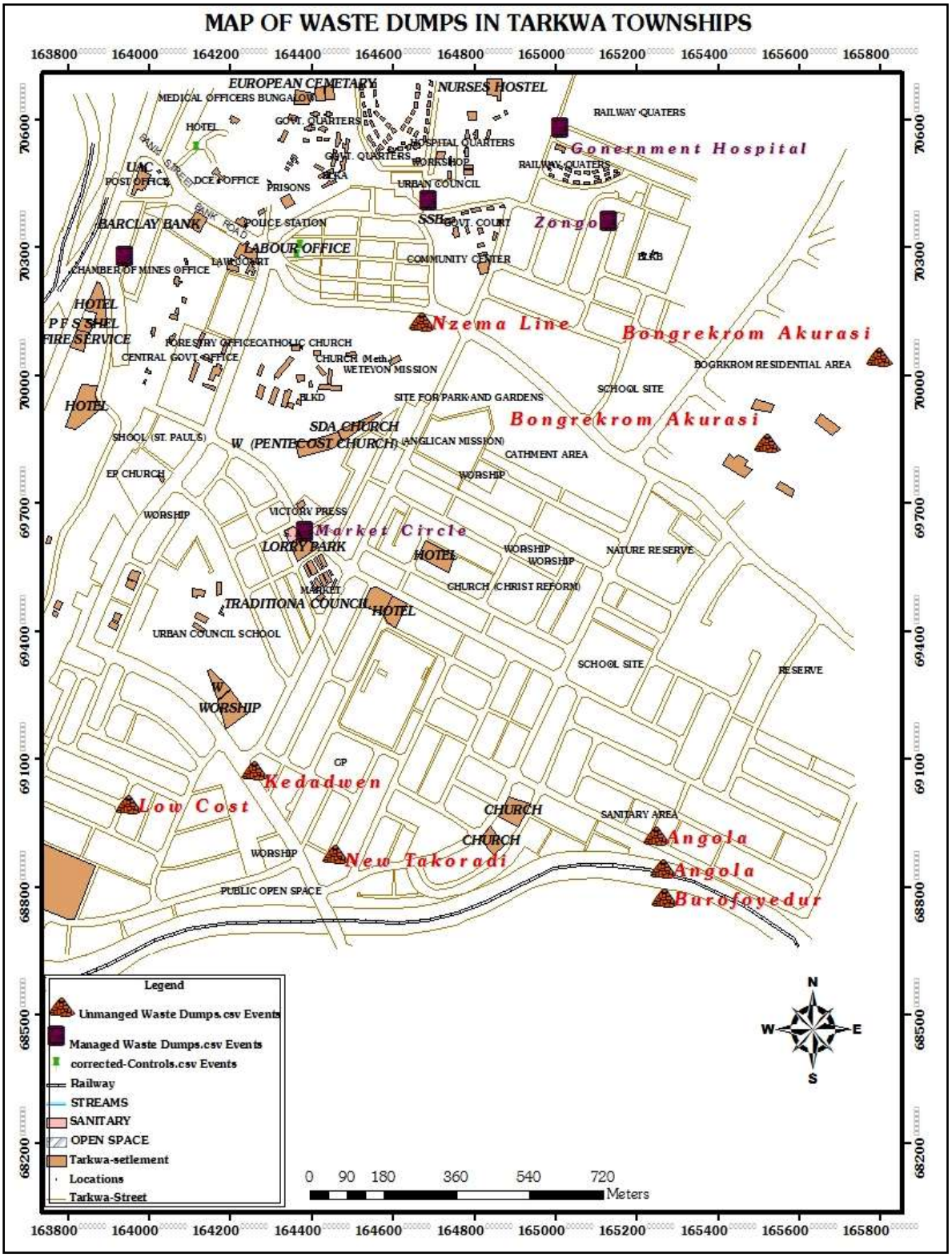

Fig. 3 Example of the Sanitation Maps Generated from Database (Tarkwa Central Areas)

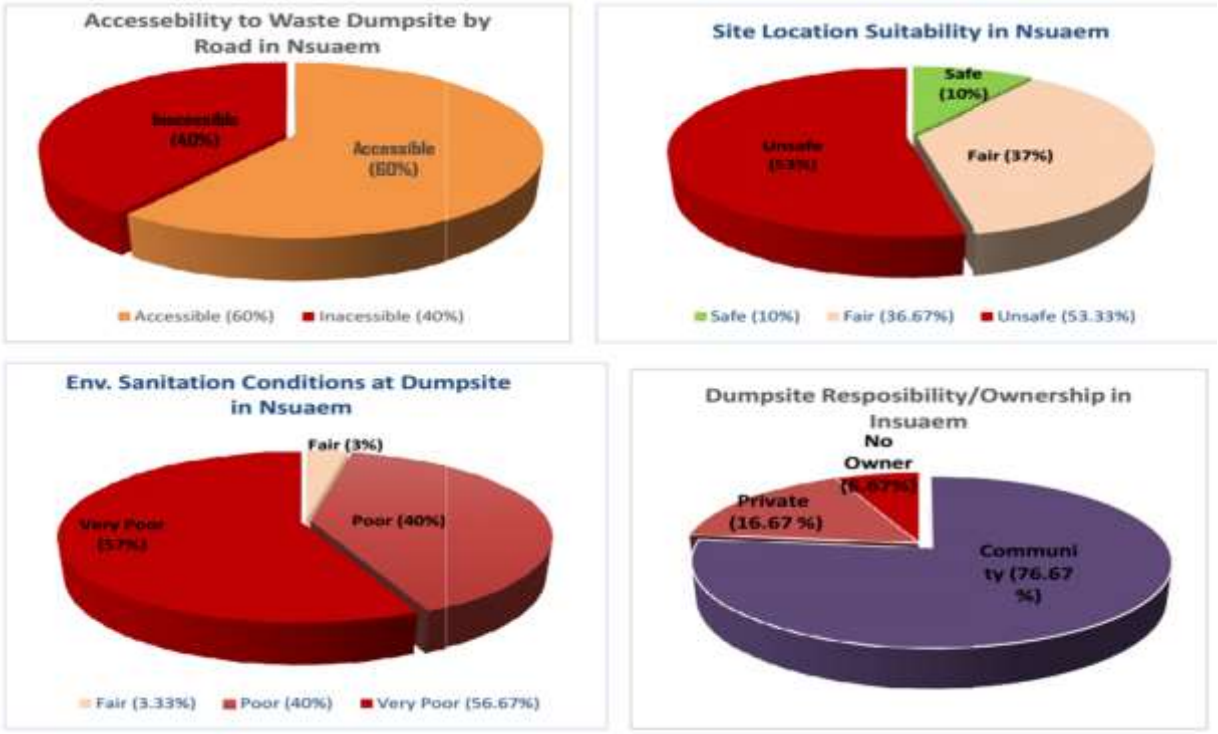

Fig. 5 Assessment of Waste Management Situation in Study Area

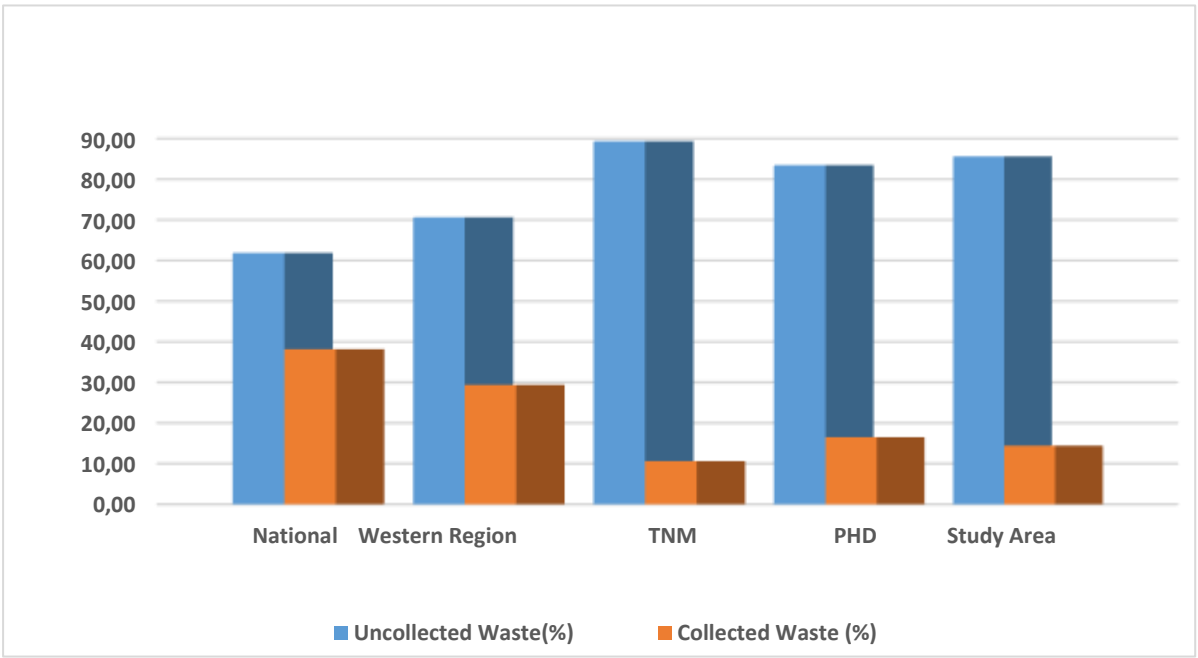

Fig. 4 Assessment of Waste Collection Coverage at National and Municipal Levels

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