Collaborative Slum Mapping in the Developing Countries. A Case of Kampala City, Uganda

BLESSINGS HAUTMAN GREY MPANGA
February, 2012

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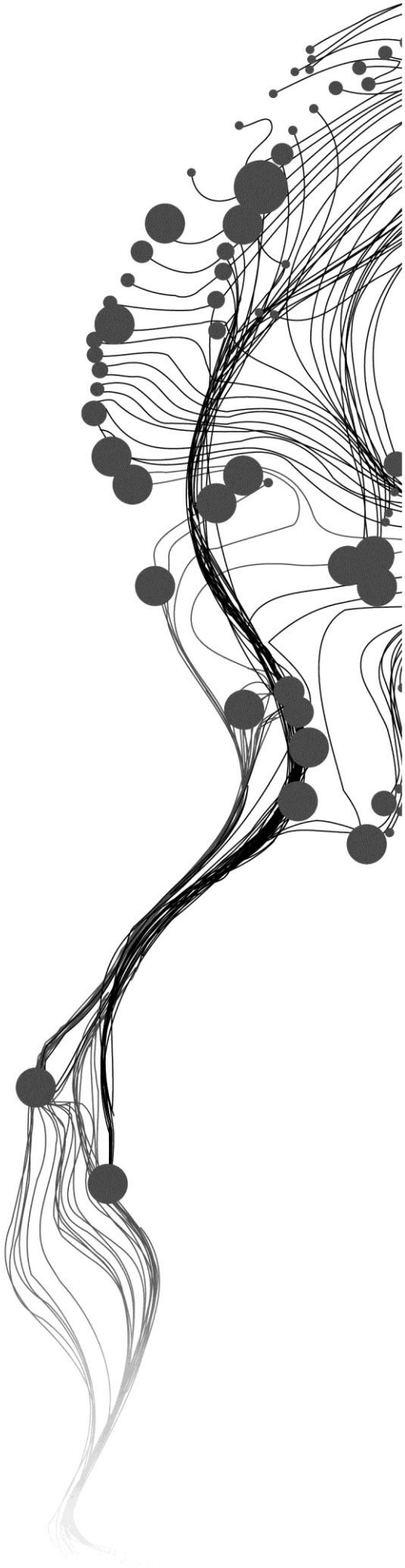

Collaborative Slum Mapping in the Developing Countries. A Case of Kampala City, Uganda

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Enschede, The Netherlands, February, 2012

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DISCLAIMER

This document describes work undertaken as part of a programme of study at the Faculty of Geo-Information Science and Earth Observation of the University of Twente. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the Faculty.

DEDICATED TO

My Mum and Late Dad

My Wife Nellie and Children (Victor, Edith and Madalitso_Grey)

ABSTRACT

Proliferation of slums in developing countries exerts enormous pressure on land and infrastructure services. As such, uncontrolled growth and sprawl renders slum mapping difficult for planners such that most slums have not been effectively mapped. The lack of maps contributes to various problems affecting the urban poor also because developing countries are often poor and technologically challenged such that they find it extremely difficult to accurately map slum settlements in detail. There are several web-based collaborative mapping tools that can be used to map slums in a cost-effective manner. The objective of this paper is to determine the effectiveness Google Map Maker (GMM) in the collaborative slum mapping for the production of spatial data. The GMM aims at improving the Google Mapdata through the expert knowledge of local citizens acquiring high-quality data to be published and used by everybody. The study assesses the effectiveness of the GMM in collaborative slum mapping by looking at (i) different web-based collaborative, mapping methods and tools (ii) analysis of users` requirements for the GMM slum maps (iii) identifying factors that lead to, or prevent potential stakeholder participation in collaborative slum mapping and (iv) assessing the current quality of web-based collaborative mapping. The outcome of the study indicates that the GMM can be used in conjunction with other collaborative mapping tools. Also, because of its flexibility, a lot of stakeholders are willing to participate in collaborative slum mapping to generate the slum map data needed by several slum map users. Features mapped in the GMM tool, undergo moderation process to unsure that the data generated is accurate and trustworthy. Voluntary mapping, political interference, lack of training and eviction threats negatively affects collaborative slum mapping.

Key words: Google Map Maker, Stakeholder, Collaborative mapping, slums, unplanned settlements

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Blessings Hautman Grey Mpanga
Enschede, February, 2012

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LIST OF ACRONYMS

AcU	:	Actogether Uganda
ASHD	:	Action for Slum Health and Development
CA	:	Cities Alliance
CBOs	:	Community-Based Organizations
CIDI	:	Community Integrated Development Initiative
CU	:	Concern Uganda
DENEVA	:	Development Networks of Voluntary Associations
DPW	:	Department of Public Works
FGDs	:	Focus Group Discussions
GIS	:	Geographical Information System
GMM	:	Google Map Maker
GPS	:	Geographical Positioning Systems
KCCA	:	Kampala Capital City Authority
MLH & UD	:	Ministry of Lands, Housing and Urban Development
MoH	:	Ministry of Health
NGOs	:	Non-Governmental Organizations
NSUSA	:	National Slum Upgrading Strategy and Action
SAP	:	Slum Aid Project
SDF	:	Slum Dwellers Federations
SDI	:	Slum Dwellers International
SWID	:	Slum Women`s Initiative for Development
OSM	:	OpenStreet Map
UBOS	:	Uganda Bureau of Statistics
UWN	:	Uganda Women Network
UN	:	United Nations
VGI	:	Volunteered Geographical Information
WAU	:	Water Aid Uganda

1. INTRODUCTION

The purpose of this chapter is to present an understanding of general components of this research project. The theme of this research revolves around proliferation of slum areas, collaborative slum mapping, and lack of up-to-date spatial information and use of Google Map Maker (GMM) in collaborative slum mapping in the developing countries. The focus of the research is to analyze the effective use of GMM for collaborative slum mapping and the quality of data generated. Lastly, data required and methodologies to be applied are outlined in the research matrix design.

1.1. Background Information

Rapid urbanization in many cities in developing countries has seen the growth of slum settlements punctuated with poor quality housing (Abbott, 2001). Due to prospects of employment and good life in the city, most of the people are lured to the cities and end up living in congested urban environment. Consequently, many of these hopefuls become the disadvantaged and marginalized,(Pugh, 2000; UN HABITAT, 2009; Zanganeh Shahraki et al.)(in Press). Many of these poor live in deplorable and inadequate housing conditions. They often lack access to adequate shelter, to safe and clean water, to improved sanitation and latrines and their houses are often overcrowded (Abbott, 2002; Gunter, 2009)

1.1.2 Definition of a slum and informal settlement

The term slum has been confused with or has been used interchangeably with "informal settlement". Although informal settlements and slums share many characteristics, this research is about slum mapping with the involvement of local knowledge. The definition of a slum varies from one country to another. According to the United Nations agency, UN HABITAT (2003), slum is defined as a group of individuals living under the same roof lacking one or more of the following conditions: access to improved water, affordable price, available to household members without being subject to extreme effort, access to improved sanitation, sufficient living area, durability of housing and security of tenure (Martínez, Mboup, Sliuzas, & Stein, 2008). On the other hand, Tannerfeldt & Ljung, (2006) has defined informal settlements as a group of people living on land they have no legal claim and regulations. They are also referred to as squatter settlements, unauthorized settlements, unplanned or a myriad of local names e.g. *favelas* in Brazil, *bidonville* in France and Africa, *basti* in Bangladesh, *barrio* or *tugurio* in Latin America, *kampung* in Indonesia, *masseque* in Angola and *ghetto* in the USA among others (Tannerfeldt & Ljung, 2006; UN HABITAT, 2007a; United Nations, 2004). Due to the fact that slums and informal settlements share many characteristics; this research will be referring to such settlements as slums.

Characteristics and politics (UN HABITAT, 2007c) associated with slums vary from place to place. Slums are characterized by urban decay, high rates of poverty, illiteracy and unemployment, lack of basic municipal services such as water, sanitation, waste collection, storm drainage, street lighting, paved sidewalks and roads for emergency access (Tannerfeldt & Ljung, 2006) and are commonly seen as

breeding grounds" for social problems such as crime, drug addiction, alcoholism, high rates of mental illness and suicide. In many poor countries they exhibit high rates of disease due to unsanitary conditions, malnutrition and lack of basic health care. (UN HABITAT, 2007a, 2007c). Housing in slums is built on land that the occupant does not have a legal claim to and without any urban planning or adherence to zoning regulations.

1.1.3 Research Problems

Proliferation of slums in developing countries exerts enormous pressure on land and infrastructure services. According to Gunter (2009), uncontrolled growth and sprawl renders slum mapping a difficult task for planners and geographers such that most slums have not been effectively mapped. The lack of maps contributes to various problems affecting the urban poor. For instance, slum dwellers are confronted everyday with substandard and often dangerous living conditions such as insecure tenure and threat of eviction, inadequate access to safe water and sanitation, overcrowding and lack of affordable housing (Ansumana et. al, (2010). The lack of up-to-date data about slums settlements means that there is no way to assess demand for such services. The UN HABITAT data indicate that many local governments do not have mechanisms to monitor informal urban growth in a systematic manner (UN HABITAT, 2009)

In addition, cities in the developing countries are often poor and technologically challenged such that they find it extremely difficult to accurately map unplanned settlements in detail. This means the poorest areas in the cities are often left out in city planning. This prevents flow of resources to people who need it most. However, some authors have a different view about proliferation of slums. Gilbert (1998) for example, argues that development of informal settlements serves as a solution to housing shortages in urban areas since a high percentage of new low-income urban dwellers meet their shelter needs with little or no support from formal housing delivery systems. He argues that the emergence of housing built in places outside the land use and regulatory codes in force, is a result of efforts by the people to access shelter and that the so-called illegal, slums become the most common "solution" for the poor living in the urban areas.

In April 2011, a slum mapping project was initiated within the Google Map Maker system. See for example, *https://sites.google.com/site/mapyourworldcommunity/events/slum-mapping*. This research focuses on exploring different aspects of the project and how it can contribute to improving data provision on slum areas throughout the world. The project`s aims are to raise general awareness on the living conditions in slums by mapping as much as possible the extents of slums, streets and other mappable features within slums across the world; to catalyse the local community and expand the capabilities of local participatory mapping, initiating mapping parties in the developing countries and increasing the quality and quantity of data on slum areas and their visibility through mapping.

In this project, the researcher will examine whether collaborative slum mapping can effectively generate spatial data that will help town planners, urban managers, local governments, local communities, NGOs and international organizations, universities and research institutions and many others to address the

problems affecting slums. Ansumana et. al, (2010) observes during health mapping which was aimed at generating municipal maps and their application to social and health concerns that, community involvement is often the only way to acquire accurate information about boundaries in areas where residential areas often begin as informal settlements. Rouse et. al (2007) also agree that by working together, users are able to collate far more data than any single individual or group could generate at little or no cost to the community.

1.1.4 Uses and Users of data generated

According to Rouse et. al (2007), Google maps and other free web mapping applications have generated considerable interest beyond the technical creation of a Geospatial web and users have focused on how this enabling technology might support a variety of projects including collaborative mapping and participatory GIS. Therefore, information generated through collaborative slum mapping can be useful in various ways. First, universities and research institutions can use this data to conduct various projects to come up with better ways of addressing problems slums do face. For example, Rouse et. al (2007) citing Krygier (1999) argue that many researchers have created projects that use the internet for the dissemination of information

The local communities can also benefit from using that data. Chambers (1994), citing Swift and Umar (1991) and Mukherjee (1992), argues that maps prepared through participatory approaches can be used by villagers as a reference for planning, monitoring and evaluating activities. He cites an example of a watershed map that can be useful in plotting current conditions, planning and monitoring action mapping, surveying degraded forest and deciding how to protect and manage resources.

Further urban planners require spatial data first to understand the problems of informal settlements and then come up with ways of dealing with such problems. Monkkonen (2008) argues that satellite imagery provides a source of data with the potential to assist planners and researchers in understanding aspects of the problems associated with urban growth. He argues that satellite images are useful in generating data about informally developed neighbourhoods through visual inspection and boundaries of urbanized areas are created to calculate and compare the extent and nature of urban growth.

Local governments can also use the database to lobby for funding to improve the living conditions of slum dwellers, create resettlement plans, and develop waste water drainage systems and re-aligning houses for more equitable access to services, (See for example, *http://www.ashoka.org/story/6458).* A community in Kibera slum in Kenya for instance, with the assistance of local technology experts surveyed and mapped their locale and pinpointed the locations of key services such as water standpipes, schools, clinics and shops as well as providing road data. (See for example, *http://www.satellitesights.com/blog/kenyan-community-mapped-together/*.) The Map Kibera project has even developed into a fully recognized "community information scheme" that is being used by the Kenyan government to provide improved facilities and sanitation to improve both quality and quantity of facilities and sanitation.

1.2. Scientific Justification

At local level, better information is required in the formulation of appropriate policies and programs for the improvement of the lives of the poor (Gilbert, 1998; Pugh, 2000). This requires the understanding of urban dynamics and general well-being as well as their socio-economic and cultural characteristics. Unfortunately, due to this lack of spatial information, governments in the developing countries find it too difficult to provide services and to control further proliferation of slums and lack of geographic information creates gaps in very important scientific knowledge. The provision of timely, accurate and policy relevant data can serve as an input to strengthen the local level data collection. It can also assist in the analysis mechanism of improving the lives of the poor. Wanjiku (2011) in her thesis wrote that in many countries local authorities have limited understanding of the slum location, extent and their dynamics. Her research results on slum development in Kisumu, Kenya, show that there is lack of quality spatial information which would have been used to address the problems slums in developing countries are facing. Sliuzas & Kuffer (2008) argue that, given the expected increase in the number of slum dwellers there is a growing need for sound methods to effectively identify and monitor slums and informal developments. It is therefore against this background that this project examines whether collaborative slum mapping can effectively generate spatial data that will help planners and urban managers address problems affecting slum settlements in the developing countries

1.3. Research Objective

The main objective of this research is to determine the effectiveness of collaborative slum mapping for the production of spatial data. This is to better understand the effectiveness of Google Map Maker as a specific example of a collaborative mapping system of slum mapping in developing countries. To attain this main objective, the following sub objectives and research questions have been formulated

1.4.1 Specific Objective

To investigate and analyse the use of GMM in collaborative slum mapping, the following specific objectives are structured.

1.4.2 Sub Objectives

1 To compare and review different web-based collaborative mapping methods and tools
2 To analyze the users' requirements for GMM slum maps
3 To identify factors that lead to, or prevent potential stakeholder participation in collaborative slum mapping with GMM
4 To assess the current status of quality of web-based collaborative slum mapping in Kampala

1.4. Research Questions

The following sub-questions are structured to attain the main objective of this research.

No	Research Objective	Research Questions
1	To compare and review different web-based collaborative mapping methods and tools	1) What tools are currently available for collaborative slum mapping?
		2) Who introduced the tools and why?
		3) How do the tools operate?
		4) What are the strengths and limitations of the tools?
2	To analyze the users' requirements for Google Map Maker slum maps	1) Who are the potential users of slum mapping data?
		2) In what ways do the interests of users of slum maps differ?
		3) How often should slum mapping take place?
		4) How does the spatial and temporal scale required affect the use of slum maps?
3	To identify factors that lead to, or prevent potential stakeholder participation in collaborative slum mapping with GMM	1) What are the enabling, disenabling factors for participation in collaborative mapping?
		2) What are the concerns local communities have in the use of GMM for slum mapping?
		3) What motivates mappers to become part of collaborative slum mapping?
		4) How much committed are the GMM mappers to continue contributing to collaborative slum mapping?
		5) How much time do the stakeholders spend on collaborative slum mapping?
		6) How much time are they willing to spend for collaborative mapping
4	To assess the current status of quality of web-based collaborative slum mapping in Kampala	1) What is the current status in the quality of slum mapping in Kampala City?
		2) How often is collaborative slum mapping being carried out?
		3) What are/could the maps be used for?
		4) What criteria are used to identify stakeholders for collaborative slum mapping?

Table 1: Research Questions

1.5. Conceptual Framework

Structuring the ideas of this research as shown in Fig. 1 below is built on the relationship between participation in collaborative slum mapping and the factors that influence individuals to participate in collaborative mapping. These factors are politico-cultural, socio-economic, technical, institutional and regulatory framework and experience or familiarity with the collaborative mapping tools. The basic premise of stakeholders behaviour is that individual participation in collaborative slum mapping depends

on how one is influenced by the above-mentioned factors. The degree to which these factors influence stakeholders, will determine the nature of stakeholders` participation in collaborative slum mapping process. The question of who may volunteer to participate, has much to do with the quality of the resulting information, the individual interests and a range of possibilities exist. Nuojua (2010) argues that kind of the technology being applied can become help to facilitate knowledge creation which is crucial in the planning process.

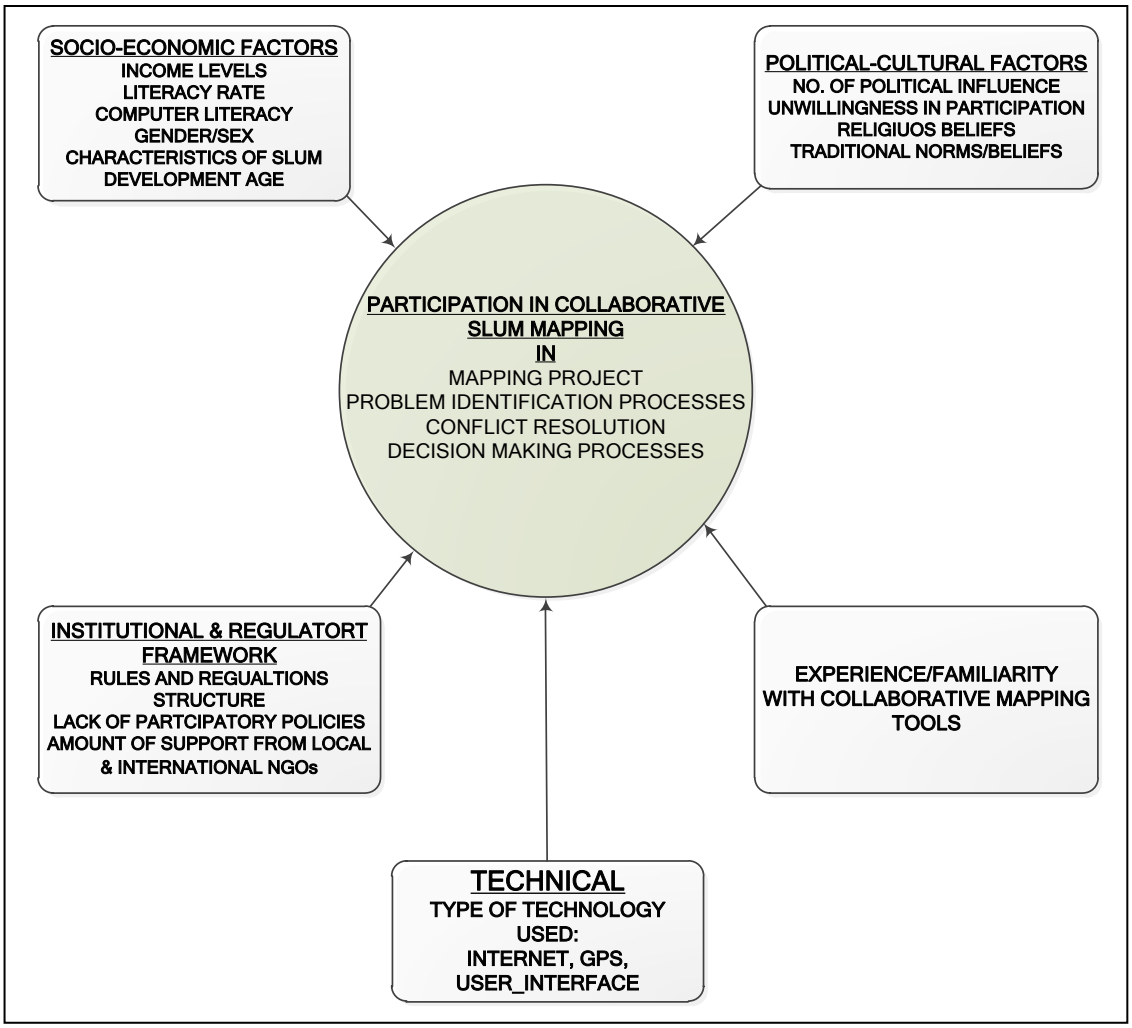


Figure 1: Conceptual Framework

1.6. Research Design

Figure 2 illustrates the methods followed in the implementation of the research. The research problem is identified through a review of literature and investigation of a real-world slum problem. Based on the research problem, appropriate research objectives were defined and research questions formulated in order to answer the research problem. Also on the basis of literature review, required data was identified and collected during field work. The data was analysed using Content Analysis in Nvivo 9 software combined with descriptive qualitative analysis to determine the effectiveness of GMM tool and the quality of map data generated in collaborative slum mapping. Eventually, the conclusions are obtained and afterwards recommendations for proposing approach for effective participatory slum mapping methods.

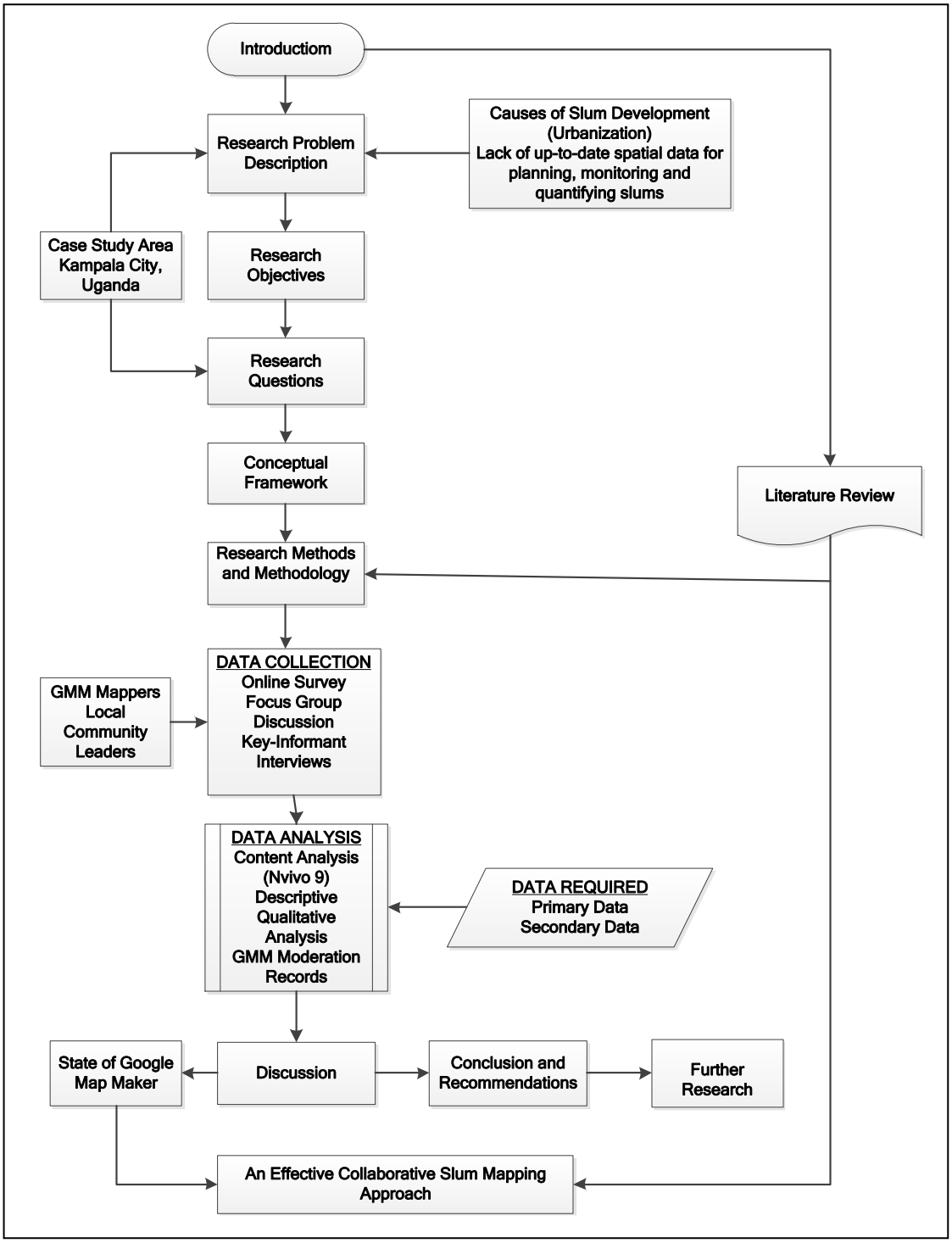


Figure 2 : Research Design

Moreover, Table 2, explains the research matrix showing the data required, methodology and source of the data for each specific research objective.

No	Specific Research Objective	Research Question	Data Required	Data Source	Methods
1	To compare and review different web-based collaborative mapping methods and tools	What tools are currently available for collaborative mapping?	Secondary	Reports, books	Literature review
2		Who introduced the tools and why?	Secondary	Reports, internet publications	Literature review
3		How do the tools operate?	Secondary & primary	Reports, internet publications	Literature review
4		What are the strengths and weaknesses of those tools?	Secondary	Reports, books	Literature search
5	To analyze the users` requirements for Google Map Maker slum maps	Who are the potential users of slum mapping data?	Primary	Stakeholders, NGOs	FGDs interviews Literature search
6		In what ways do the interests of users of slum maps differ?	Secondary & Primary	Reports Publications Stakeholders	Literature review, FGDs Interviews
7		How often should slum mapping take place?	Primary	Stakeholders	Interviews FGDs
8		How does the spatial and temporal scale required affect the use of slum maps?	Primary & secondary	Reports Stakeholders	Literature review & Interviews
9	To identify factors that lead or prevent potential stakeholders from participation in collaborative slum mapping	What are the enabling and disenabling factors for participation in collaborative mapping?	Primary	Reports by NGOs and govt. depts. stakeholders	Interviews, FGDs and Literature review
10		What are the concerns stakeholders have in the use GMM for slum mapping?	Primary	Stakeholders	Structured Interviews & FGD
11		What motivates mappers to become part of collaborative slum mapping?	Primary & secondary	Reports Stakeholders	FGD Interviews & literature review
12		How much committed are the GMM mappers to continue contributing to the collaborative slum mapping?	Primary	Stakeholders	FGDs & Interviews
13		How much time do stakeholders spend on collaborative slum mapping?	Primary	Stakeholders	FGDs & Interviews
14		How much time are they willing to spend for collaborative slum mapping?	Primary	Stakeholders	Structured Interviews
15	To assess the current status of quality of web-based collaborative slum mapping in Kampala	What is the current status in the quality of slum mapping in Kampala City?	Primary & secondary	Stakeholders Ordinance Survey maps Internet connection GPS	Interviews, Transect mapping FGD
16		How often does collaborative slum mapping take place?	Primary	Stakeholders and Reports	Interview, FGD, review literature

17		What are/could slums maps be used for?	Primary	Stakeholders	Interviews Focus Group Discussions
18		What criteria are used to identify stakeholders for collaborative slum mapping?	Primary & Secondary	Stakeholders Community Leaders	Structured Interviews

Table 2: Research Matrix

1.7. Thesis Structure

The thesis consists of 7 chapters as follows:

Chapter 1: Introduction

This chapter includes the background, definitions of some key concepts, justification, research problem, research objectives, research questions, conceptual framework, and research design and thesis structure.

Chapter 2: Literature Review

It includes the theoretical background about collaborative mapping and the effectiveness of collaborative slum mapping using GMM and other internet-based collaborative mapping tools. This chapter also describes the study area of Kampala City in Uganda in general and the characteristics of slums in Uganda and Katanga Slum in particular.

Chapter 3: Data Collection: Approach and Methodology

It describes the approach and methodology, consists of field work plan, survey design and equipment used in the field work, collection of secondary, collection of primary data, FGDs, interviews and online surveys.

Chapter 4: Data Management and Analysis

This chapter consists of for example Content Analysis method used to analyse the primary data, the software used in data analysis and research findings.

Chapter 5: Discussion

This consists of the results of the analyzed data about collaborative slum mapping with GMM and a discussion of the results of the analysis.

Chapter 6: Conclusions and Recommendations

This chapter includes general conclusions, results research objectives, limitations of the research and this is followed by the recommendations and proposed method of slum mapping.

Chapter 7: List of References

This part contains the literature and journals used in this research.

2. LITERATURE REVIEW

In recent years there have been an explosion of interest in using the Web to create, assemble, and disseminate geographic information provided voluntarily by individuals (M.F. Goodchild, 2007). There are various sites such as OpenStreetMap (OSM), Wikimapia, Ushahidi and GMM for example that are empowering citizens to create geographic information about their local communities. These tools rely both on volunteers with local knowledge to contribute towards generation of spatial data about local neighborhoods and volunteers with specialist knowledge to monitor information.

According to (Ball, 2002; Ballatore & Bertolotto, 2011; M.F. Goodchild, 2007); the rising interest in compiling geo-referenced data has maintained itself in the growth of volunteered geographical information (VGI) websites. This is an assertive method of collecting geospatial information as opposed to the authoritative method employed by government agencies and private industry. They argue that Wikimapia for instance is a site that encourages participants to post comments about geo-referenced locations while OSM is an international effort to create a free source of map data through the efforts of volunteers. According to Goodchild et. al, (2007), using various internet-based participatory mapping tools, volunteers on one hand are encouraged to provide geographic information about their local communities and on the other hand playing an increasingly important role in ensuring that authoritative sources of geographic information are accurate and kept up-to-date.

Web-based participatory mapping tools have the potential to be a significant source of geographers` understanding of the surface of the Earth. By motivating individuals to act voluntarily, it is far cheaper than any other alternative, and its products are almost invariably available to all. (Ansumana et al., 2010; Ballatore & Bertolotto, 2011; M.F. Goodchild, 2007). Sites such as the OSM often provide the cheapest source of geographic information, and sometimes the only source, particularly in areas where access to geographic information is regarded as an issue of national security (Ansumana et al., 2010; Goodchild et al., 2007; Gunter, 2009). Anyone with internet connection can select an area on the Earth`s surface and provide it with description and edit entries. Cartwright (2008), also argues that accelerated by relatively inexpensive access to the internet, the availability of small, inexpensive, mobile computers and the availability of social software have changed the way in which users access information via the internet. The internet is now being used in a way where users 'build' their own information resources by placing their own information on-line or linking to many distributed resources. It is therefore clear that participation by stakeholders is becoming accepted as a vehicle for the policy and decision maker and planners to gain access to local knowledge, which is a vital complement to scientific knowledge.

This research is reviewing and examining the effectiveness of collaborative slum mapping using GMM. It tries to answer such questions as: What drives people to participate in collaborative slum mapping? How accurate are the results? How are the maps being used? And, how can they augment more conventional sources?

2.1. Definition of Collaborative Mapping and Participatory Mapping

Collaborative mapping is the aggregation of web maps and user-generated content from a group of individuals or entities, and can take several distinct forms. Collaborative mapping applications vary depending on which feature the collaborative edition takes place, on the map itself or on overlays to the map. (See for example, *http://en.wikipedia.org/wiki/Collaborative_mapping*). Other authors have defined collaborative mapping as an initiative to collectively produce models of real-world locations online that people can then access and use to virtually annotate locations in space (*http://www.webmapper.net/carto2003/*). In this research, collaborative slum mapping implies the contributions, addition, edition etc. by several distinct stakeholders towards production of maps. So the term excludes applications where the maps produced are not meant for the general user to modify, but the maps for slum areas have been produced by sharing a common surface based on user-generated contributions. On the other hand, Chambers (2006) defines participatory mapping as the process involving many stakeholders in which various forms of spatial representations are made by the local people themselves. Similarly, Steinmann et. al (2005; Vajjhala, 2005) argue that in participatory mapping, participants can geographically express suggestions for changes or can make comments on specific objects in the selected map.

Although the focus of this research is on collaborative slum mapping with the use of Google Map Maker, the terms "*participatory mapping*" and "*collaborative mapping*" are being used interchangeably simply because within the collaborative slum mapping process where GMM has been used as a web-based collaborative mapping tool, there is involvement of many stakeholders including some drawn from the local communities; hence it is participatory.

2.1 Relationship between collaborative slum mapping with GMM and other conventional mapping methods

Some schools of thought have maintained that products of maps that are generated through collaborative mapping are not accurate, and yet others argue that collaborative mapping produces more accurate information within a short period of time and in a low cost manner (Ansumana et al., 2010; Chang et al., 2009; Hessel et al., 2009; IFAD, 2010). To this effect, other mapping methods such as use of global positioning system (GPS), geographic information systems (GIS) and participatory aerial photographic interpretation (PAPI) have to be used to make collaborative slum mapping more effective.

2.1.1 Geographic Positioning System (GPS)

A global positioning system is used to produce geographically accurate maps with local communities because local communities are a reliable source of local knowledge (Voss et al., 2004). It is capable of providing the latitude and longitude readings of any position on the surface of the earth. GPS enables the operator to plot the position of objects on the ground. Thus for example, by picking points with the help of local people; it is possible to draw a very accurate boundary map that can be elaborated upon to show the positions of different features and important local uses of the area (Bonham-Carter, 1991)

Although these techniques do allow community members to decide what is put into the maps they do, however, generally rely to some extent, on trained personnel from outside to prepare the base maps. In this case, maps produced through collaborative mapping can be used as a base map to record the field data directly on the maps (Blaschke & Schmidt, 2006). Alternatively, waypoints can be recorded using a GPS, and in the GMM environment, Google Fusion tables can be created using GPS readings.

Google Fusion Tables is a modern data management and publishing web-application that makes it easy to host, manage, collaborate on, visualize and publish data tables online. (See for example: *http://www.google.com/fusiontables/public/tour/index.html#)*. The tables can be uploaded from spread sheets as KML, csv or Excel files and instantly see the data on a map or as a chart immediately. Google Fusion tables can turn location tables into maps. GPS readings for points, lines, polygons including customer attributes, countries etc. can be mapped in minutes with Google fusion tables. Since fusion tables can also be created in GMM environment, it can therefore compliment with other collaborative mapping methods in generating spatial data in a short period of time. These marked positions can be verified further through the use of GIS. To achieve this, GMM maps have to be downloaded and saved as KML file which is then opened and converted in GIS from KML to layer for further processing.

2.1.2 Participatory Aerial Photographic Interpretation

Collaborative slum mapping can be complimented with other conventional mapping methods such as the participatory aerial photographic interpretation. Several authors (Carton & Thissen, 2009; Mac Gillavry, 2003; Mather, 2000) point out that the local people find it easy to interpret aerial photos and that aerial photos are a basis for participatory mapping that enhances transferring of information between groups. Therefore greater accuracy of maps prepared through collaborative slum mapping can be achieved through consulting and incorporating information from alternative sources such as existing maps or aerial photographs. Participants can use aerial photos to discuss about the extents of slums and their characteristics and locations of key features within the slums. This for example, will enable mappers to easily delineate slum boundaries and locate key features on the map. Aerial photographs make information, issues surrounding physical conditions of slums more accessible to non-literate people, thereby empowering them to take greater control over decision making (Mather, 2000; Voss et al., 2004)

2.1.3 Geographic Information system (GIS)

A geographic information system is a relational database whose main feature is the use of a common coordinate system for accessing both spatial data (on objects) and descriptive or attribute information defining those objects (Carter, 1992). A GIS can capture, store, update, retrieve, organize, manipulate, analyze and display spatial information. It provides a means to integrate many layers of spatial information to develop dynamic models, to analyze trends over time and to stimulate scenarios (Carter, 1992; Griffiths, 2002; RoumaniDenn, 1996). This feature makes GIS ideal for storing and analysing information and thus helps understanding the relationship between spatial objects and the context in which they exist.

Therefore collaborative slum mapping with GMM and GIS can complement each other in that GMM maps can be saved as KML files and be exported to ArcGIS for further analysis, interpretation and visualization. For example, in positional accuracy assessment, a GMM data set can be overplayed with a dataset of maps prepared by technical experts. This operation is possible in a GIS environment and a layer in GIS can also be converted to KML file and be opened in Google earth. Conclusions can therefore be drawn based on the overlaying of different layers of slum maps.

2.2. Effectiveness of Collaborative Slum Mapping

The main objective of this research is to determine the effectiveness of collaborative slum mapping for the production of spatial data. This is to better understand the effectiveness of GMM as specific example of collaborative mapping system of slum mapping in developing countries. In this research, effectiveness of collaborative slum mapping has been looked at, first, in terms of the process in which the GMM tool is used in order to produce spatial data of high quality and how reliable the tool can be in mapping of slums. The second element is by looking at the quality of information that is generated with GMM as a collaborative mapping tool.

Many authors have argued that collaborative mapping is a fast and reliable data collection method. (IFAD, 2010; Voss et al., 2004) and also that collaborative approaches offer several advantages over conventional mapping approaches. Lemma et. al (2004), have also argued further that collaborative slum mapping is advantageous in the sense that, it is timely and low cost, increases ownership of the data collection process and the revealed problems, enhances local learning that results from participation and a greater ease of embedding locally generated information in institutions such as city, sub-city authorities and community-based organizations (CBOs). Batty et. al (2010) also argues that maps built in this may rival or surpass anything produced in more conventional way as they are likely to be more informative

Therefore, based on the above understanding, effectiveness of collaborative slum mapping in this case means how the use of GMM can effectively be participatory in the production of spatial data of high

quality using local knowledge in a low cost and short time manner, while at the same time increasing ownership of the data collection process. It also means how flexible collaborative mapping is for different stakeholders to map slums in a participatory manner or the flexibility of GMM to allow different players or stakeholders including the community to participate and collaborate so that the maps produced are user-generated products created by sharing a common surface. Furthermore, flexibility, also entails whether the method and techniques is able to integrate with other conventional mapping techniques, e.g. mapping with GPS. The second aspect about "effectiveness of collaborative slum mapping" using GMM is determining whether the approach can generate data of high quality which can be used for town/urban planning and policy and decision making purposes.

2.3. Web-based Coallaborative Mapping Tools

Web-based collaborative mapping tools are methods of web interaction borne from a trend of web application that allow people to upload information to the web easily and so many people can view and react. According to Murugesan (2007), Wigand et. al, 2008) as cited by Google Map Maker (see for example *http://www.google.com/mapmaker*), sub web applications refers to a stage where data providers ranging from individual mapper enthusiasts to geo-information professional upload information. Goodchild (2007), has termed the way of mapping based on contributions by individuals as Volunteered Geography and the resulting information as Volunteered Geo-information (VGI). There are several tools available which allow users to create, edit and view Web content such as the ones described in Table 3-Pg.16-19 below.

2.4. Comparisons between Web-based Collaborative Slum Mapping

Table 3 presents the comparisons between some of the web-based collaborative mapping tools namely, GMM, OSM, WikiMapia and Ushahidi. These tools vary in terms of the breadth of end-user coverage, data entry and end-user clients, data licensing, data moderation methods, (that influencing quality and speed of publication, and ease of use). In general all the four tools use crowdsourcing which relies on the principle that a lot of knowledge resides with individual citizens, being experts of their local environment. In the table below, each tool is described in terms of definition, who introduced it and why, interface and how the tool operates, strengths and limitations of these collaborative mapping tools.

	Comparison between Collaborative Mapping tools			
	Google Map Maker(GMM)	**OpenStreetMap (OSM)**	**Wikimapia**	**Ushahidi**
Definition and general Description	It is a web-based collaborative mapping application for creating, viewing and editing online geo-information (*http://www.google.com/mapmaker)*	It is a collaborative tool to create a free editable map of the world. Map data are usually collected using a GPS unit, although this isn't strictly necessary if an area has already been traced from satellite imagery.	It is a privately owned, online map and satellite imaging resource that combines Google Maps with a wiki system, allowing users to add information, in the form of a note, to any location on Earth. Users may currently use this information for free.(See e.g. *http://en.wikipedia.org/wiki/WikiMapia* Although registration is not required to edit or add to WikiMapia, over 1,100,000 users from around the world currently are registered.	"*Ushahidi*" according to (*http://ushahidi.com/about-us*) means "testimony" in Swahili. It was a website initially developed to map inputs from citizens during the 2008 Kenyan post-elections violence and later used for hazard mapping of the 2010 Haiti earthquake
Who Introduced the tool?	GMM was launched by Google in 2008 to expand the breadth of the service currently offered by Google maps. Collaborative Slum mapping with GMM project was launched in April, 2011	OSM was launched on 1 July, 2004 by OpenStreetMap Community.	It was launched on 24th May, 2006 by two Russian internet entrepreneurs (*Alexandre Koriakine* and *Evgeniy Saveliev*) after being inspired by the success of Google Maps and Wikipedia (See for example, *http://en.wikipedia.org/wiki/Wiki Mapia*	It was introduced in 2008 in Kenya for post-elections crisis mapping in order to give information to those providing relief for rapid responses
Reason (s) for introducing the tool	To support the improvement of existing Google map data through the expert knowledge of local citizens. The ultimate goal of GMM acquires sufficient high-quality mapping data to be published and used on the existing Google maps service.	To encourage the growth, development and distribution of free geospatial data and provide geo-spatial data for anybody to use and share	To describe the whole world.	To report about what is happening to them or around them during disaster or emergency situations. Currently, it is for information collection, visualization and interactive mapping
Interface of	According to	The maps are created using data from	WikiMapia allows any contributor to add a	Ushahidi is an open source

the tool and how it operates	(*http://www.google.com/mapmaker*) at first glance, the site appears identical to Google Maps and the three views (map, satellite and hybrid) are available which allow users to view the map data, a satellite image of the area of interest (AOI) or a combination of both. Using the find or browse tools, contributors are able to add to and edit existing features on the map. In GMM, three kinds of drawing tools are available: (1) Placemark - a single point of interest on the map (2) Line- for drawing roads, railways, rivers, and the like (3) Polygon- for defining boundaries and borders, adding parks, lakes and other large features.	GPS devices, aerial photography and other free sources or supply from local knowledge. Both image and the vector data are available to download under a Creative Commons license Once the data have been collected, they are entered into the database by uploading it on the project's website. At that point in time, no information about the kind of uploaded track is available. Thus, in a second step, editing takes place using one of several purpose-built map editors. This is usually done by the same mapper, sometimes by other users registered at OSM. As collecting and uploading data is separated from editing objects, contribution to the project is possible also without using a GPS unit. In particular, placing and editing objects is done based on editors' local knowledge.	"tag" (placemark) to any location by marking out a polygon around the location and then providing a default language, title, description and one or more categories. Multiple categories can be added to any placemark by clicking the *add category* link and either selecting from a list of common categories, or by typing in the first few letters of the word to search for a category. Basic functions also allow users to link to a corresponding Wikipedia article, add an address, or specify whether a polygon outlines a building (as opposed to a parcel of land). Users can also add "linear features", e.g. roads, railroads, ferry lines, and rivers. It allows users to specify the size of the road (major highway, side street, dirt road, etc.), to indicate one-way streets, and to provide a brief description. It also allows users to describe intersections and tunnels. Users also can add up to seven pictures to each tag by selecting *Add/Manage Photos* from the placetag's menu. This opens a dialog box, allowing the user to upload a photo from their computer or the internet.	platform in which anyone can contribute information through: (1) SMS from a phone (2) Photo or video from a smart phone (3) Report submitted online (4) Gather information from any device with a digital data connection After a report is submitted, it is posted in a near real-time to an interactive map that can be viewed on a computer or smart phone.

Similarities	GMM is web-based and requires internet connection Registration is required for contributors	OSM requires internet connection Registration is required for contributors	All content uploaded by users is currently made available under Creative Common license for non-commercial use through WikiMapia API.	
Advantages Of the tools	GMM obtains a perpetual, irrevocable, worldwide, royalty-free and non-exclusive license to reproduce, adapt, modify, translate, publish, publicly perform, display and distribute spatial information	OSM provides its map data under a Creative Common license (See for example, *http://en.wikipedia.org/wiki/Google_Map_Maker* Allows for a low-cost and fast dissemination of specific geo-information onto base maps to a smaller dedicated audience or to the public at large.	Unlike GMM and OSM, registration is optional in WikiMapia. The integration of bulk-input can be managed by dedicated software applications	Has the ability to take call application and deploy it to oneself to suit ones community needs It is flexible such that anyone can improve the service in any way It is easy to learn use and deployable worldwide
Limitations of the tools	The changes made in GMM are not immediately reflected on Google Maps The approach can be is stifled in areas with poor satellite imagery, and can hinder the creation of map data in those areas. GMM does not cater for features as borehole, water point in the categories.		There is no provision in the WikiMapia interface for distinguishing residential areas from places of public interest in urban areas covered with thousands of overlapping rectangles.	Can only map point features

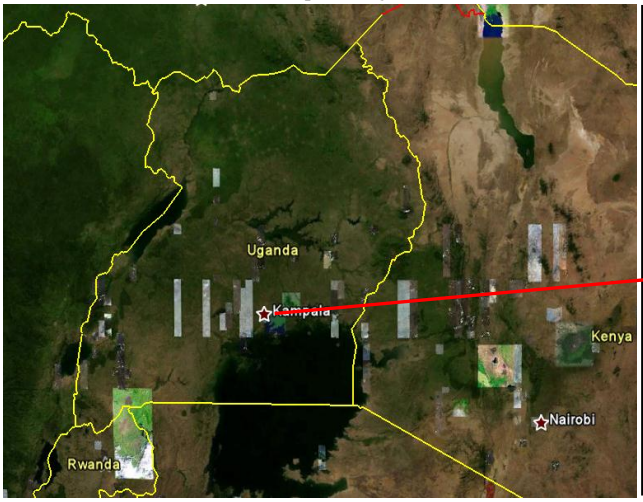
Table 3: Comparison of Collaborative Mapping Tools

2.5. Study Area

2.5.1 Location

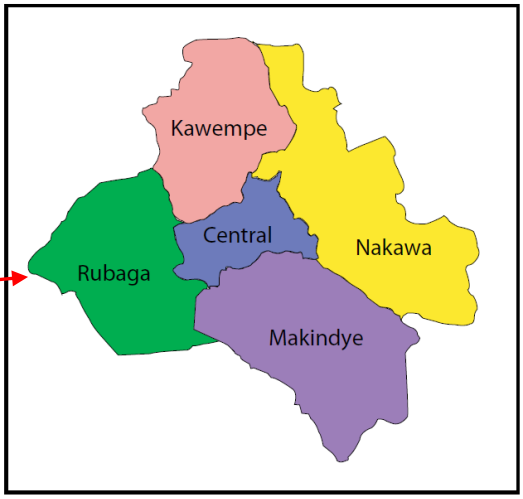
The research was conducted in the City of Kampala in Uganda where majority of the population lives in slums. According to Rugadya (2003), Kampala means a "hill of Impalas" derived from a Luganda word impala, a type of antelope (Aepyceros melampus). Situated approximately 45 km North of the Equator, Kampala is one of Uganda`s 80 districts. It is both administrative and commercial capital city of Uganda and has five political and administrative divisions namely: Kampala Central, Nakawa, Kawempe, Rubaga and Makindye. See Fig. 4 below. Politically, it is headed by the Mayor who presides over a council that makes political decisions of the district (Nyakaana, Sengondo, & Lwasa, 2008; Slum Aid Project, 2007)

Satellite Image (Oct, 2010) of Uganda showing Location of Kampala City.



Source: Photo @ 2011, Image NASA, Technologies

Map of Kampala Showing the Divisions of Kampala City



Source : Adopted from (UN HABITAT, 2007b) Europa Google Map Page 5

Figure 3: Map of Uganda showing location of Kampala City

2.6. Population

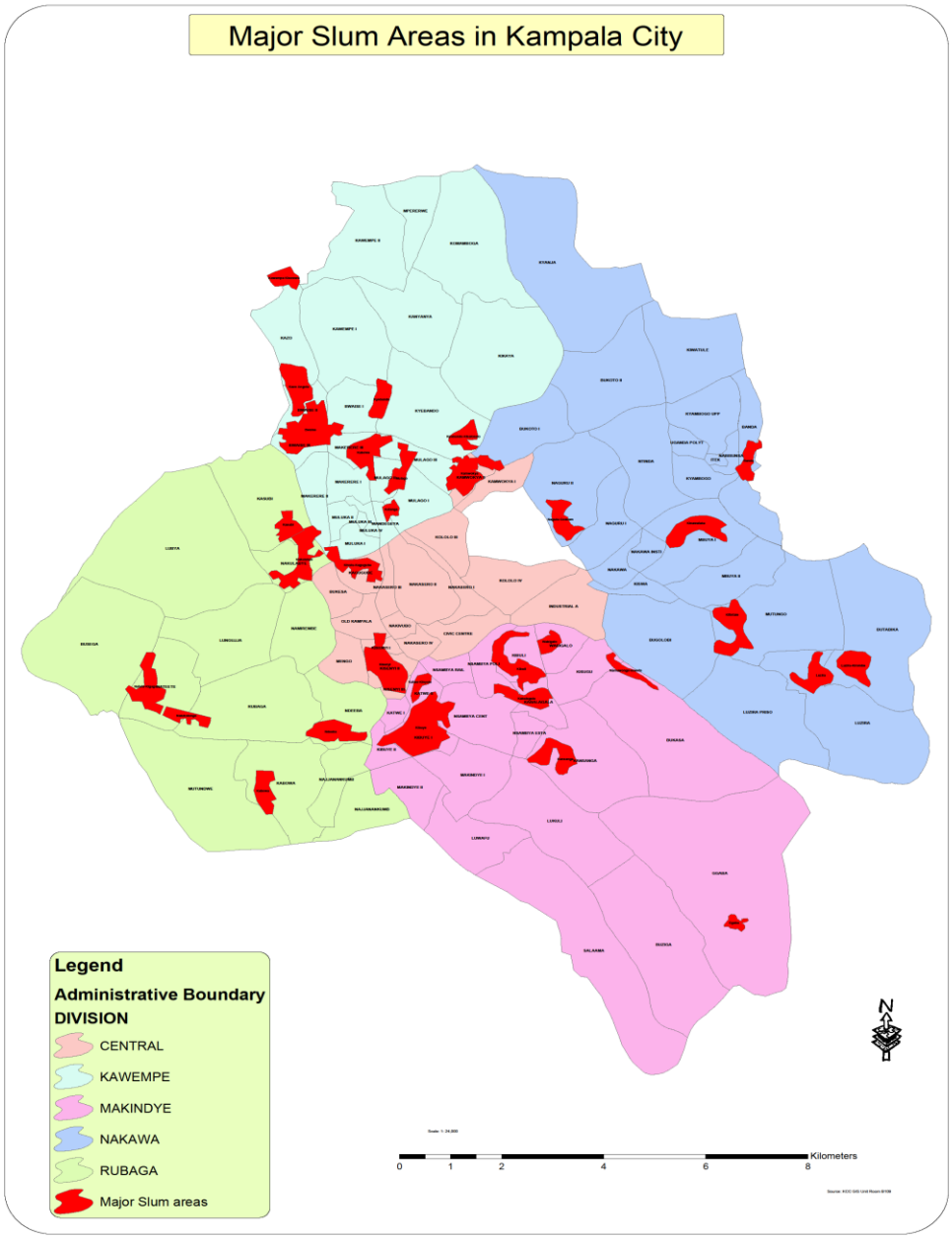
The national census of 2002 estimated the population of Kampala City at 1,189,142. The Uganda Bureau of Statistics (2002) estimated the population of Kampala at 1,420,200 in 2002 . In 2011, it estimated the mid-year population at 1,659,600. The population of Kampala City is growing at annual average rate of 4.1% due to migration and not just the natural rate of increase and over 60% of Kampala's population lives in slums (Rugadya, 2003; Uganda Bureau of Statistics, 2002). Consequently, a lot of unplanned developments are coming up with many of them taking place in prohibited areas such as wetlands

2.7. Slum Development and Urban Poverty

According to recent studies (Slum Aid Project, 2007; United Nations, 2004), 44% of Kampala's population lives in unplanned, underserviced slums which cover up to 25% of the city's total area. Slums are a product of urbanization and particularly rural-urban migration. In the case of Kampala, slums had their advent in the colonial period when poorly paid urban migrant African labourers and servants were

made to live in shanty places (Kampala City Council, Dec 2002; Slum Aid Project, 2007). Most of the slums today were swamps or forested areas which provided easy settlement for the rural to urban migrants since no one seemed to care about who settled there. The main slum settlements in the City of Kampala are shown below:

Figure 4: Main slum Areas

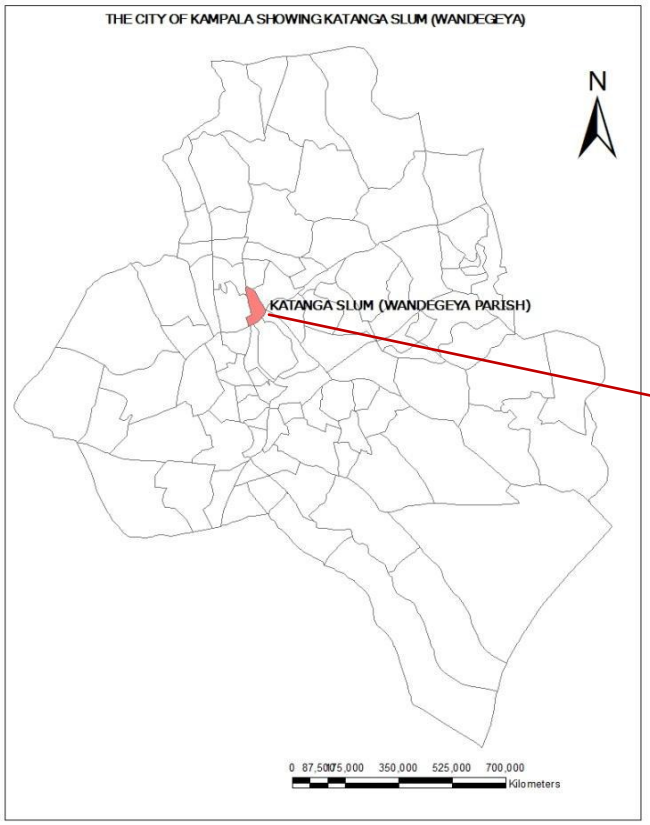


Source: KCCA (2010)

SAP (2007) also argues that urbanization has contributed to the rapid increase in populations and rising levels of urban poverty and that urban poverty is rated at 80% of the population in Kampala. Furthermore, it is reported that the economic profile of the urban poor indicates that a disproportionately larger female population is engaged in agriculture. 25% of the urban poor are not employed, the majority of whom are

women and lack adequate skills and education to enable them have gainful employment. They are also characterized with hunger and lack of food, poor income (daily earnings), lack of markets, factors linked to gender inequalities, child poverty.

Katanga slum in Wandegeya was selected as case study because the GMM tool was used more to map details of this slum unlike other slums where mainly the boundaries and a few features were mapped. Katanga, located in Wandegeya parish, in Kawempe division covers an area of 37.446 acres or 15.154 ha. Wandegeya is located between Yusuf Lule Road and Bombo Road, 4.8 kms North of Kampala along Bombo Road bounded by Makerere University in the South, Mulago Hospital in the North and Ministry of Public Service in North East and Gayaza Road roundabout in the South West. This slum has four (4) zones (Busia, Kimwanyi, Katale and Soweto). It's a slum area with a population of 5000 residents (2002 Census). The population zone per size is Busia 600 people, Kimwanyi, 3000, Soweto 1000 and Katale 400. The location of Katanga slum and is shown in Figure 5 below.



Source: Uganda Bureau of Statistics (2002)

Satellite image of Katanga Slum in Wandegeya Parish, Kampala City

Source: Google 2011-Tracks4Africa, DigitalGlobe, Geo Eye

Figure 5: Map of Katanga Slum (Kampala, Uganda)

3. DATA COLLECTION: APPROACH AND METHODOLOGY

This section discusses the methodological approach used to answer the research questions set out to meet the main research objective. Primary data was collected through Focus Group Discussions (FGDs) with both active and non-active mappers and local mapping committee leaders, key informant interviews with local community leaders, CBOs working on slum mapping/upgrading programmes, urban planners, and government officials. Primary data was also collected through online surveys targeted at stakeholders who registered as GMM mapper. Details of these are highlighted in Section 3.2. Primary data was supplemented by secondary data which was collected through literature review from academic research papers; government documents, maps, reports and internet-based sources. This includes population census data, shape files of study area, other maps (showing locations and extents of slum areas in Kampala) and some pictures.

3.1. Research Methodology

To carry out the research, the following phases were adopted: proposal preparation, pre-fieldwork, fieldwork, post-field work and thesis writing phases. Figure 5 below illustrates details of the research methodology

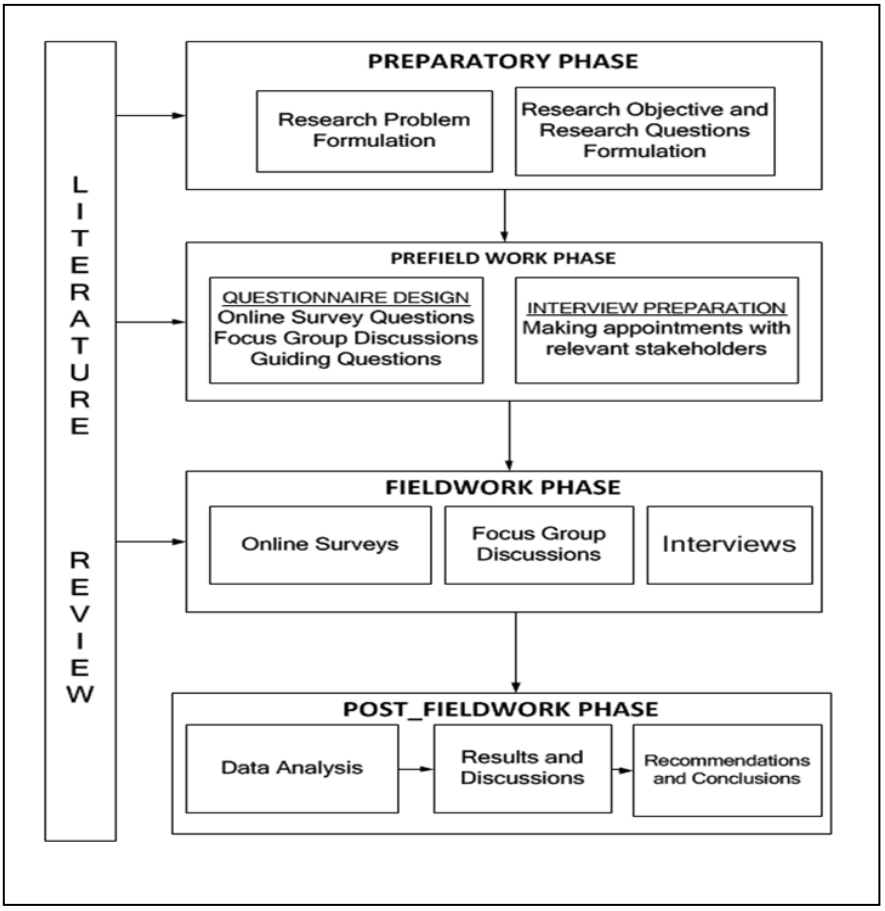


Figure 6: Research Methodology

(a) Preparatory Phase

Literature review- Literature review is carried out from journals, books, and papers on internet or library in order to come up with the research problem and on the basis of this be able to formulate research questions.

(b) **Pre-fieldwork Phase**

Questionnaire Design – Questionnaires for online survey targeting registered mappers who are both active and non-active and guiding questions for Focus Group Discussions and key-informant interviews are designed aiming at collecting data from stakeholders such as government departments, NGOs, CBOs, GMM mappers and local communities involved in the slum related issues. The guiding questions for FGDs are outlined in sections 3.2.1. See Appendix 1 and 2 for online survey and key-informant interviews questionnaires.

(i) Interview preparation

Before fieldwork, the questions for different groups, number of FGDs and the interview plan such as making appointments with relevant stakeholders are prepared in advance.

(ii) Fieldwork phase

This involves the collection of both primary and secondary data about how collaborative mapping using GMM is being done in the slums of Kampala such as Katwe, Kisenyi, Naguru, Wandengeya/Katanga, Nakulabye, Kasanvu, Assubi, Kibuli and Wabigalo etc. Data to be collected is about the mappers` knowledge of the GMM tool, names of slums and features being mapped, the mapping process being followed, the challenges they are facing with the GMM, collaborative stakeholders and tools and their different user`s` interests. These were collected through FGDs, key-informant interviews and online surveys. For secondary data, maps of the slums, shape files of Kampala City, reports and documents from government offices and other stakeholders was also collected group discussions, questionnaires and interviews.

(iii) Post-fieldwork

This involves analysis of data. First data collected from the field is transcribed, coded and analysed using Content Analysis method in Nvivo 9 software and Excel in order to identify the relationship between different parameters in this study. Based on the research findings, effective slum mapping methods are proposed. The following software and tools are used during research. Assessment of quality of slum maps generated is analysed using (a) moderation track records of selected mappers and also using the GMM history of edits.

Google Earth- to illustrate the study areas; i.e. slum areas within the City of Kampala and also for drawing the slum boundaries and other key features found within the slum areas

GMM - a web-based collaborative mapping tool which is used to map the slum was also used to illustrate the study

Excel – to plot the graphs for the analysed primary data.

Nvivo 9- for coding and analysing the primary data from interviews and FGDs

3.2. Data Collection

Primary (qualitative) data collected through the following approaches namely focus group discussions, interviews and online survey using SurveyMonkey. Below is the description of each of these approaches.

3.2.1 Focus Group Discussions (FGDs)

During fieldwork, FGDs were conducted to collect primary data about the mappers` knowledge of the tool (GMM) itself, definition of a slum in the context of Uganda, procedures being followed when mapping slums using GMM, challenges encountered, factors that motivate or de-motivate stakeholders from participating in slum mapping, use of maps produced, involvement and the role of different stakeholders in slum mapping and how came to learn about GMM. The challenges are categorized into three groups: (i) problems to do with GMM tool itself (ii) problems to do with an individual mapper and (iii) problems to do with the environment within which slum mapping is done as perception and attitude by local communities on slum mapping or political etc. that affect slum mapping in Kampala.

Five FGDs were conducted involving 18 participants of whom 13 were active GMM mappers and 5 non-active mappers. Of the 13 active participants, 8 were computer science university students and 3 urban planning students while 2 were active mappers with vast knowledge of the GMM tool but working in a private company and the university. Of the 11 active students 3 were new mappers.

These FGDs were conducted in order to get insights about the mappers` knowledge of the tool and the challenges associated with it, factors that motivate or discourage them from participating in slum mapping, slum mapping procedures being followed and features being mapped. This non-active group are registered GMM mappers but have not mapped any slum so far due to different reasons that this study is also interested in. This group was interviewed to get more insights as to why they have not done any slum mapping. The focus group discussions were guided by a set of open ended questions as follows:

1) How would you define a slum?
2) Which slums have you mapped using GMM? (provide names and area)
3) When did you start mapping slums with GMM?
4) What type of information have you already mapped?
5) How much time (hours) do you spend on slum mapping?
6) What problems do you encounter when mapping slums?
7) What suggestions can you give to ensure that mapping with GMM becomes effective?

Apart from active and non-active GMM mappers, one FGD involved 5 representatives of CBOs who were local leaders and also members of the slum mapping committees. The aim was to get data about their general understanding of the slum, fears they have towards slum mapping in general such as evictions and land grabbing and also the nature of local knowledge being generated and kept by the local communities and is crucial for slum mapping.

Figure 7: FGDs with Active GMM Mappers (Kampala)
Source: Mpanga (2011)

The discussions were held at community level but with different types of stakeholders. This enabled the researcher to observe differences in the competences and knowledge in mapping the slums using GMM between professionals, students and participants from the local communities.

All of the FGDs and interviews were conducted in English and all but 2 were digitally recorded and transcribed. Some participants did not want the discussion to be digitally recorded and their wishes were respected.

Figure 8: FGDs with non-active mappers, Kampala

Source: Mpanga (November, 2011)

3.2.2 Interviews

Apart from FGDs, key informant interviews were conducted involving government officials, urban planners, local community leaders and slum dwellers. In total 7 interviewees were drawn from SAP, Actogether Uganda, ASHD, KCCA, SDF, MLH&UD and Urban/Town Planning Department. Of the 7 interviewees, 3 were community leaders but with vast knowledge about slums and their conditions. These discussions were aimed at gathering information on the kind of knowledge or information local communities keep other experts do not have, roles and interests of NGOs/CBOs in slum mapping, existence of a policy on slum in Kampala, existing interventions on slums by both government and non-governmental organizations and more insights regarding issues of evictions and areas within the city deemed slums by different stakeholders.

These interviews were also aimed at gathering information about the perception, attitudes and fears or threats local communities have towards slum mapping or planning in general in the City of Kampala since evictions was mentioned as one of the contributing factor for people`s resistance to accept or participate in slum mapping. Due to differences in the nature of informants and also the environment in the course of discussions, some questions were adjusted so as get as more information as possible. See Appendix 2 for the questionnaire used for this category.

3.2.3 Online Survey (SurveyMonkey)

In addition to FGDs and key informant interviews, primary data collection was also done by means of online SurveyMonkey. The online surveys specifically targeted group of stakeholders who are actively participating in slum mapping using GMM and also those who were once participating but have stopped due to various reasons. In this case, 70 people were selected, 24 responded with 13 completing the questionnaires while 11 just answered first two questions which were about personal details. The online survey was conducted to collect data from registered members of GMM that are still active or not. The focus was on such areas as characteristics of mappers, prior survey knowledge and knowledge about GMM, factors that affect people`s participation in collaborative slum mapping which could be political, technical, social or financial; time spent on slum mapping, partners in slum mapping and other collaborative tools, potential users of the maps produced and follow-up approaches being applied to ensure effective slum mapping.

3.2.4 Secondary Data

Secondary data was also collected from KCCA, Actogether Uganda, Slum Dwellers Federation, SAP and GMM mappers. The documents include map of Kampala City showing all the major slums, copy of information collected and kept by the local communities in slums, map of Katanga Slum prepared using GMM, maps of Kisenyi prepared through other approaches, census data for the City of Kampala (2002), ArcGIS data (shape files) for the Kampala City administrative boundaries including photos of the slum areas visited

4. DATA MANAGEMENT AND ANALYSIS

4.1. Background Information

The data collected was transcribed, coded and classified using a Content Analysis approach combined with descriptive qualitative analysis using Nvivo 9 software. First, the data collected through FGDs, key-informant interviews was transcribed and combined with the data collected through online SurveyMonkey output was imported into the software as internal sources for coding. It was then analysed thematically along the main themes of the study. Figure 9 below shows the imported interviews as an example of sources

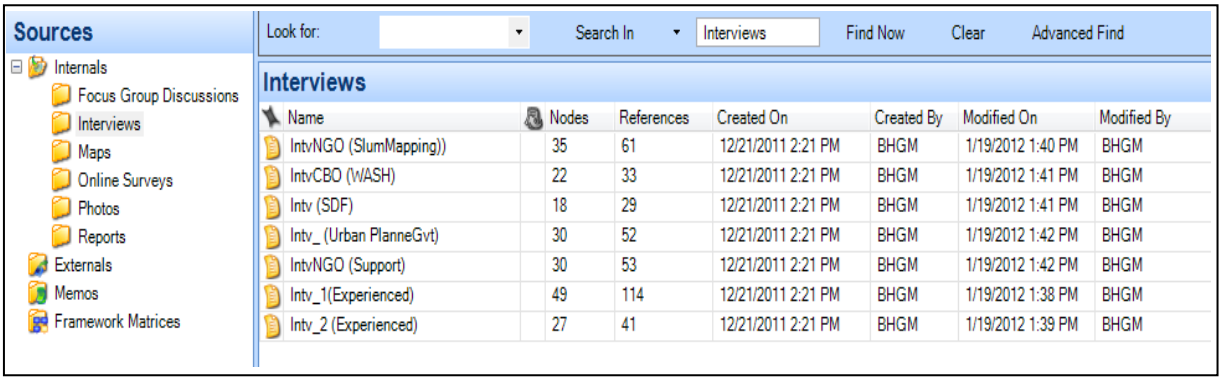


Figure 9 : Screen dump of Nvivo 9 showing Imported Data Sources

When analysing data, Nvivo 9 uses sources, codes also known as nodes, themes, classification and relationships. According to QSR (2011), "sources" is the collective term for research materials ranging from primary materials such as documents, videos or survey results to memos that record the ideas and insights. Sources can be imported or created at any stage of the project. Primary research materials can be stored in the *Internals* or *External* folders. In this study, primary materials i.e. transcribed documents (FGDs and interviews), pictures, excel sheet contain online survey responses were stored in Internals as shown in Figure 9 above. On the other hand, *External* are proxies that represent research materials that cannot be imported such as books or manuscripts.(QSR, 2011)

A node (code) is a collection of referenced about a specific theme, place, person or other area of interest. One gathers the references by "coding" sources such as FGDs, articles or survey results. While exploring the sources, one could code any content related to the node. For instance, "*lobbying*" was coded at the node "*Use of Slum Maps*". Nodes are central to understanding and working with Nvivo 9 software. Nodes let one gather related material in one place so that he can look for emerging patterns and ideas. Nodes can be created or organized nodes for themes or cases such as participants, slum mapping procedures and stakeholders (Nvivo Tutorial notes, 2011).

Nvivo 9 software also uses Relationship types. These classify the relationships within the project and allow you to make comparisons between all the relationships of a particular type. Relationship types have both a name and direction. For example;

a) Associative relationship (e.g. mappers know GMM tool) ——

b) One way relationship (e.g. Slum mappers use population figures) ——→

c) Symmetrical relationship (GMM mappers work with slum dwellers/residents ←——→

In this analysis, themes were created based on the research questions and also using the common answers given for each research question. For example, "evictions" was created as sub theme under "Challenges encountered" during collaborative slum mapping. The data was coded into different themes in order to clearly identify the required responses and were analysed thematically along the main themes of the study. Figure 10 below shows different codes/nodes into which data was assigned for analysis.

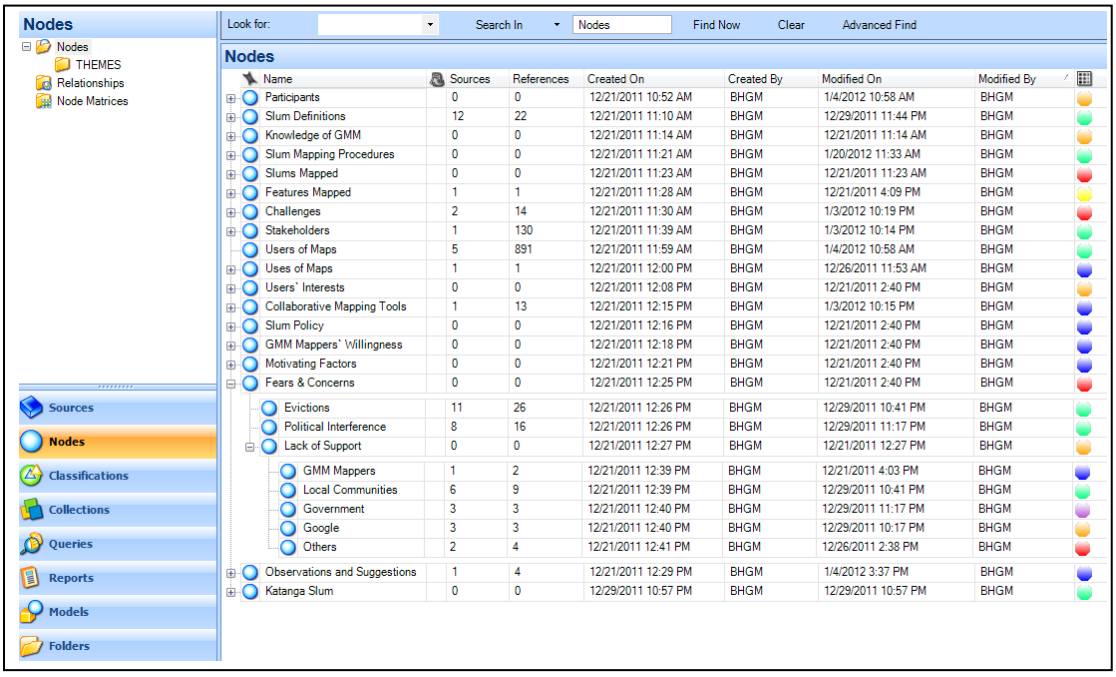


Figure 10: Screen dump of Nvivo 9 showing nodes and themes

Source: Nvivo

Different queries were conducted to determine if the all sources of data i.e. FGDs, interviews and online survey responses were able to be read or captured by the software. Below are the examples of such queries.
A Cluster Analysis which is an exploratory technique in Nvivo 9 that is used to visualise patterns by grouping sources or nodes that share the similarly words, similar attributes or are coded similarly by nodes was done to see nodes that were coded similarly. Cluster analysis diagrams provide a geographical representation of nodes to make it easy to see similarities and differences. Figure 11, 3D Cluster Map below shows the link between the themes of the study.

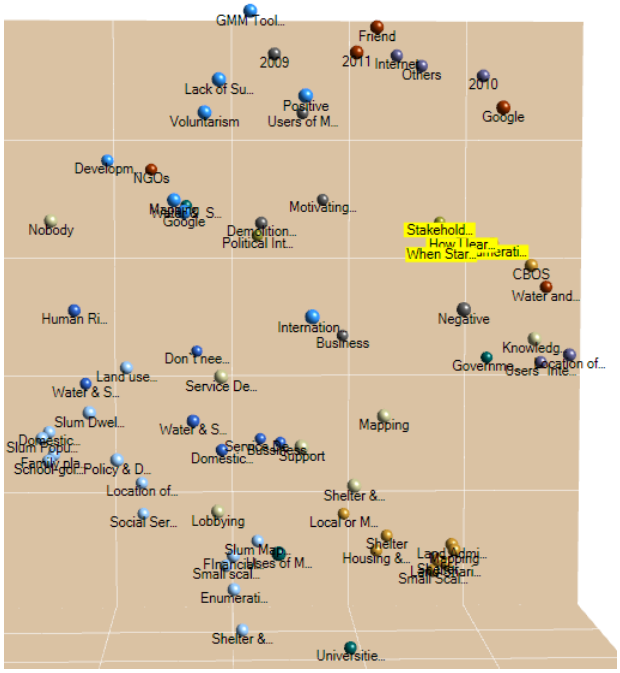


Figure 11 : 3D Cluster Map Showing Nodes coded similarly

Source: FGDs & Interviews

In the diagram above, similar items are clustered together and different items are further apart. For example, "*How I learnt about GMM*", "*When started GMM slum mapping*, and "*Stakeholders*" are very close to each other meaning because these are closely related and were coded similarly. These three share the same sources. So too are items like *Friend*, *2011*, *internet*, *others*, *2010* and *Google*. They are from different themes but are coded similarly. 3D Cluster Map also shows how similar or different were the responses from the participants.

Furthermore, Figures 12 and 13 show the link between the themes of the study and the sources. The diagrams show each theme and the sources from which it was coded. Figure 12 involves Non-active mappers and Local Community Leaders. The linkages show that different respondents gave more information that concerned problems that affect them as slum dwellers, while Figure 13 which involves active mappers, respondents were giving information about GMM tool itself unlike inexperienced mappers who contributed much on the fears and concerns.

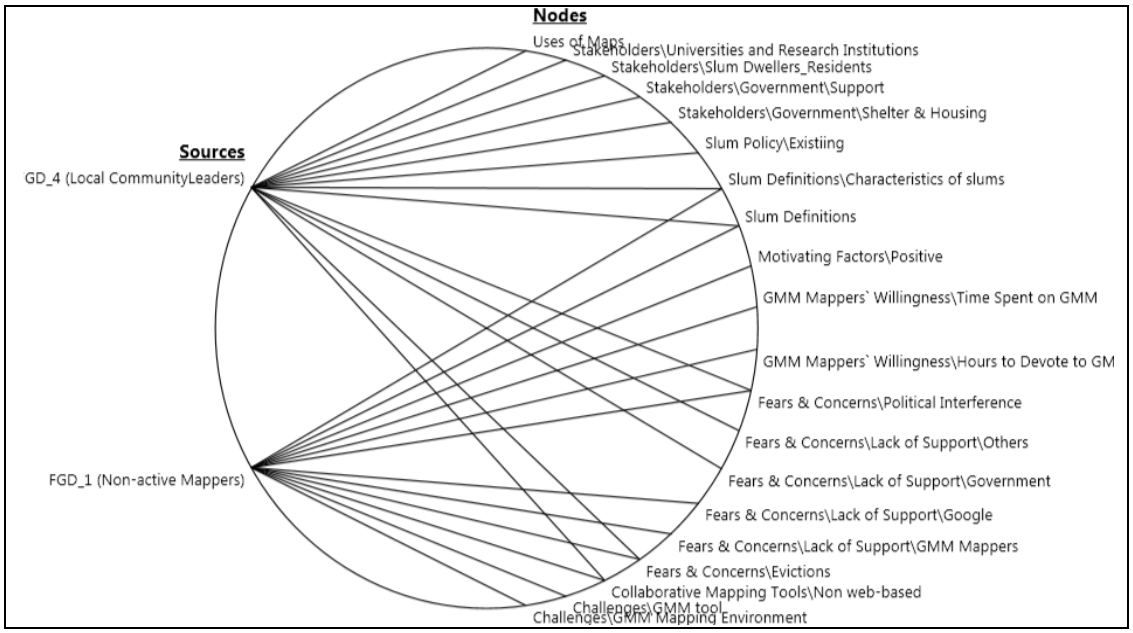


Figure 12: Data Source and Node Linkages
Source : Focus Group Discussions (Kampala, 2011)

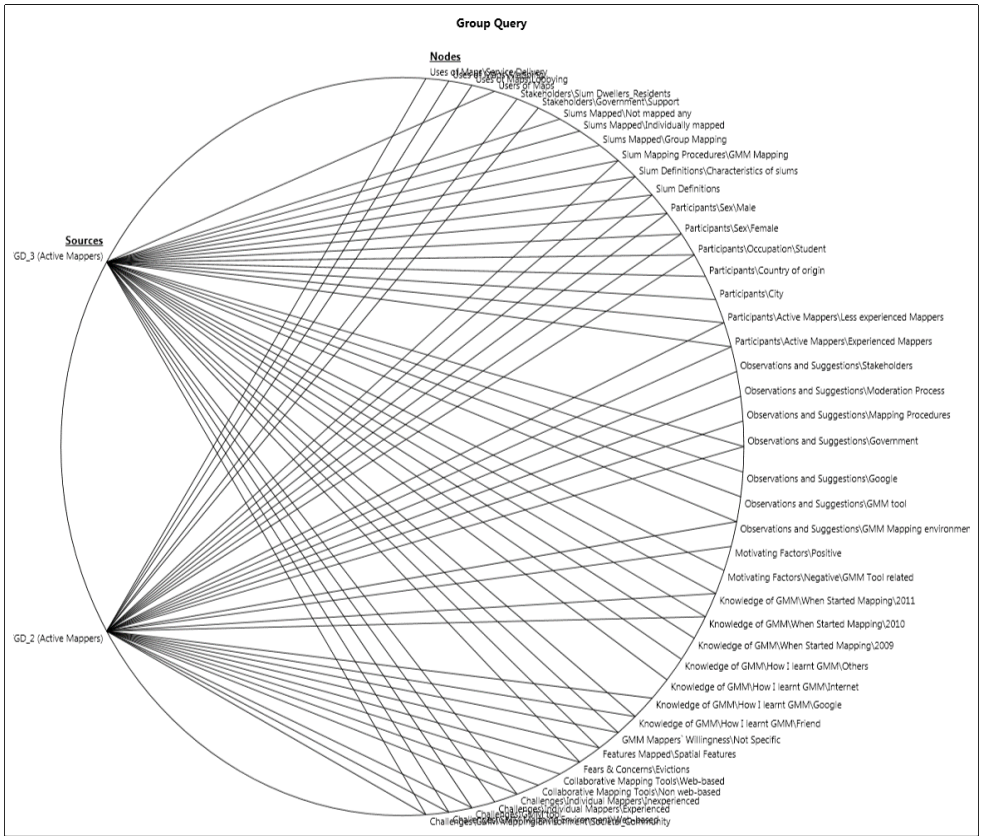


Figure 13: Source-Node Linkages (FGDs of Active Mappers)
Source: Focus Group Discussions

4.2. Description of Respondents

In the FGDs, 13 students were involved of whom 9 (69%), were active and experienced GMM mappers and 31% active but less experienced ones. Apart from these, there were also five non-active mappers and another 5 who were slum dwellers. One clear difference in the knowledge of the GMM between experienced and non-active respondents was that non-active respondents focused on issues to do with threats of evictions, land grabbing, political interference and lack of technical support from the experienced mappers on how to use the tool; as one of the challenges affecting collaborative slum mapping. On the other hand, the experienced active mappers dwelt much on the technical aspects of the tool such as need for Google to update the satellite imagery as one way of improving slum mapping. Experienced-active mappers were also able to describe how the tool operates unlike non-active mappers who showed lack of knowledge about GMM tool.

The second group of respondents were those who participated in the key-informant interviews. Of the 7 participants, 29% (urban planners) were experienced GMM mappers. Another 29% represented government officials working in urban planning sections lacked knowledge about GMM. 42% accounted for officers working in NGOs but collaborating with GMM mappers in different ways. Both government officers and those working in NGOs showed very little knowledge about GMM.

The last group was that of online survey questionnaires respondents. A total of 14 respondents answered the entire questionnaires. Amongst them were 2 GIS experts or cartographers, 3 urban planners, 2 students and 7 university teachers. Figure 14 below presents the general picture of the respondents. It also shows the relationships between types of respondents.

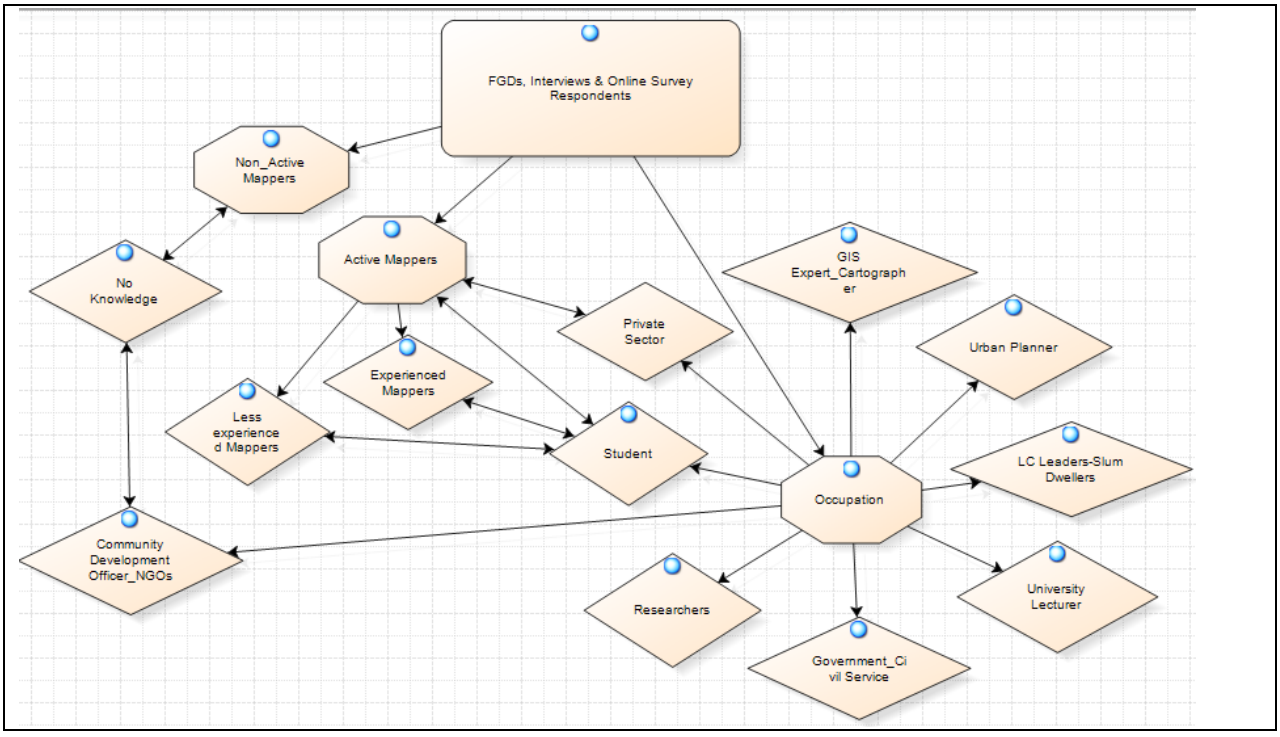


Figure 14: Linkages between Respondents of FGDs, Interviews & Online Survey

4.3. To compare and review different web-based collaborative mapping methods and tool

This section presents the comparison and review of different web-based collaborative mapping methods and tools that are currently available for slum mapping, who introduced the tools and why. It also highlights how the tools operate and their strengths and limitations. Web-based collaborative mapping tools are the methods of web interaction borne from a trend of web application that allow people to upload information to the web easily and so many people can view and react [sic]. The web-based collaborative mapping methods and tools under discussion are WikiMapia, OSM, Ushahidi, GMM and My Tracks.

4.3.1 Comparisons between currently available collaborative mapping methods and tools

Though web-based collaborative mapping tools are crowdsourcing, they differ in many ways such as: how they work, webpage designs and the reasons for their introduction. First, WikiMapia, OSM, Ushahidi and GMM use Google maps to add, edit features and visualisation of final maps. Except in WikiMapia where one can add a place without logging in when working in the Map mode, one needs to create an account and login is the other three methods.

While in Ushahidi Platform allows you to easily collect information via text messages, emails, twitter and web forms *(http://ushahidi.com/products/ushahidi Platform)* OSM uses data collected through a GPS and GMM relies on expert knowledge of local citizens.

These collaborative mapping tools have different webpage designs and therefore operate differently. The differences indicate that these methods operate differently. In WikiMapia for example, the interface has Edit Map, Map Type, Categories, Login and Add Place and Measure Distance buttons. Map Type is categorised into Wikimapia and Alternatives which contains Map, Satellite and Satellite +old places and Alternative sources comprises Google Map, Google hybrid, Google satellite, Google terrain, Google Panoramia, OSM and Wikimapia Classis. (See for example: *htpp://wikimapia.com*). These give the contributors freedom to choose which mode to work in. Like GMM, Wikimapia does not have borehole or water point under categories. Most of the features mapped using Wikimapia are polygon as shown in Figure 15 below:

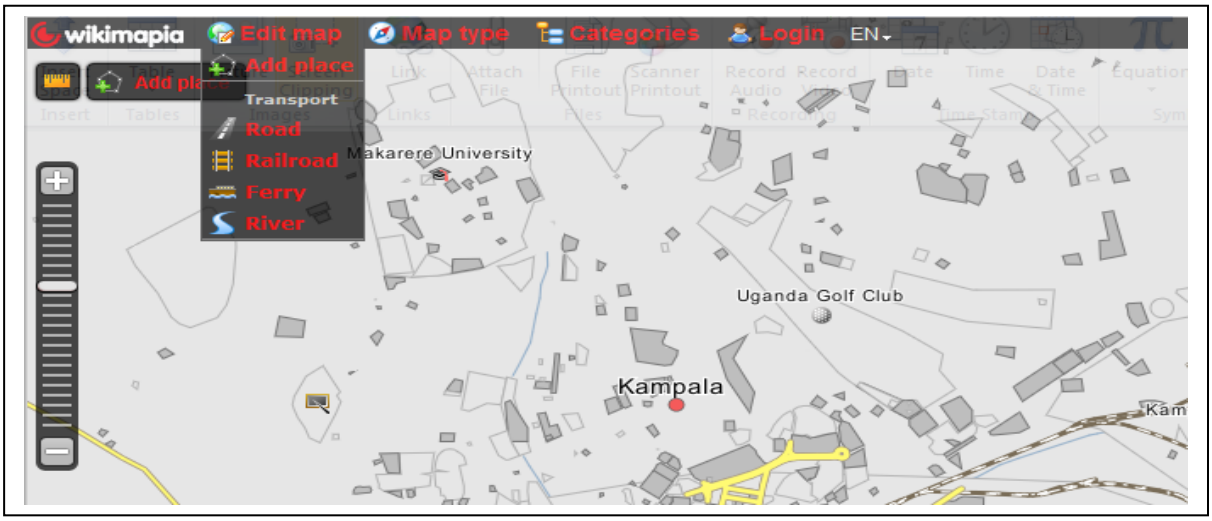


Figure 15 : Screen dump of Wikimapia showing map products created by Wikimapia for part of Kampala City
Source: Imagery @ 2012 DigitalGlobe, GeoEye @ Wikimapia.org

The map above shows the resultant map of Wikimapia visualized in Map mode. The areas mapped are shown by outlines and shades polygons.

4.3.2 How do the tools operate?

Though these tools are crowdsourcing relying on contributions through local knowledge expert, they differ in the way they operate. Table below outlines how the collaborative tools operate.

WikiMapia	Ushahidi	OSM	GMM	My Tracks
1. Any contributor can add a "tag" (placemark) to any location by marking out a polygon around the location and then provide default language, and other attributes 2. Multiple categories can be added to any placemark by clicking the *add category* link and either selecting from a list of common categories, or by typing the first few letters of the word to search for a category. The numbers displayed in parentheses next to each category indicate the number of placemarks belonging to that category. 3. Basic functions also allow users to link to a corresponding Wikipedia article, add an address, or specify whether a polygon outlines a building (as opposed to a parcel of land). 4. "Linear features", e.g. roads, railroads, ferry lines, and rivers can also be added. 5. Users can specify road sizes and provide brief description. 6. Users can add up to seven pictures to each tag by selecting *Add/Manage Photos* from the place tag's menu. *(http://en.wikipedia.org/wiki/WikiMapia*	Open-source platform and anyone can contribute data through: 1. SMS 2. Photo or video from a smart phone 3. Online Reports 4. From any device with a digital data connection 5. Submitted reports are posted in a near real-time to an interactive map that can be viewed (*http://ushahidi.com/about-us)*	1. Maps are created using data from GPS, aerial photography and other free sources or supply from local knowledge. Both image and the vector data can be downloaded under a Creative Commons license 2. Data are entered into the database by uploading it on the project's website. At that time, no information about the kind of uploaded track is available. Thus, in a second step, editing takes place using one of several purpose-built map editors. This is usually done by the same mapper, sometimes by other users registered at OSM. 3. Collecting and uploading data is separated from editing objects, 4. Contribution to the project is possible also without using a GPS unit. 5. Placing and editing objects is done based on editors' local knowledge. *(http://www.openstreetmap.org)*	1. Map, satellite and hybrid views, allow users to view the area of interest (AOI). 2. The find or browse tools, help contributors add, edit existing features on the map. 3. Drawing tools in GMM are: a) **Placemark**- a single point of interest on the map b) **Line**-for drawing roads, railways, rivers, and the like c) **Polygon**- for defining boundaries, borders, adding parks, lakes and other large features (http://www.google.com/mapmaker)*)*	1. It is activated in android phones 2. Once activated it records GPS tracks and view live statistics such as time, speed, distance covered and elevation while moving one point to another. 3. Once recorded, tracks are uploaded to Google spread sheets and visualise them on Google My Maps (Refer to Appendix 4 for an example of the product of My Tracks) *(Ref: FGDs,)*

Table 4: Operations of Collaborative Mapping Tools & Methods

In addition to the above-mentioned tools, My Tracks activated on android smart phones was used when mapping Katanga slum. It was used to mark paths through which mappers passed around the settlement picking points and taking of photos of different features. Figure 40 in appendix 4, shows the path drawn My Tracks and was later uploaded onto GMM to display the trails. Other mapping tools used to compliment GMM include cameras with GPS; GPRS enabled phones which were helpful in the collection of some data useful for slum mapping.

Furthermore, the Ushahidi webpage is different from that of OSM, GMM and Wikimapia in the following ways. *(http://ushahidi.com/about-us)* It uses Google maps like OSM, Wikimapia and GMM. Its interface has Map, Satellite and Hybrid. These enable users to switch from one mode to another, e.g. from Satellite to Map. On its sidebar Ushahidi has Categories. The categories in Ushahidi contain Violence related themes such as riots, looting while in GMM, OSM, Wikimapia, most features apart from boundary are physical features such as buildings, roads, shops etc. On the sidebar, Ushahidi has a "Submit an Incident" and Submit via SMS" buttons making it unique to contributing information via text messages or emails, reports submitted online and information gathered from any device with digital data connections. Unlike in GMM, Wikimapia and OSM where contributions can be mapped as a point, line or polygon, in Ushahidi, all submissions are mapped as points.

Below the map in Ushahidi, there is a detailed description of the incidents, location, and date, nature of the problem and the name of the contributor. Submissions are mapped as points in Ushahidi maps as shown in Figure 16 below. The points in red in the map are points mapped to have one form of post-elections violence

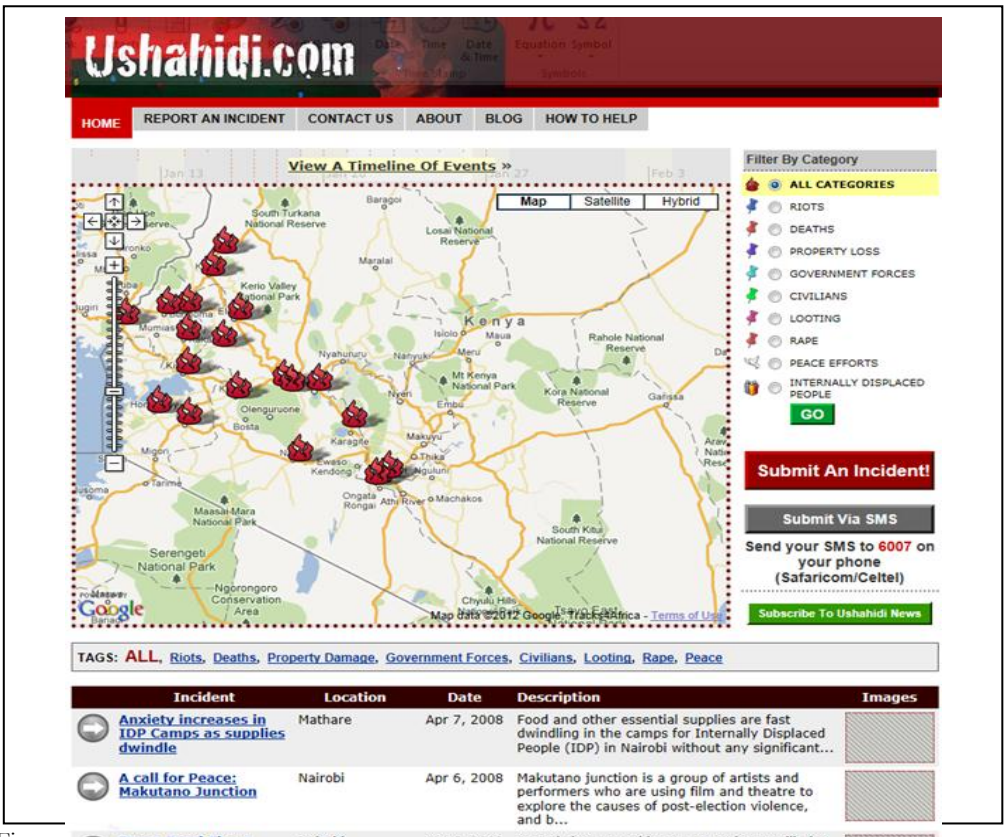


Figure nce map

Source: Mapdata @2012 Google, Track4Africa

On top of the map, is the "View a Time Line of events" button which shows the time the incidents happened and reported to the platform. Ushahidi like GMM uses mobile applications such as iPhone, iPad and Android to interact with any deployments of Ushahidi Platform (See for example, htpp://legacy.ushahidi.com/index.asp)

OSM shares some common features such as using Google maps to show map features and visualize final map products. OSM data is collected through GPS while in GMM; GPS is used as one of the complimentary mapping methods. OSM interface shows View, Edit, History, Export, GPS Traces and User Diaries. Likewise in GMM, Ushahidi and Wikimapia, to edit in OSM one has to create an account and login. All linear features such as street, railways buildings on this platform are referred to as ways (*http://www.openstreetmap.org*)

Although OSM provides for creating a polygon, line and a point, most of map products of OSM show road networks making it good for mapping road networks. OSM is easy to operate. For example, to create a point, one just needs to drag the appropriate icon from the side bar onto the map. According to *http://www.openstreetmap.org*, OSM data can be exported as OSM XML, data, Mapnik Image, Osmarender and Embeddable HTML with options of exporting the data as PNG, JPEG, SVG, Pdf or Postscript. The Figure 17 below shows the how map product of OSM looks like.

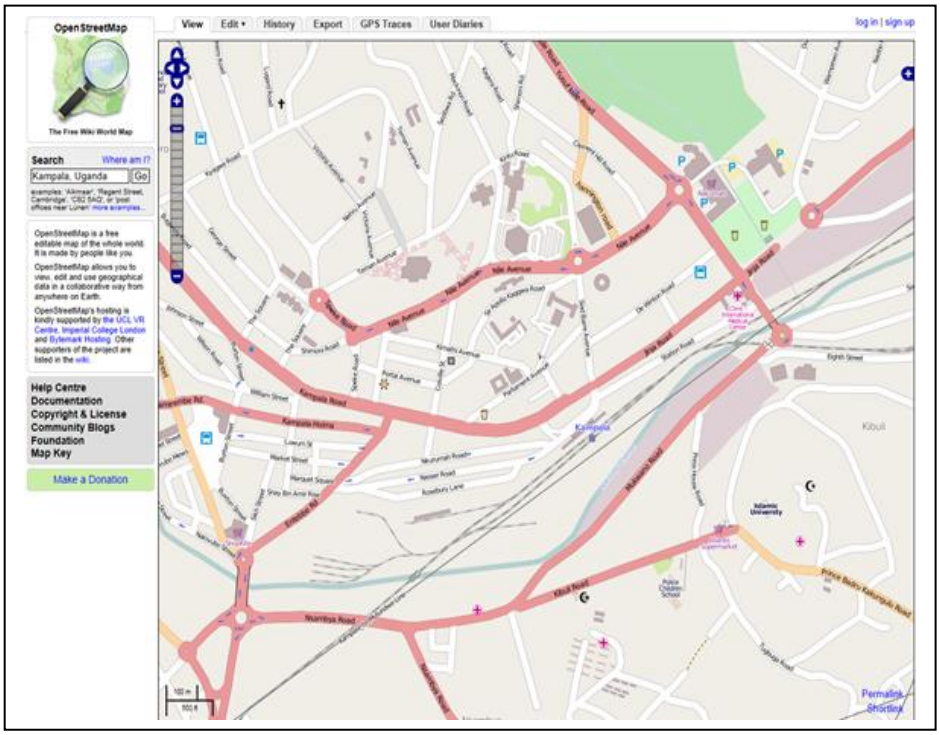


Figure 17: Screen dump of OSM showing the final road network
Source: *http://www.openstreetmap.org*

GMM also uses Google Maps and linear, point and polygon features can be mapped at ease. Features of shape can be drawn using GMM and it relies on local knowledge. Its interface shows Satellite, Map and Labels. Editor can switch from satellite to Map mode and under "*Label*", names can be switched on and off. Also on the map, GMM shows "*Add new*", "*Edit*" and "*Browse*" buttons that helps in adding or editing a feature. Only features that are approved after moderation are published and can be seen on the GMM maps. Figure 18 below shows the map product of GMM and the webpage interface.

In slums where road network is not shown on satellite imagery, OSM generated road network can complement GMM slum mapping, since GMM is flexible to use data generated by other devises or tools.

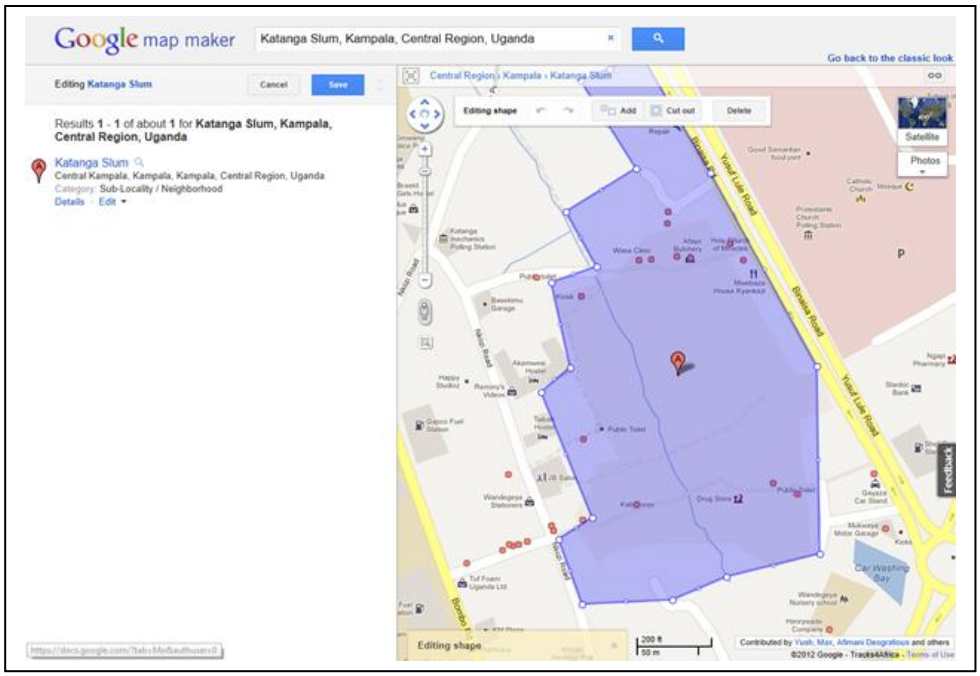


Figure 18: GMM webpage showing Katanga Slum and point features
Source: Google Map Maker @ 2012 Google, Tracks4Africa

4.3.3 Who introduced the tools and why?

WikiMapia was introduced to describe the whole world while Ushahidi was introduced in Kenya for post-elections crisis mapping to give information to humanitarian relief organizations to respond rapidly to the crisis {sic]. Furthermore, OSM was introduced in order to encourage the growth, development and distribution of free geospatial data to everybody to use and share. GMM on the other hand was introduced Google [sic] mainly to open up Google maps to collaborative community efforts as a way of supporting the improvement of existing Google map data through local expert knowledge. The ultimate goal of GMM is to acquire sufficient high-quality mapping data to be published and used on the existing Google map services.

4.3.4 Strengths and limitations of the tools

Unlike in OSM and GMM and Ushahidi registration in Wikimapia is optional while Ushahidi has the ability to take call application and deploy it to oneself to suit ones community needs. It is also flexible such that anyone can improve the service in anyway. Similarly GMM obtains a perpetual irrevocable, worldwide, royalty-free and non-exclusive license to reproduce, publish, adapt, modify, translate, publicly perform, display and distribute spatial information. On the other hand, all these mapping methods and tools use Google maps to add new place, edit and visualize final map products and rely very much on the public contributions since they are crowdsourcing.

These tools on the other hand have limitations. For example, WikiMapia interface has no provision for distinguishing residential areas from public interest in urban area covered with thousands of overlapping rectangles. OSM provides it's a map data under a Creative Common license (*http://en.wikipedia.org/wiki/Google_Map_Maker*). In Ushahidi, since people contribute by text messages, emails etc., it is prone to abuse such that unverified and incorrect information can be uploaded. Though GMM is more flexible to users, changes made in GMM are not immediately reflected on Google maps. The approach encourage users to trace features from the existing satellite imagery, this is stifled in areas with poor or old satellite imagery and can hinder the creation of quality map data for a particular slum area. According to fieldwork findings, GMM also does not cater for some categories of features commonly found in slum settlements like borehole and water points. As a result it is difficult to enter attributes of a borehole in GMM tool.

In conclusion, the main difference between the above-mentioned tools is that unlike OSM, GMM and WikiMapia in which one can add a polygon, line or point, Ushahidi cannot be used for mapping polygons such as boundaries, buildings. Ushahidi can therefore be useful in mapping point features in slum settlements as a complimentary tool to GMM. Second, Ushahidi applies a rapid-response approach since it deals with violence or disaster related type of mapping. Rapid-response in this case refers to a situation whereby an immediate response is needed once an incident is reported; while in GMM, OSM and Wikimapia edits have to undergo moderation process during which edits are either rejected or approved. This can ensure that only accurately mapped features are published.

4.4. To analyze the users` requirements for GMM slum maps

Section 4.2 above has presented the web-based collaborative mapping methods and tools. This current section now looks at the potentials users of slum mapping data, different users` interests, how often collaborative slum mapping should take place and how spatial and temporal scale required affects the use of slum maps.

4.4.1 Potential users of the slum mapping data

Different stakeholders use slum maps in various ways. To analyze the potential users of slum mapping data, it is important in this study to first know the type of data GMM mappers generate. To determine this, the frequency count analysis of slum features that were actually mapped was done based on FGDs, interviews and online survey responses. Figure 19 and Figure 20 below present results of this analysis. The results enabled the researcher to analyze further the common features that were being mapped using GMM tool.

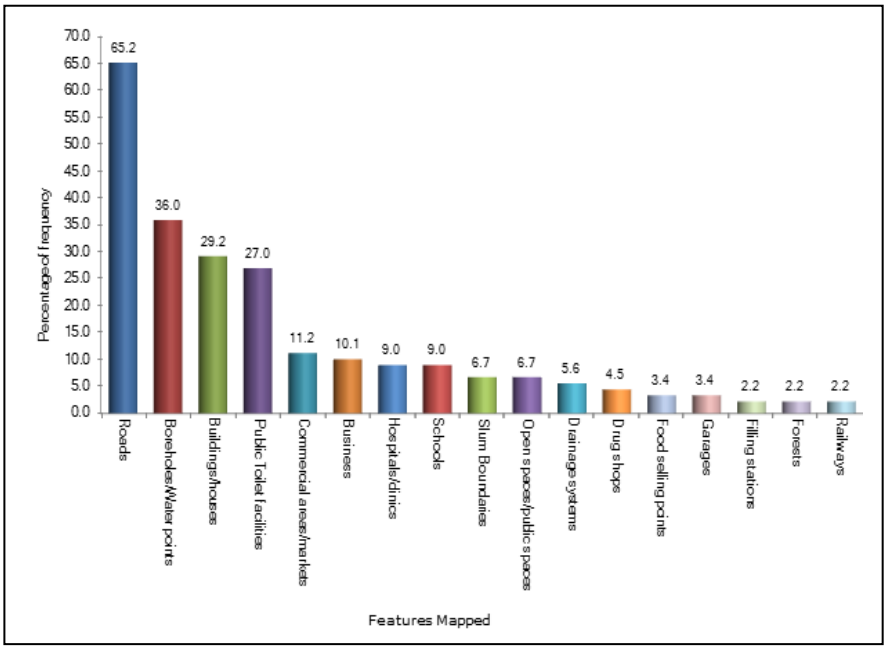


Figure 19: Slum Features Actually Mapped

Source: FGDs & Interviews (n=19)

According to the results presented in the figure above, the most commonly mapped features were roads which account for 65.2% followed by boreholes/water points (36%). Public toilets according to FGDs came third accounting for 27%. Railways, filling stations, churches and bars account for 2.2% each as features that were mapped in slums using the GMM tool. Comparing the results in Figure 19 above to that of Figure 20 below (from online survey responses), the study found that roads are the commonly mapped features in slum settlements. These account for 85.7% while buildings/houses, rivers/streams, water points and commercial areas/markets each account for 71.4%. Slum boundaries and schools and hospitals account for 57.1%.

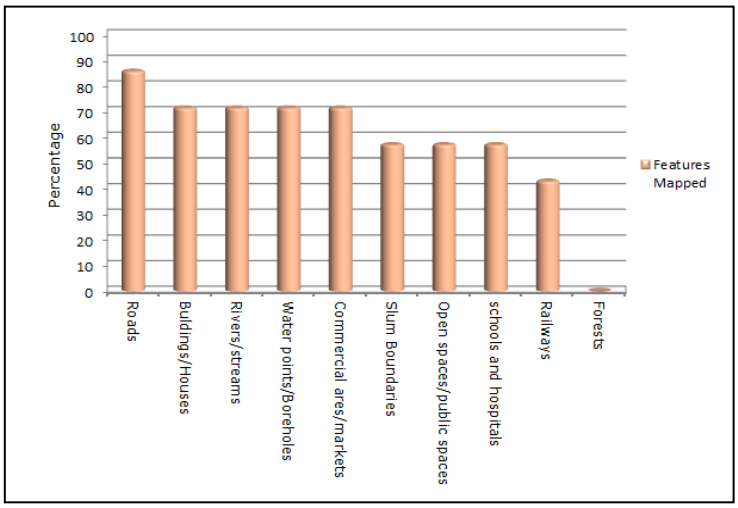


Figure 20: Slum Features Actually Mapped
Source: Survey Monkey (n=14)

The results in both cases show that roads, boreholes/water points, buildings, commercial areas/markets, public toilets, hospitals and schools were the commonly mapped features in slum settlements with GMM tool. The results in the two figures above show that roads are commonly mapped using GMM tool, because roads are fast to map so they give a more immediate sense of achievement for the mappers` effort. More roads can be mapped within a short period of time. Roads are also very important in most mapping exercises because they provide a structure for built up area and the rest of the elements which are to be mapped. Furthermore, according to the respondents roads were commonly mapped because they were easy to map as they are easily identified on the satellite imagery unlike features like drainage systems and water points that need local knowledge for one to correctly map it. Figure 21 below shows examples of some of the features mapped in Katanga slum in Wandegeya in Kampala City, Uganda.

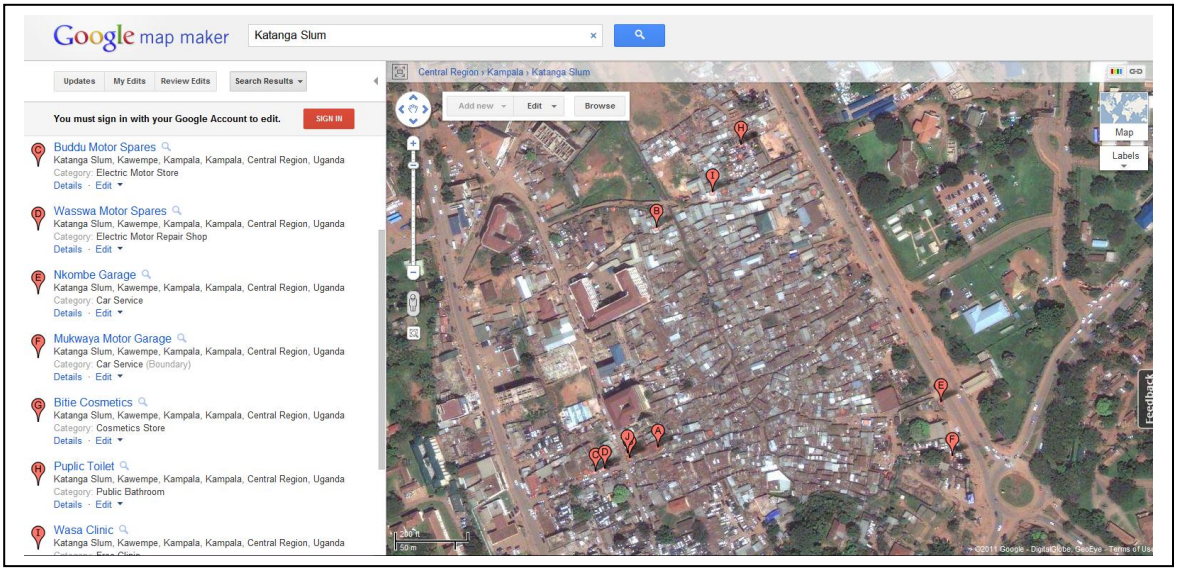


Figure 21: Screen dump of GMM Showing features mapped in Katanga Slum

Source: Google Map Maker, 2011

4.4.2 Users` Interests

Different potential users of slum map data have different interests in the maps. Users in this study refers to both public and private organizations and individuals who use slum map data for different purposes like mapping or planning, policy and decision making, delivery of social services to the urban poor in the slum settlements, training, business and those who contribute data/information for the production or updating of slum maps While some potential users are interested in data that can help them do slum mapping, others are interested, in the slum population to enable them conduct advocacy and family planning activities. In order to compare these differences, a Cluster analysis was carried out with Nvivo 9 where Node comparison by number of coded items was conducted. Figure 22 below presents the summary of the analysis and a Matrix in Table 4 presents the users of slum mapping data and their interests. The matrix shows the general picture of users and areas of their interests. It outlines specific names of users under each category. These categories Government, CBOs, International organizations, local or municipal authorities, universities and research institutions, residents, business and utility companies, They are further sub-classified into different fields like shelter and housing, land administration, mapping, service delivery, water and sanitation and support.

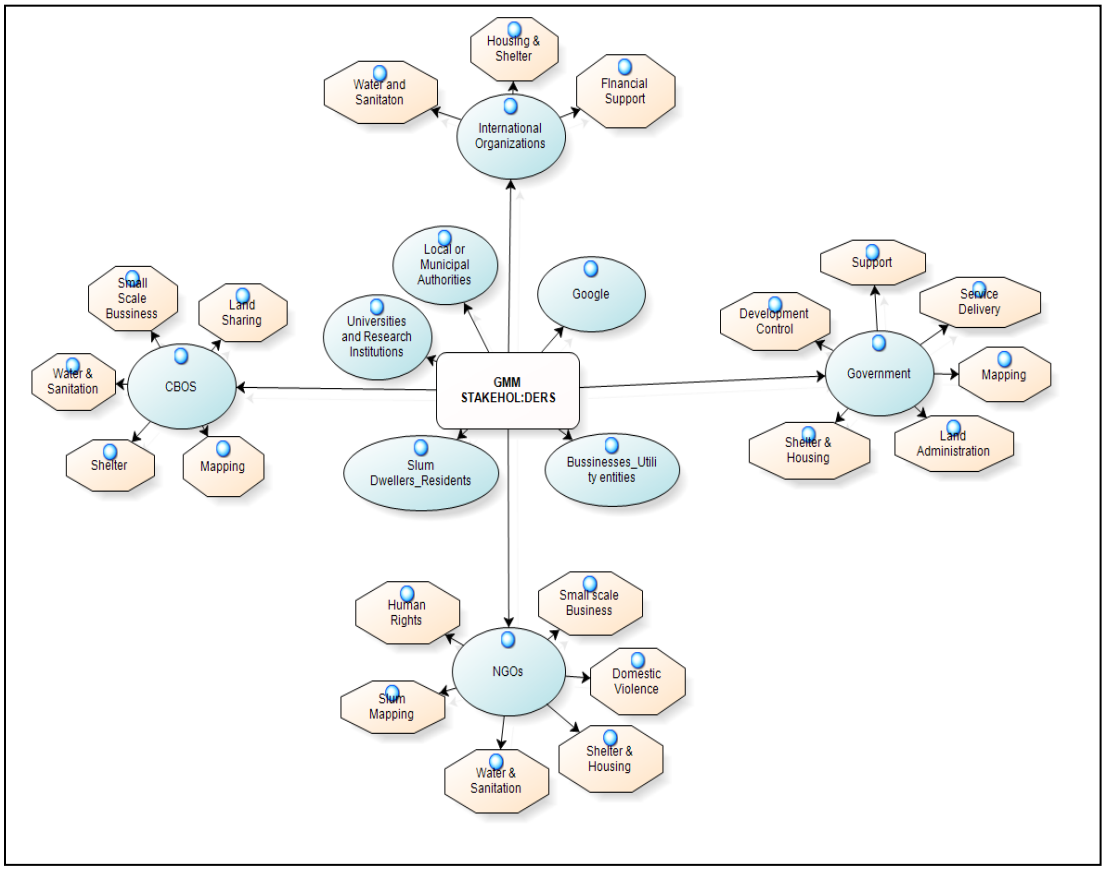


Figure 22: Stakeholders and their Areas of Interest

In the Matrix below, the first column represents the categories of stakeholders and the second column contains names of stakeholders. The total count represents number of areas each stakeholder is interested in.

Most users (10 of them representing 40%) were interested in shelter and housing issues such as SDF, residents, KCCA, etc. This result indicates that most of slum map data is used for the purposes of improving housing conditions for the slum dwellers. Others common users` interests were lobbying for funds and land for resettlement of evicted slum dwellers and other services, slum mapping g, water and sanitation and land sharing. Only NGO`s interest was in domestic violence, waste disposal management, revenue collection, human rights and technical and financial support had 2 stakeholders each interested in these areas.

		Slum Mapping	Shelter & Housing	Lobbying (Funds & Land)	Water & Sanitation	Slum Population & Family Planning	Domestic Violence	Small-scale Businesses	Land Sharing & Land Admin	Location of Public Services	Waste Disposal Magt.	Revenue Collection	Human Rights	Tech & Financial Support	Training & Research
CATEGORY	Total Count →	**6**	**10**	**6**	**6**	6	**1**	5	**6**	**3**	**2**	2	2	**2**	**4**
NGOs	SAP				X	X	X								
	Actogether	X						X							X
	UWN		X	X											
	Concern Ug.				X			X							
	WAU				X			X					X		
	CIDI			X				X							X
GOVERNMENT	MLH&UD	X	X						X						
	DPW									X					
	UBOS					X								X	
	Legal Aid												X		
CBOs	SDF	X	X	X					X						
	DENEVA			X		X		X							
	ASHD				X						X				
	SWID			X		X			X						
LA	KCCA	X	X	X	X				X		X	X			
BUSINESS	Google													X	
	Nat. Water				X					X					
	Electricity Commission					X				X		X			
SLUM DWELLERS	Residents	X	X						X						

Universities & Research Institution	Mak. Univ.		x												x
INTERNATIONAL. ORGANIZATIONs	UN HABITAT		x												
	Cities Alliance		x												
	SDI		x												
PLANNERS	Urban/Town Planners	x	x			x			x						x

Table 5: Matrix of Slum Map Users Showing Users` Areas of Interests

Source: FGDs & Interviews

Therefore, the analysis of the data indicated that the user's interests also differ in the type of slum map data that they want and how they use the data. These differences determine also different levels of participation in slum mapping process. While some users are interested in the quantitative data like slum population, population of vulnerable groups (women and children) in the slums, others e.g. KCCA are interested in the spatial data such as location of businesses, water points, roads for various purposes. The analysis as presented in Figure 18 above shows that users such as SDF, Actogether Uganda, slum residents, UN HABITATA etc. are interested in slum map data that is related with land use planning and mapping, others are interested in the location of businesses within slum settlements so that they can easily locate businesses for revenue collection.

Government departments e.g. DPW, National Water and Electricity Commission use slum map data in order to locate public services such as clinics, schools, sources of water, and yet others are interested in slum population and domestic violence so that they can come up with advocacy programmes to assist slum dwellers. The diversity of interest creates a potential benefit from pooling resources for mapping but this can only be harnessed through collaboration between stakeholders and to do so, requires a level of initiative and commitment which as at present is lacking.

4.4.3 Stakeholders

Collaboration between stakeholders is believed to be important in slum mapping. Results of online survey data show that majority of mappers collaborated with other stakeholders when mapping slums. In Figure 23 below, 57% of the respondents indicated that they collaborated with slum residents while local or municipal authorities accounted for 50% while universities and research institutions accounted for 43%. Government departments, international organizations and CBOs accounted for 29% each. 29% indicated that they were collaborating with nobody with NGOs accounting for 21%.

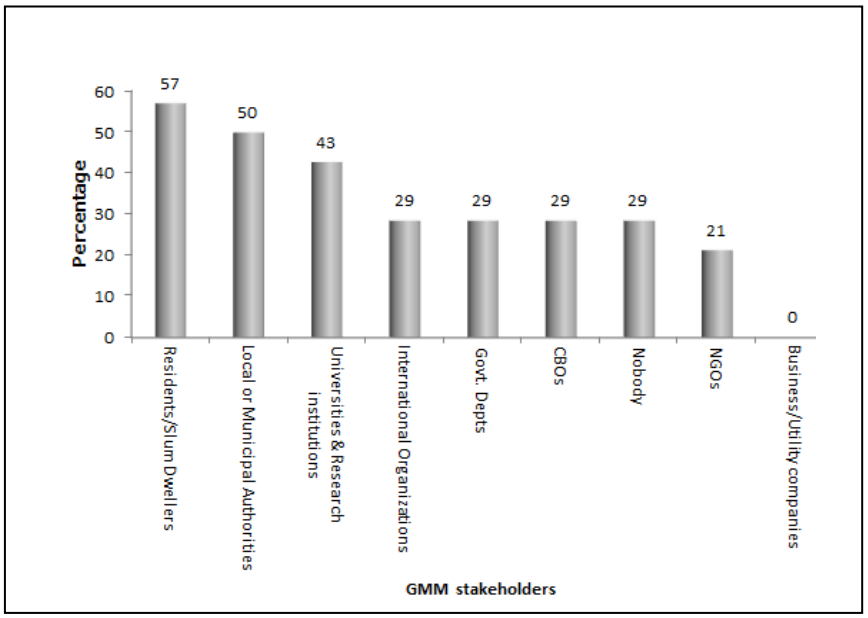


Figure 23: GMM Collaborative Stakeholders

Source: Online Survey (n=14)

It was noted that most of CBOS and NGOs were interested in shelter and housing related issues and also issues linked with delivery of housing like water and sanitation and slum mapping. (See, Table 4 above). For example CBOs interested in slum mapping include Actogether Uganda, SAP, DENEVA, ASHD, SWID, SDF, CU and local communities. For example, one active GMM mapper said, "*During mapping, you have to involve other "friends" because you cannot know everything in that area. I call someone to help me but using my account when doing mapping, a friend just helps me".* "Friends" in this case refers to the resident of the slum being mapped. 50% of the active mappers in the FGDs made similar remarks that they were involving either friends from the slums or the local leaders. On the other hand, 3 key interview respondents indicated they were using friends when doing slum mapping who said that "*We make sure the word is sent around such that slum mapping is done hand in hand with them and they should know the benefits of why you are mapping their slum settlement*". This shows that GMM mappers value the participation in slum mapping by local community members who had local knowledge about slum settlements being mapped.

4.4.4 How often should slum mapping Take place

The frequency of collaborative slum mapping is influenced by a number of factors. The results of the question lead to two interpretations. The first is the number of times slum mapping should be conducted and second is time in terms of hours per week that slum mappers should work. According to the results presented in Figure 24 below, 46% were not specific while 23% indicated that slum mapping should be carried out quarterly in a year while 8% opted for once a month, meaning slum mapping should be conducted 12 times per year.

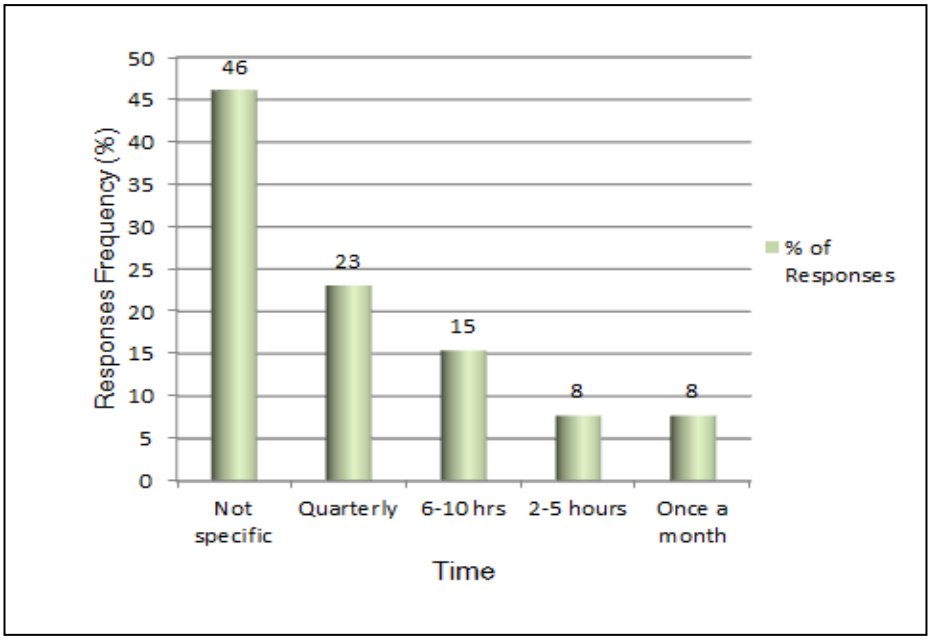


Figure 24: Suggested Frequency for Slum Mapping

Source: FGDs (*n=13*)

The analysis on the other hand indicates that 8% wanted GMM slum mapping to be carried out for 2-5 hours and 15% between 6 and 10 hours per week. Those that were not specific on how often collaborative slum mapping should take place cited different reasons for such a position such as busy schedules of mappers, slowness and

unreliability of internet connection, individual mapper`s interest in slum mapping and size of the slum and density of features in a particular slum area to be mapped. For instance, one GMM mapper said, "*I can go the whole month without doing any mapping due to low bandwidth and internet is slow"*

Similarly, on the individual mapper`s interest in slum mapping, one interviewee said "*If a person who has an interest in slum mapping and is mapping for a purpose, I think he would not have a problem of devoting time, but because of different personalities and also were are volunteers, I would not like to do slum mapping every week."* The reason given for not doing slum mapping every week was that, mapping of slums was carried out on voluntary basis. As a result mappers were motivated to devote more time to GMM slum mapping. The other reason was that accessibility to internet connection was a challenge which could prevent mappers from doing slum mapping every week. For instance, one active and experienced GMM mapper said, "*It depends. Here the internet is too slow and you can spend the whole day mapping one area when the speed improves one spends less hours. It also depends on the size of the area, some slums are small yet some are very big and it is difficult to allocate time to the mapping of slums. Some areas have so many features, structures within".* 90% of all active and non-active mappers made similar remarks when asked about how often slum mapping be carried out.

The results above were compared with the one from the online survey responses presented in Figure 25 below. From the results, two interpretations can be drawn, first is, how many times should slum mapping be repeated per year and second is hours per week that slum mapping should be conducted. This analysis indicates that 37.5% opted for doing slum mapping quarterly in a year, with 25% opting for twice a year and 12.5% for both once a year and once a month. 0% devoted for twice a month. In the second interpretation only 12.5% selected doing slum mapping once a week while no respondent (0%) opted for thrice a week.

From the two scenarios, majority opted for doing slum mapping quarterly in a year if it is organized group mapping exercise. This allows enough time for through preparation and organization of stakeholders as well as moderation results so that changes can be effected if edits are rejected. But if mapping is done individually, devoting hours per week would be tricky considering that mappers concerns of doing slum mapping voluntarily coupled with internet connection problems.

Also quality of slum maps generated could be affected by the issue of voluntary mapping because mappers are not fully dedicated to the exercise. Individual mapping means GMM mappers map slums at their own will which can minimize the input by other stakeholders with vast local knowledge of the slum settlement being mapped.

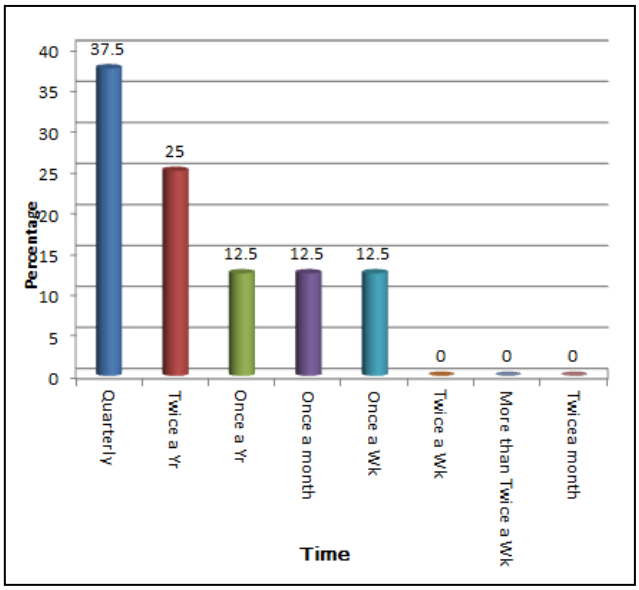


Figure 25: Suggested Frequency for Slum Mapping
Source: Online Survey (n=*14*)

4.4.5 The effect of spatial and temporal scale requirement on the use of the slum maps

Mapping of slums and use of slum map data is affected by both spatial and temporal scale requirements. First, slum mapping using GMM is done in tow levels, i.e. the small spatial scale and large spatial scales. At the small scale e.g. 50 metres, only such features like slum boundaries, roads, rivers, buildings, open spaces/parks and railways can be easily mapped. At this spatial scale, certain features especially point features cannot be seen on the imagery. For a detailed slum mapping to be effectively done, the large spatial scale is required to enable detailed type of slum mapping. At this scale e.g. 10 metres mapping of social service such as water points like boreholes, public toilets and attributes of features such as names are assigned. This level of slum mapping requires local knowledge. Also, for these to be accurately mapped, one needs to carry out field visits before the mapping and ground verification after the mapping process with the use of other mapping tools such as GPS. This will only ensure that features are accurately amped.

Furthermore, the study has also found that spatial scale requirements may affect the use of the slum maps. For example, if the old imagery is used, a moderator can reject the edits existing on the ground but is not captured in the satellite imagery. Such maps could be incomplete, hence not of good quality due to the missing features. Users may therefore not use such a map until revisions and moderations. It may also take time for Google to update the imagery.

On a temporal scale, edits or changes made in GMM are not immediately reflected on Google maps. It is a requirement that every edit has to undergo moderation process. This makes potential users of the slum map data to wait for the approval of the edits so that maps can be used. Since, there is no specific period set aside for

approved maps to be published; use of maps relies upon the time when edits are approved. It was also reported during FDGs that, the time given for mapping for Katanga for example was not enough. With lots of features in the slums, mappers could not pick all features because the time was fixed for the maps to be completed. This could lead to having a slum that is not completely mapped which is turn can affect for example decision making process or lobbying for funds.

Furthermore, to ensure effective slum mapping with GMM tool, it is important that satellite imagery be up-to-date so that a true ground picture is represented. According to the FGDs 100% of experienced and less experienced mappers and 86% respondents from online survey indicated that lack of updated imagery affects slum mapping in two ways. First, mappers found it difficult to map an area with an outdated satellite imagery which does not match what is found on the ground in some parts of slums. Second, when a new feature existing on the ground but is not captured by the imagery is mapped; moderators tend to reject such edits. This according to the respondents discouraged mappers from making further contributions.

These factors cumulatively affect the morale of mappers on one hand that coupled with mapping slums on voluntary basis, mappers get demotivated and the drive to map more slum features lowers down. On the other hand, the quality of quality of slum maps is compromised because slums are mapped by de-motivated people using outdated imageries. Also some users may fail to use the map because of the incompleteness due to missing information.

4.5. Objective 3: To identify factors that influence or prevent potential stakeholder participation in collaborative slum mapping with GMM

Results from FGDs, key-informant interviews and online survey have revealed that stakeholder participation in collaborative slum mapping is influenced by a number of factors which in turn affects the effectiveness of GMM tool and subsequently affecting the quality of slum maps generated. These are both enabling and disenabling factors for the participation in collaborative mapping.

4.5.1 Motivating Factors

According to the FGDs stakeholders were motivated by:

(1) The stakeholders` desire to help mapping slums in the city so that lives of the poor people in the slums were to improve. This was based on the stakeholders past experience with slum living conditions. For instance one local leader said, *"I want to help mapping slums in my city so that the lives of people in slums settlements improve. As a person who has once lived in the slums, I know the problems people are facing there, like lack of water, no good roads, no hospitals no schools no electricity. Nobody cares about slums"*. So the personal experience of the poor living conditions in the slums was motivating some stakeholders to participate in slum mapping hoping that once slums are mapped, living conditions were going to improve.

(2) The involvement of Google motivated many to participate in the mapping process. Google Uganda organized a mapping competition in which winners received prizes such as laptop computers and phones.

Although the mapping competitions was not solely for mapping of slums, it was revealed that 60% of GMM mappers were motivated by Google`s initiative of mapping competition. For instance respondents during FGD said that most of them were encouraged to continue mapping with GMM because students who did well in mapping competitions, were given phones and laptops every week. Students who made most mapping sessions using GMM were rewarded and this encouraged the people/students to do slum mapping.

(3) As for the active mappers, they were encouraged by the flexibility and easiness to operate GMM tool. For example, the study found that less experienced mappers were able to map features easily with minimum assistance form the experienced mappers. Similarly, the active GMM mappers were motivated because they were able to use to use My Tracks activated on android phones to mark their paths and exported the track as XML and that mappers were able to change names of roads using the section tool. This flexibility indicates the capabilities of GMM tool to accommodate users of different levels of knowledge about the tool to use it easily, making it ideal for collaborative slum mapping.

4.5.2 Demotivating Factors

The manner in which GMM slum mapping is conducted, the flexibility to allow other stakeholders participate without problems, the knowledge of the GMM tool by mappers and general environment in which GMM slum mapping is taking place can positively or negatively affect the effectiveness of the tool and subsequently the quality of slum map data generated. This section describes factors that demotivate stakeholders from participating in collaborative slum mapping. These are categorized as GMM related, political interference, lack of support and voluntarism as well as threats of evictions.

4.5.2.1 GMM Tool-Related

1) The study results indicated that 80% of the active but less experienced mappers and 100% of non-active mappers cited lack of knowledge to operate GMM tool as being responsible for demotivating them from participating fully in slum mapping. For instance mappers one less experienced mapper said "*I first tried to map a few areas and I was discouraged because I didn`t know what to do. They told me to look for some points on the satellite image but I did not know what to do. But later my friend encouraged me to try again. You should also know that we just joined GMM slum mapping and we do not have full knowledge how the tool operates*". This means that lack of good training materials to equip mappers with skills and knowledge about hoe GMM operates was demotivating many people.
2) Lack of access to internet and its unreliability with low bandwidth also demotivated mappers. 96% of the active mappers cited this as a major problem affecting and slowing down slum mapping. It was therefore established that slum mapping is not very effective and easier when internet is slow.

3) 100% of GMM mappers interviewed mentioned that GMM slum mapping was also being affected by the old imagery used for Kampala and many other cities in developing countries. Results of the analysis indicate that the imagery was showing few features as compared to what exists on the ground, citing that development is

very fact and new structures were built on areas shown as empty or green spaces on the imagery. This demotivates mappers in that once the edit is moderated, it may be rejected by the Super mappers who could in fact be less familiar with the mapped areas

4) While experienced mappers indicated that use of other tools like My Tracks, the less experienced mappers found it hard to transfer points plotted on applications such as like My Tracks onto GMM tool. This is due to lack of training on the tools to be used for slum mapping.
5) Edits are not quickly approved by the moderators. Since the process allows that edits are put on a pending state, delays in approving edits is also seen in this study as one factor responsible for demotivating mappers because some of the mappers particularly inexperienced feel they are not doing anything commendable
6) Categories are limited for entering mapped features are limited. For instance, features seen as important in slum settlements such as boreholes, water points are not catered for in GMM tool. The categories for entering new features are limited, so it is impossible to give names to new features that are not catered for in GMM. .

4.5.2.2 Slums and Slum Dwellers

Not only GMM related factors were demotivating mappers, but also factors related to slum and slum dwellers. For instance, some of the signs marked in the slum areas have moved or relocated because faces of slums are fast changing due to movements of slum dwellers or some developments; e.g. clinics and some business in Katanga had closed. Slums Dwellers are always on the move looking for cheaper housing, as a result most features do relocate as slum dwellers keep on shifting from one place to another in search of cheap housing and other services or opportunities. So this calls for constant revision of the slums because slum population keeps on changing.

4.5.3 Political interference

Stable political environment and absence of political interference in the slum mapping process is key to the effectiveness of the collaborative slum mapping. Since collaborative slum mapping involves working with other stakeholders, political interference in the slum mapping can negatively affect the quality of maps produced. This study found out that political interference demotivated GMM mappers in the following ways:

1) Slum dwellers had a wrong perception about slum mapping. They took slum mapping as political move advanced by government to grab land and evict slum dwellers from their homes so that the land is changed into a different uses or is sold to developers. As a result people were not receptive. For instance, one informant said "*Nowadays because of the misunderstanding and misconception slum dwellers have towards government, particularly us doing the planning and mapping, government decided that mapping of slums should be done by the slum dwellers themselves while we do provide technical expertise*".

2) The study also found that slum mapping was negatively affected by political interference because; politicians were telling people that any mapping exercise is designed to evict slum dwellers from their houses This brought fears among people and discouraged stakeholders from full participation in collaborative slum mapping. Some were not giving the data or information required for GMM slum mapping. In Katanga Slum for

example, slum dwellers thought GMM mappers were surveying to take away the land road-side traders feared that mappers were surveying for road expansion which would lead into possible evictions. Hostile environment due to threats of evictions is therefore seen in this study as being responsible for demotivating both non-active and active GMM mappers from active participation in collaborative slum mapping.

4.5.5 Lack of Support

FGDs with non-active mappers indicated lack of support by experienced GMM mappers as being responsible for their demotivation. No follow-ups were done to see what these inexperienced and inactive stakeholders were doing. As a result, these were not doing slum mapping any more due to lack of interaction between non-active and experienced mappers.

4.5.6 Voluntarism

The study revealed that voluntary slum mapping was negatively affecting the GMM mapping process because were not motivated to spend a lot more time on slum mapping without any payment or benefit. One active mapper for example said *"What I said is that I am only doing it as a volunteer so there no reason to spend much time on voluntary things, because I need time to do other things as well* and added further that *"the idea of voluntarism is not so wide, so most times people will ask what they are going to benefit from doing slum mapping.* Therefore the general feeling of most GMM mappers is that time spent on GMM mapping can be spent on income generating activities.

4.5.7 How committed are the GMM mappers to continue contributing to collaborative slum mapping?

Effectiveness of GMM slum mapping and the level of quality of maps produced are among factors influenced by the commitment of the GMM mappers to continue contributing to collaborative slum mapping. Figure 26 below presents results of the analysis done based on online surveys responses on how much time GMM mappers were willing to devote to slum mapping. The results show that some mapper's commitment is on a yearly basis while other opted for hours per week.

The results in Figure 26 shows that while less experienced mappers devoted time in terms of months others devoted hours per week. This analysis shows that 44% from FGDs wanted slum mapping to be carried out quarterly while 25% devoted 10 + hours per week with less than 1 hour per week accounting for 19%. Some of the student active mappers (13% each) devoted 4 hours, 6-10 hours, and 3-5 hours per week. 6% each accounted for 8 hours/week, 2 hours/week and once a week.

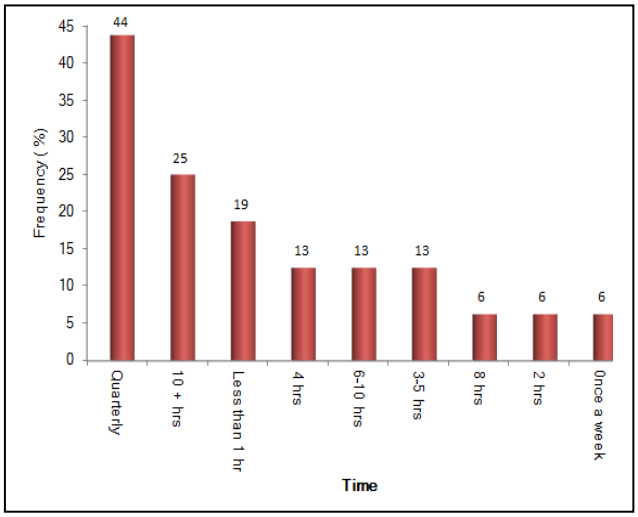


Figure 26: Time GMM Mappers Devote to Slum Mapping
Source: FGDs (n=13)

It was interesting to note that the experienced mappers devoted more hours e.g. 10+ hours per week to GMM slum mapping than less experienced mappers although the general picture established by this study was that 10+ hours per week was on the higher side.

Comparing the results above with online survey results shown in Figure 27 below, the analysis indicates that those who opted to devote between 10+ hours and 6-10 hours accounted for 28% each with 2 hours, 3-5 hours and less than 1 hour accounting for 14.3% each.

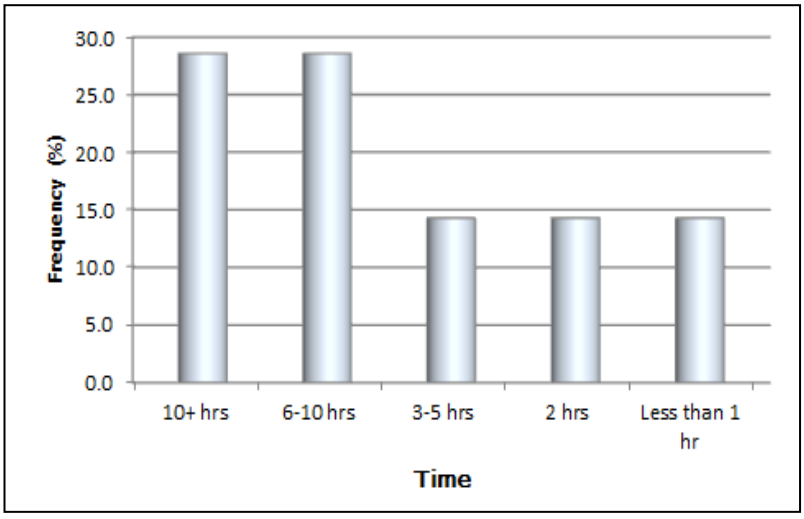


Figure 27: Time GMM Mappers Willing to Devote to Slum Mapping
Source: Online Survey (n=14)

From the two results presented above, it can therefore be concluded that more stakeholders are willing to map the slums with GMM. Also most of the stakeholders are willing to devote time to slum mapping in the ranges of 2- 6 hours per week.

4.5.8 How much time do the stakeholders spend on collaborative slum mapping?

Based on the online survey results, 25% were spending less than 1 hour per week, 25% also were spending between 2 and 5 hours per week with 12.5% spending 6 hours and 6-10 hours per week. Another 25% [(urban planners (2) and GIS experts/Cartographers (2)] were spending 10+ hours per week. This group of had prior survey knowledge

On the other hand, results from the FGDs indicated that 62% of active mappers but less experienced and experienced (all students) were conducting slum mapping once a week spending between 1-2 hours per week. 23% (active and experienced GMM mappers) experienced were spending 5 hours per week on slum mapping. Only 2 (15%) were mapping slums once in a month spending 2 hours. But 100% of non-active mappers were spending 0% on slum mapping because they were not doing the mapping due to lack of technical support from their experienced colleagues and also lack of access to internet facilities. Results from the two scenarios above show that majority of the GMM mappers were spending between 1-2 hours per week, and only due to a number of reasons as busy schedule and internet access problems.

4.6. To assess the current status in quality of web-based collaborative slum mapping in Kampala.

4.6.1 Current status in quality of slum mapping in Kampala

To assess the current status in quality of web-based collaborative slum mapping in Kampala, first, this study analysed the stakeholders understanding of a slum, nature of GMM mappers, when they started slum mapping using GMM, mapping procedures followed when mapping Katanga slum, other collaborative mapping tools used, challenges encountered with the tool, type of features or data were mapped and finally evaluating the quality of the slum maps generated using moderation results.

4.6.2 General understanding of a slum in Kampala

Existence of slums in Kampala City pose a challenge to both government and slum dwellers themselves as residents face problems such as congestions, poor access to public services, high crime rate, unemployment, poor sanitation among others. To deal with these problems, slums need to be correctly defined so that stakeholders should be aware of what a slum is all about. Payne (1977) points out that the first step in solving a problem is to define it correctly so as to be able to quantify, locate, plan and take actions as necessary. To determine the people`s understanding of a slum in Uganda, FGDs and key-informant interviewees were asked to define a slum and state what characterizes a settlement as a slum. The following statements define a slum and reflect the Ugandan situation.

a) It is as settlement which is highly congested (See Figure 28 below)
b) It is an area with a lot of disease outbreaks, because there are no toilets and no piped water supply and people get drinking water from wells and springs

c) It is an unplanned settlement with too many people where living standards are very poor and houses made of poor quality materials such as plastics, mud, poles and roofed with metal scraps or very old iron sheets, poor drainage system

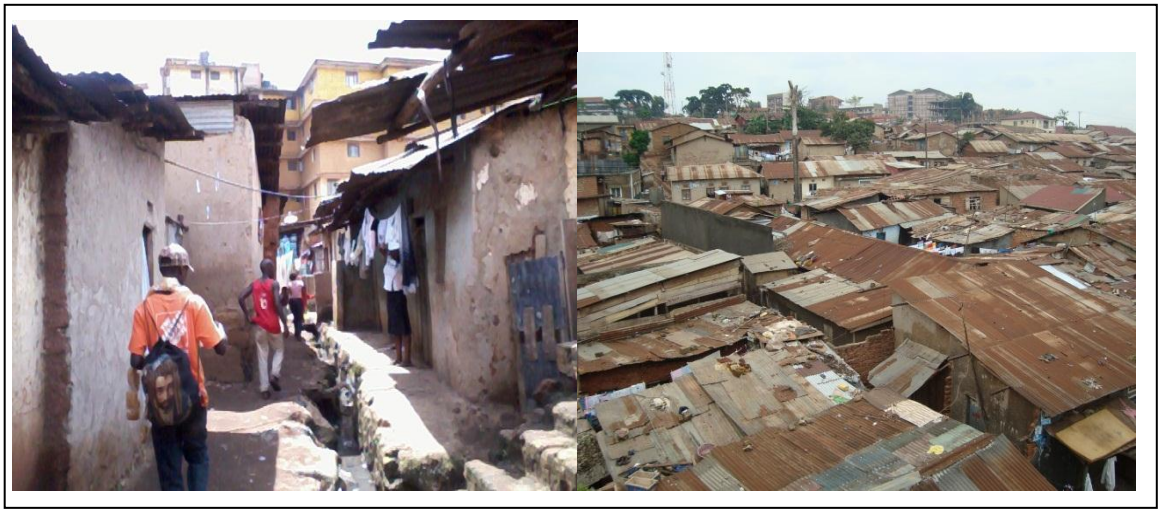


Figure 28: Housing Congestion in Katanga Slum, Kampala
Source: B. Mpanga (2011)

d) It is a settlement with no or poor road network and no or very poor social facilities such as water, electricity, hospitals and schools (See Figure 29 below)

e) It is a disorganized and undeveloped settlement lacks employment opportunities

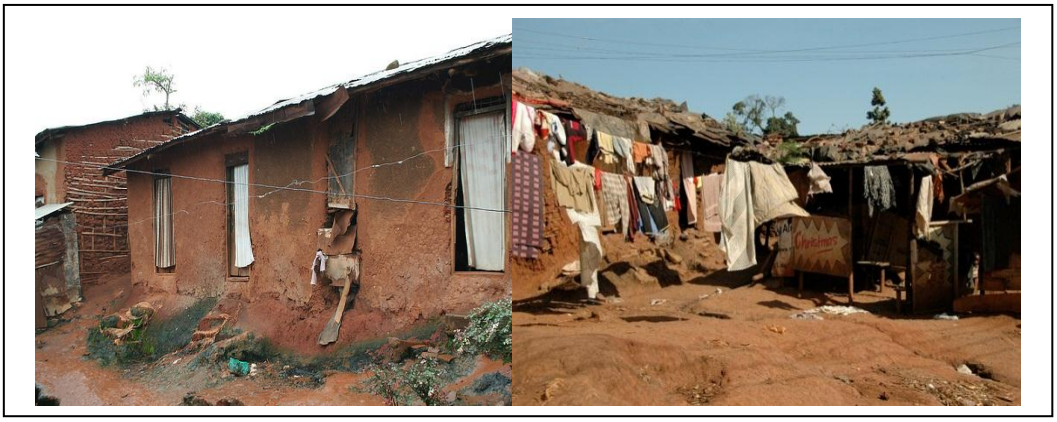


Figure 29: Poor Quality Housing in Makerere-Kivulu Slum in Kampala
Source: E.R. Batte (2011)

The findings show that majority of mappers in Kampala know what a slum is and its characteristics. There were no differences in the understanding of a definition of a slum between the experienced, less experienced, non-active GMM mappers, local community leaders and slum dwellers. Though most of slums in Kampala are located in swampy areas that are prone to floods, it cannot therefore be concluded flooding is a characteristic of slums since there are other slums that do not experience floods, In Kampala floods (Figure 30) are common even in places that are not slums

Figure 30: Flooding in Kisenyi I Slum, Kampala
Photo by B. Mpanga (2011)

4.6.3 GMM Mapping Procedures

In order to determine the quality of current web-based slum mapping in Kampala, an assessment on how GMM slum mapping process was done. The kind of GMM mappers was also done and by what kind of mappers. According to the FGDs, the following steps describe the procedure that was followed to map Katanga Slum using GMM.

- According to FGDs and key informant interviews, mapping of Katanga slum started with a brief introduction where mappers were briefed on the mapping guidelines and share ideas. There were 18 mappers in total of which 22% were females and 78% males.
- After the briefing session participants were divided into 8 groups and each group was assigned a specific area of Katanga Slum capture different features. During the visit, mappers had additional field work equipment such as cameras that they used to take pictures of features found in the slum so that they were reminded of what was existing in the area; printed maps of the slum which enables them to walk through the slum settlement and finally, each group had an android-activated phone with My Tracks. My Tracks was used to track the paths mappers follow through Katanga Slum. See Appendix 3. The field visit lasted for two hours.
- Then GMM mappers assembled at once centre to map the collected points onto GMM or inputting the features and edits into the map.
- Finally they a feedback session was conducted to get feedback from mappers about the whole mapping process and the collected data. Figure 31 below illustrates the procedure GMM mappers followed when mapping Katanga slum.

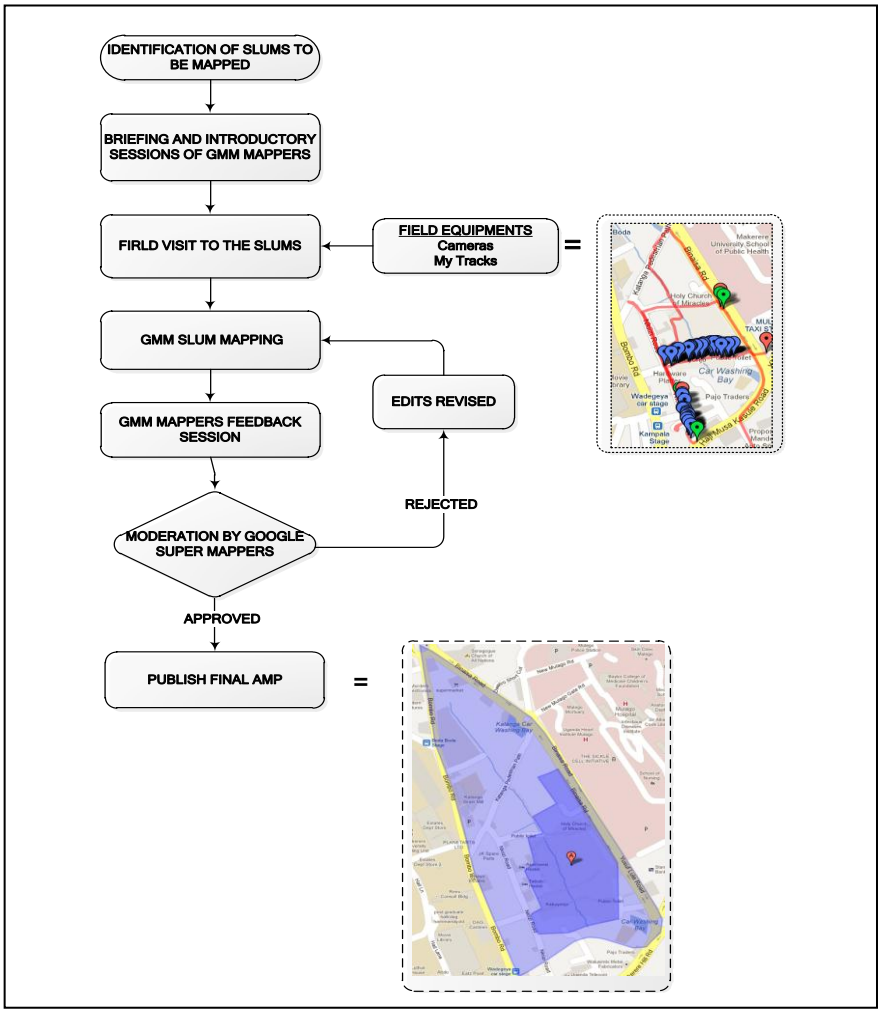


Figure 31: GMM Slum Mapping Procedure Used by Mapping Uganda Team
Source: FGD & Google Map Maker (2011)

Although the active GMM mappers mentioned visit to Katanga Slum as part of collaborative slum mapping using GMM, 15% of the active GMM mappers disagreed with visiting slums to capture points because collaborative mapping emphasizes depends on utilizing local knowledge when conducting slum mapping. As collaborative slum mapping relies on local communities keep rich data that GMM mappers can use when generating or updating slum maps. Figure 32 below, for instance show socio-economic data about Kisenyi slums.

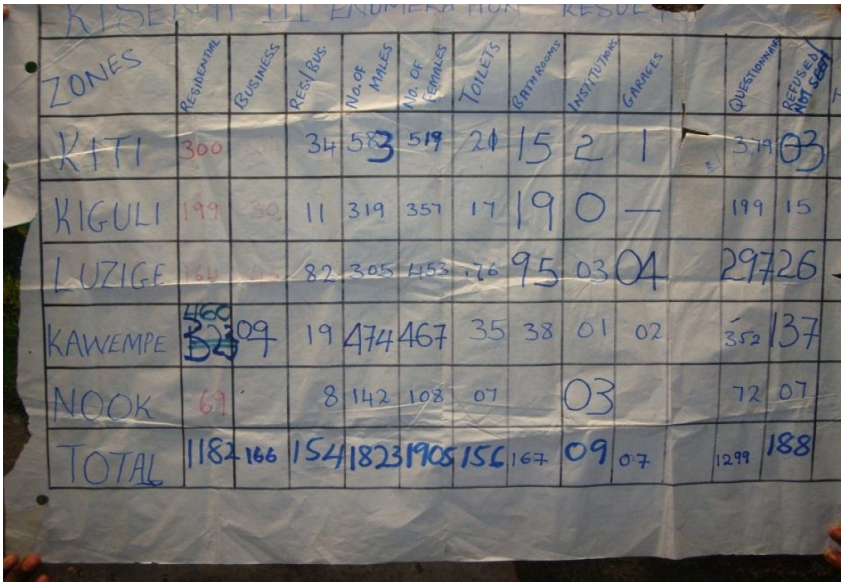


Figure 32: Example of Data Generated by Slum dwellers
Source: SDF, Kisenyi III Slum, Kampala (2011)

4.6.4 Challenges Encountered

Effectiveness of the GMM mapping process and the quality of data generated is among other factors affected by the degree of challenges mappers encountered. The challenges mappers encountered are covered in Sections 4.5.2 to .4.5.6. It was however interesting to note that GMM mappers complained about the existence of new features on the ground which were not shown on the imagery. The field visits to the slums seems to this study as a way of updating the slum maps by actually verifying the imagery and ground features at various points within the slum settlements. The challenges encountered had the potential of affecting the quality of maps by lowering down the morale of mappers.

4.6.5 Slum Policy

Existence and implementation of a slum policy can help to ensure effective and smooth slum mapping and slum upgrading programmes. On whether Uganda had a slum policy, the study findings had revealed that Uganda did not have a policy to guide slum mapping nor upgrading programmes but had the National Slum Upgrading Strategy and Action (NSUSA) of 2008 which was developed to provide a framework, direction and plan to all stakeholders so that they can individually contribute towards achieving the national target by participating in developing and implementing slum upgrading activities and initiatives (MLHUD,(2008))

According to MLHUD (2008), the NSUSA is aimed at slowing down growth of slums and eventually be stopped through legal and land market reforms and revamping planning and zoning regulations and building codes to make housing more affordable. Its main thrust is turning around the current status quo by ensuring that slum upgrading or improvement efforts are integrated into national policies, legislation, programmes and plans to enable their implementation by taking key steps to manage and guide the process of urbanization so that so many

people do not unjustly suffer from inadequacies of basic human requirements such as water, sanitation, shelter, health and education. (MLHUD (2008))

Results from FGDs and interviews showed that majority of respondents were not aware of the existence of a slum policy. Of the 18 FGD participants, 4 (22%) said they did not know if there was a slum policy in place, while 78% indicated that there was no slum policy in Uganda. All active-experienced GMM mappers didn`t know about the existence of a slum policy. On the other hand, out of 7 key-informant interviews, only 3 (43%) one urban planner, one slum dweller/leader and one NGO officer, indicated that Uganda had a slum policy while the remaining 57% reported that there was no slum policy in place. Table 5 below summarizes the findings

Data Collection Method	No. of Participants	% of Participants - Policy Existed	% of Respondents - Slum Policy Not Existed	% of Respondents t "I don`t know"
Focus Group Discussions	18	0	78	22
Key Informant Interviews	7	43	57	0

Table 6: Participants` Knowledge about Slum Policy Existence in Uganda

Source: Focus Group Discussions & Interviews (2011) (n=26)

One of the local community leaders who indicated that a slum policy was in place said "the policy says, before land owners sell their land to developers, they should first invite squatters and give them a chance to buy the land if they can afford". Landowner discuss with slum dwellers in order to reach a compromise that the ones to be evicted should leave freely after full compensations are paid". Respondents from both NGOs and CBOs said Uganda did not have any slum policy. For instance, informant responded that "Actually we don`t have such a policy, if there is one, then I have not seen it. But surely, we do not have such a document here in Uganda". From the above discussions, almost all GMM mappers and local communities were not sure whether or not the slum policy existed. The 43%, who said the slum policy existed, only cited issues that are more to do with managing evictions, compensations and resettlement process.

4.6.6 How often is collaborative slum mapping being carried out?

In order to further determine the current quality of web-based collaborative slum mapping the study assessed how often collaborative slum mapping was being carried out. Results of the FGDs presents two pictures on how often collaborative slum mapping was carried out. The results in Figure 32 below show that slum mapping was carried out individually and as a group at different times. As group, mapping was being done quarterly as evidenced by what one key-informant said; "We have tried to engage the local people. At least we have tried to have 4 slum mapping." Apart from mapping slums quarterly by group, individual mappers were mapping several slums at different frequencies as presented in Figure 33 below.

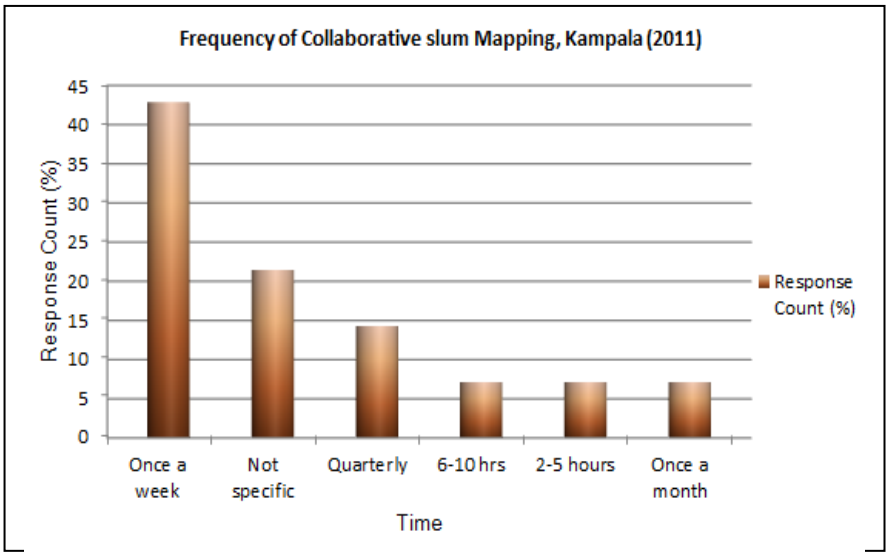


Figure 33: Frequency of Collaborative Slum Mapping, Kampala
Source: FGDs (n=13)

The results presented in Figure 33 above indicates that 43% of the respondents were carrying out collaborative slum mapping once a week, while those that were not specific accounted for 21%. This group cited unreliable access to internet, busy schedule and personal interest as the major reasons for not being specific. They comprised experienced-active GMM mappers. Those that were carrying out collaborative mapping between 6-10 hours per week (7%) were experienced mappers. The less-experienced (7%) indicated that they were carrying out collaborative slum mapping once a month and between 2-5 hours per week. Therefore, experienced mappers were doing slum mapping quite often than the less-experienced ones. The study found that those whose response was "once a week" and "Not specific" and "6-10 hours" were all experienced and active mappers. On the other hand, the less experienced mappers responded were carrying out slum mapping 2-5 hours per week. Those who were mapping slums once a month accounted for a total of 28%.

4.6.7 Criteria are used to identify stakeholders for collaborative slum mapping

In order to determine the criteria that was used for the stakeholders to learn about the GMM tool, the frequency count analysis was done. Figure 34 below presents the results of the frequency count based on FGDs. This analysis shows that the majority of mappers learnt about GMM through a friend. This accounts for 60% followed by Internet (17.1%) with Google accounting for 11.4%. On the other hand 2.9% learnt about GMM through PPGIS.net and Linkedin respectively. Newspaper adverts and Google organized mapping competitions accounted for only 5.7%.

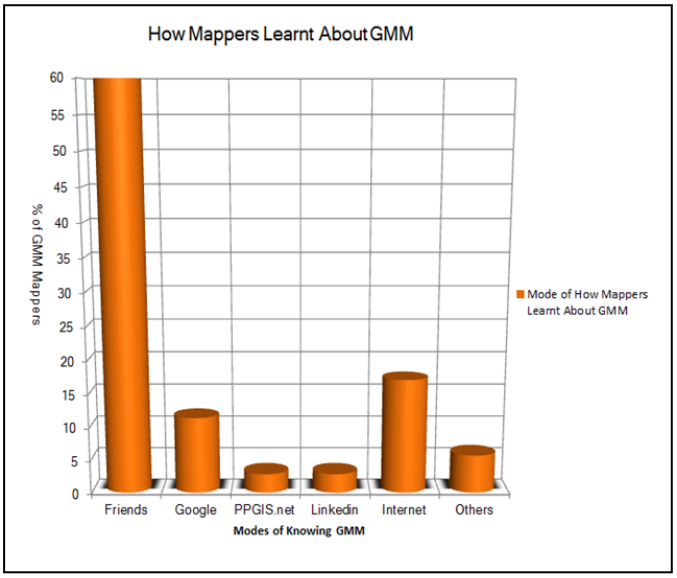


Figure 34: Modes of Knowing GMM
Source: FGDs, (n=18)

Comparing the results in Figure 34 above with the online survey results presented in Figure 35 below, it is clear that likewise in the above results, (66.7%) learnt about GMM collaborative slum mapping through a friend or workmate. Similarly the Online survey shown below, indicates GMM mappers learnt about the tool through a friend or workmate while those that learnt about GMM tool though internet accounted for 22.2% and PPGIS.net and Linkedin accounted for 11.1% each. The results have also shown that other web-based social network fora such as Twitter and Facebook and newspaper adverts accounted for 0%.

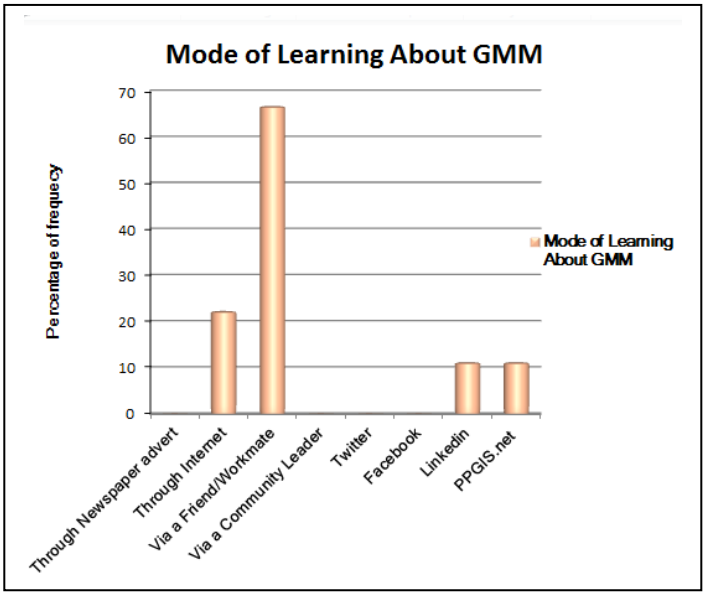


Figure 35: Mode of learning about GMM
Source: Online Survey (n=14)

It is interesting to note that despite GMM Mappers working on internet, all web-based modes of identifying stakeholders such as internet, Linkedin, PPGIS.net accounted for a total of 44.4% with Twitter and Facebook

accounting for 0%; in Online survey results and 22.9% only in FGDs and key-informant interviews. This shows low levels to internet access.

4.6.8 Time GMM Mappers started slum mapping

The quality of slum maps generated and the effectiveness of the slum mapping process among other factors is affected by the knowledge and the experience of the mappers about the GMM tool. To assess this, Cluster analysis in Nvivo 9 was done to determine distribution of mappers over the period. Figures 36 and Figure 37 below present these results

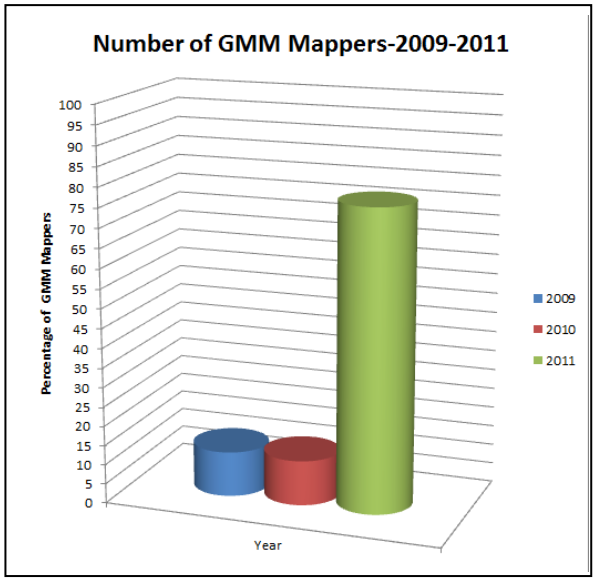


Figure 36: Months GMM Mappers started Slum Mapping
Source: Online Surveys, (n=14)

According to the results presented in Figures 36 and 37 above, it is evident that majority of GMM mappers have been participating in slum mapping with GMM tool since May 2011. In Figure 36 for instance, 76.9% accounted for mappers who started GMM slum mapping in 2011, with 11.5% starting slum mapping in 2009 and 2010 respectively.

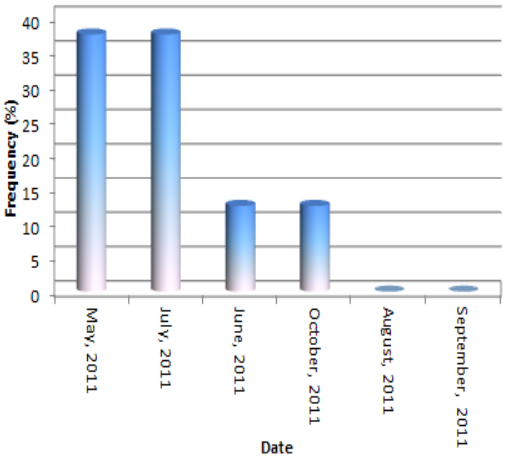


Figure 37: Time GMM Mappers started Slum Mapping

Source: FGDs (n=13)

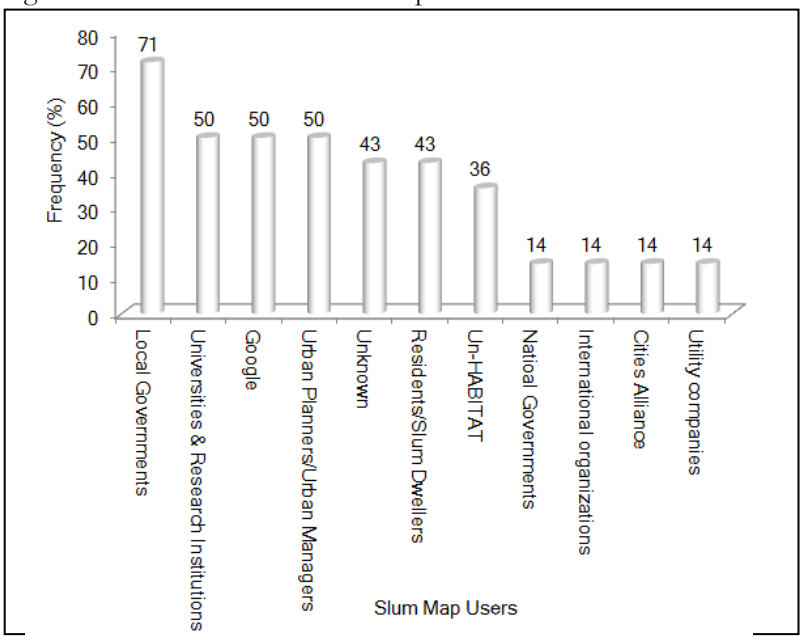
Similarly from the online survey analysis, 100% of mappers had been participating in slum mapping since May 2011, with May and July accounting for 35.5% respectively while June and July accounted for 11.5% each of GMM mappers starting slum mapping in those months. This analysis shows that only 23% of the mappers interviewed, had previous knowledge of the tool by the time (April, 2011) the Slum Mapping with GMM project was introduced. It can therefore be concluded that many stakeholders are joining to do map slums with the GMM tool; although not all features mapped using this tool are found in slum settlements.

4.6.9 Potential Use of slum maps/data

Slum maps/data generated with GMM can be used in different ways and by different users depending on their interests. While some use slum maps data for decision and policy making, others use it for planning or mapping and business**.** According to the results slum maps/data are or could be used in the following ways.

In addition to using slum map data for lobbying for funds and land, to demolish illegal developments/evictions, collection of revenue formulating planning theories, provision of services, the slum map data can also be used in emergency responses in times of natural disasters. During interviews, it was reported that slum maps or data can be very useful for relief aid agencies who respond to natural disasters. For example, data on place names and road names generated via GMM can be used by international humanitarian community to coordinate humanitarian responses to major crises and disasters such as floods, fire, hunger and earthquakes. Emergency response maps in times of natural disasters and crises. Figure 38 below presents potential users of slum map data

Figure 38: Potential Use of Slum Maps



Source: Online Survey Responses (n=14)

The results in Figure 38 above, most stakeholders (71%) mentioned local governments as the main potential user of slum map data followed by universities and research institutions (50%), Google (50%) and urban planners (50%) with slum dwellers accounting for 43%. Another 43% indicated that slum map data could be used by other unknown entities because after mapping the slums, the mappers do not really follow on who is using their maps

since maps are accessed online. National Governments, international organizations, Cities Alliance and utility companies accounted for 14%. Comparing these results with Table 5 (Matrix of Slum Map Users), the results seem to agree because local authority in the matrix is has interest in seven different areas; urban planners are interested in five areas while international organizations such as UN HABITAT are only interested in one area.

4.7. Assessing Quality of slum maps

Assessment of quality of slum maps/data generated with GMM is a very important component of web-based collaborative slum mapping. Mooney et. al (2011), argue that assessing the credibility of contributors is important to evaluate the overall reliability of their contributions. One way of determining quality of map data generated through collaborative web-based approached is assessing the mappers moderation track records. This is by looking at number of edits by each GMM mapper, % of edits approved and rejected. The moderation results give feedback on map accuracy to the editor by indicating features that have been approved and/or require error correction. Table 6 below presents moderation records of ten selected GMM mappers from City of Kampala. These moderation track records indicate whether a particular feature was correctly or accurately mapped or not. Features that were correctly mapped were published after undergoing moderation process.

Table 7: Moderation Track Records as at 1st January, 2012

Name of Mapper	Yr. started Mapping	No. of Edits	% of edits Approved	% of Edits Rejected
Max	2009	18,577	100	0
Yush	2010	4,700	99	1
Kakande	2011	1,969	98	2
Mmtt	2010	12,524	100	0
Ed	2011	9	80	20
Kuts	2011	404	92	8
Xstepho	2011	7,311	100	0
Akanga	2010	799	97	3
Swantos	2010	6,820	100	0
Deed	2010	20,566	100	0
Total				

Source: Google Map Maker (2011)

From the table above, 50% had a 100% perfect record with 80% scoring above 97% and above. Only 10% scoring 80% approved edits. Of the total 73,679 edits, only less than 1% was rejected. This means the mappers were more accurate hence their data could be trusted since it was approved by Google experts. According to GMM (See for example *http://mapmaker/bin/answers),* approved edits will take about 10 minutes to appear on Google maps.

GMM data is constantly changing and evolving and through analysis of the history of the evolution of objects, one can see how objects have changed in response to edits over time.

The second procedure to evaluate the quality of slum maps is by analysing the history of Map Maker edits. The history shows all of the editing history of a particular feature. This includes dates when a feature was added on

GMM who added it, what attribute was improved, how many times the features has undergone changes and finally whether or not the change was approved. Such history of edits reveals the quality of slum maps generated. Table 8 below illustrates the history of edits for some of the features mapped in Katanga slum between March 2011 and January 2012.

While there are many mechanism through which open source projects ensure the quality of the data, the number of people engaged in it receives special attention in what is known as "Linus Law according to (Raymond, 2001), p. 19), in Haklay et. al, (2010). For mapping, this law can be translated into the number of contributors that worked in a given area. The rationale behind it is that if there only contributor in an area, he or she might inadvertently introduce some errors for example forgetting to survey a street, or positioning a feature in the wrong location. However several contributors might notice inaccuracies or: bugs" and therefore the more contributors the fewer inaccuracies, the quality the map. The quality of slum maps can be improved through the collaborative contribution of multiple contributors (Haklay, 2010). The more contributors there are, the more likely it is that they will identify the feature in their correct positions. On the basis of this law, Table 8 below shows some of the selected features that were added and edited by various contributors.

Name of Feature	Date Added	Date (s) Changed	Feature/ Attribute Added	Changed From	Changed To	Total No. of Changes	Contributor
Chaw Hall Restaurant	11/6/ 2011	15/9/ 2011	Name			2	Zulu
Akamwesi Hostel	10/2/ 2011					14	Anonymous
		25/4/2011	Categories-student hostel				Anonymous
		22/6/2011 (4.57pm)		Payment Type-Cash			Yush
		22/6/2011 (5.07)	Geometry	Boundary modification			Kurts
		22/6/2011 (5:12)	Business Hours		Mon-Sun 8:30 am to 10:00 pm		Yush
		22/6/ 2011 (5:19)					Yush
Public Water Tap	13/6/ 2011					6	Max
		22/6/ 2011	Boundary				Kakande
		15/9/2011		Public water Tap	Public Toilet		Dan
		5/10/2011					Stunner
		6/1/2012		Public Toilet	Public Bathroom		
		25/1/2012					
Wasa Clinic	18/6/2011		Category			4	
		15/09/2011	Geometry				Yush
		16/01/2012		Name			Stunner
		25/01/2012					
Be-friends Hair Saloon	18/6/2011						Max
		15/9/2011	Boundary			4	
		16/01/2012	Name and Address	Saloon	Wasu hair Saloon		
		25/01/2012					
Mwelaza House Kyankazi Restaurant	11/6/2011					5	Anonymous
		18/6/2011	Name Working houses and category				Yush
		15/9/2011					
ABC Car Wash	3/3/2011		Function			5	Max
		15/4/2011					
		13/7/2011					Stunner
		16/01/2012					
		25/01/2012	Business Hours				

			Mon-Fri 7:00 am – 12:00 pm				
Road	18/6/2011					1	Stunner
		13/7/2011	Number of Lanes	0	1		
			Type of road	Asphalt	Dirt		
Trail/Path	25/4/2011					3	Anonymous
		15/6/2011	Segment added				Max
			No. of lanes	0	2		
Bulldog Bar	10/11/2011					3	Davie
		23/01/2012	Building/Ground				
			Adjusted nodes of polygon	Less coverage of polygon	Polygon covering exact area of the feature		
			Category -bar				
Katanga Slum Boundary	?	2/9/2010	Boundary			16	Anonymous
		22/12/2010	Population (33,600)				Anonymous
		9/3/2011					Anonymous
		13/4/2011		Boundary modification			Anonymous
		13/5/2011		Population- 33,600	5,000		Max
		19/5/2011		Modified boundary			Max
		25/11/2011		Modified boundary			Yush
		19/4/2011					

Table 8: Showing History of edits of some of the features mapped at Katanga slum, Wandegeya in Kampala Uganda.

Source: GMM @2012 Google-Digital Globe, Geo eye)

5. DISCUSSION

5.1. Other web-based collaborative slum mapping methods and tools

There are several web-based collaborative methods available which allow users to create, edit and content, upload information to the web easily and so that many people can view and react. These methods differ in many aspects such as breadth of end user coverage, data entry and end user clients, data licensing, data moderation methods which influence data quality and speed of publication. (See for example, *http://www.google.com/mapmaker*) and ease of use. Data providers also do vary ranging from individual enthusiastic mappers to geo-information experts. This study has looked at the collaborative aspect of such methods as WikiMapia, OSM, Ushahidi and GMM and also My Tracks activated in android phones to trace the trails followed by mappers.

These methods can be used in conjunction with each other since no method can effectively be used to generate spatial data about slum settlements. For example, data collected and managed by software like Ushahidi can be integrated into GMM to help the slum mapping process. Also a KML layer of road networks produced by OSM can be used as a background layer or reference points for mapping slums in GMM.

The study further revealed some similarities and differences between these collaborative slum mapping methods and tools. First, they are all crowdsourcing methods relying on public participation in contributing local knowledge necessary for slum mapping. This means that stakeholder in slum mapping are of paramount importance when using these mapping methods and tools; because, placing and editing objects is done based on the editor's local knowledge. The principle is that data collection relies on a lot of knowledge from individual citizens, as community members are the custodians of local knowledge necessary for slum mapping. Voss et. Al (2004) agreed that maps produced with local communities are geographically accurate because local communities are a reliable source of local knowledge. An example of local knowledge is shown in Figure 32.

In terms of flexibility of the collaborative slum mapping methods and tools the study has shown that, GMM is very easy to learn and use. Anybody without prior survey or planning knowledge can add or edit a feature or can contribute information to the mapping process. GMM like OSM, Ushahidi and Wikimapia also accommodate data captured by using other devices such as GPS, My Tracks, cameras, Google Fusion tables which can be uploaded onto the tools for further processing such as slum mapping.

According to Haklay(2010), however, one of the limitations for these web-based collaborative mapping methods is that use of crowdsourcing activities to create, reliable information or quality maps is carried out by a large group of volunteers, who work independently and without much coordination each concentrating on their own interests.

All in all, the study has shown that these mapping tools are collaborative enough considering that various users contribute data and also that the methods can be used in conjunction with each other.

5.2. Users` requirements for GMM slum maps

Of importance to this research was analysing stakeholder participation in slum mapping with GMM, their requirements, interests and frequency of slum mapping. Different slum map data users have different interests and that most users are interested in a number of areas. Users in this case refer to organization and individuals that use slum map data for various purposes. For example, 10 (40%) of the stakeholders were interested in shelter and housing issues meaning that slum map data could be used for improving housing conditions in slum settlements. (See, Table 5). The study also has shown that various users of slum map data share similar interests. For instance, Actogether Uganda, MLHUD, SDF, KCCA, residents and urban planners are interested in slum map data for mapping/planning of slums in order to improve the living standards of slum dwellers. The findings also show the usefulness of slum map data in lobbying for funds and land for slum upgrading programmes and resettlement of the would-be evictees. Others are interested in the improvement of water and sanitation among the slum residents. It therefore means, that without slum map data, problems facing the slum populations cannot be addresses since any intervention relies on the availability of accurate and reliable data about slums. This is the area where collaborative slum mapping with GMM is contributing through generation of accurate data as argued by many authors (IFAD, 2010; Voss et.al, 2004) that collaborative mapping is a fast and reliable data collection method, timely and low cost. The research findings further show GMM tool`s effectiveness in that it is able to accommodate various stakeholders to participate in slum mapping process. (See Figure 19)

In addition to the above, the study has also revealed that most mappers collaborated with slum residents (57%) and local communities (50%) with universities and research institution accounting for 43%; while government, international organizations and CBOs accounted for 29% while NGOs accounted for 21%. This means that the GMM tool is effective in terms of flexibility to accommodate various stakeholders in slum mapping (sic). Despite slum residents being crucial in the GMM slum mapping process, their knowledge of the tool is very low. Results in Figure 19 also mean that different user interests in slum map data determine different levels of stakeholder participation in slum mapping process.

On how often slum mapping should take place, the findings of this research provides two interpretations. First, is that slum mapping should be conducted quarterly (23%) thus organized group slum mapping. This can allow time for mappers to adequately prepare for mapping events and revisions after moderation feedback. The study has shown that although only 23% opted for mapping slums quarterly, majority of mappers including the 46% who were not specific, individually, GMM slum mapping should be done weekly where mappers could be spending between 2-5 hours per week.

On the basis of these findings, it can therefore be concluded that a lot of stakeholders are willing to do slum mapping with GMM though some were not specific on how often should it take place. Failure by experienced mappers to specify time can be a useful tool or a basis for addressing concerns raised by GMM mappers that can prevent stakeholders from participating in collaborative slum mapping. Among other reasons for not being

specific was voluntary slum mapping this research has revealed as being one of the major factors demotivating GMM mappers.

5.3. Effects of spatial and temporal scale requirement on the use of slum maps

Mapping of slums and use of slum map data can be affected by both the spatial and temporal scale requirements. First, slum mapping using GMM is done in two levels, thus the small scale and large scale. Each level has got its own spatial scale which is required which in turn affects the mapping and use of the final map products, At the small spatial scale e.g. 50 meters, only features like slum boundaries, roads, rivers, buildings, open spaces/parks, railways can be easily mapped. At this spatial scale, certain features especially point features cannot be seen on the imagery and the map does not give enough detail necessary for other uses such as policy and decision making due to absence of important details. For a detailed slum mapping to be effectively done with GMM, the large spatial scale is therefore required to enable detailed slum mapping. At this scale e.g. 10 meters mapping of social service such as water points, boreholes, public toilets and attributes of features such as names are assigned. This level of slum mapping requires local field based data acquisition. Also, for features to be accurately mapped at the large scales, one needs to carry out a field reconnaissance before actual slum mapping and ground verification after mapping with the help of local community leaders and other mapping tools such as GPS, camera, My Tracks etc. This will help to ensure and validate the accuracy of the mapped features.

Furthermore, the study has also found that temporal scale requirement may affect the use of the slum maps. For example, if the old imagery is used to map or edit certain features in GMM, a moderator who is not familiar with the area can reject the edits and subsequently not published for use. Such maps may be incomplete hence not of good quality due to the missing features. Users may therefore not use such a map until revisions and moderations of the edits are done which may take time for Google to update the imagery. GMM mappers require that the imagery be up-to-date so that it is able to show the correct ground picture. According to FGDs, 100% of experienced and less experienced mappers and 86% from online survey mentioned that lack of updated satellite imagery , was negatively affecting slum mapping such that moderators could reject ones edit based the outdated imagery. This was discouraging GMM mappers from continuing with slum mapping. To deal with this problem, Google should ensure that satellite imageries for cities are frequently updated, also because faces of slum settlements are fast changing.

However, considering the fact t that updating of the satellite imagery may not be immediate as it requires a lot of funds, contributors of data in GMM should be communicating with moderators about the features rejected. GMM should use local moderators to validate the accuracy of data uploaded onto the GMM tool.

The effects of temporal scale requirement on the use of slum maps can also affect the quality of slum maps generated. This research has revealed that use of slum maps depends on the time edits are moderated and approved. Since edits and changes in GMM are not immediately reflected on Google maps until they are

approved, it means using slum map data cannot be done before the moderation process. This can affect the levels of local community participation because; they may feel loss of ownership of the local knowledge that they contributed towards the preparation of the slum map data.

In addition, findings of the research have revealed that time given to GMM mappers to produce the maps was not enough to cover all the features. This requirement can affect both the quality of maps based on the completeness of map and use of the maps because slum maps may not be able to cover all the slum features due to limited time. Under such situations, incomplete maps may be produced subsequently rendering them of low quality.

The study has therefore revealed the effects of both spatial and temporal scale requirements on slum mapping process and the use of slum map data. So, having an up-to-date satellite imagery to use in GMM slum mapping is very important. .

5.4. Factors influencing or preventing stakeholder participation in collaborative slum mapping

Findings of the study show that GMM mappers were motivated to continue mapping slums by various factors. First, the personal experience of the poor living conditions in slums was motivating mappers to participate in slum mapping so that once mapped, slum map data would be used to improve the poor living conditions slum dwellers face. Since stakeholders do slum mapping voluntarily, this research has revealed that rewarding GMM slum mappers motivates mappers while at the same attracting more others to join slum mapping groups. For example, it was revealed that organizing mapping competitions where mappers get rewarded has the great potential to motivate more mappers to continue participating in slum mapping. For example 60% of the GMM mappers were motivated by the prizes that were being given to mappers during the competitions organized by Google in Kampala, Uganda.

On the other hand, the GMM mappers were demotivated by a number of factors which in the end could negatively affect the quality of slum maps and the effectiveness of the GMM tool. Among the major factors discouraging mapper's, particularly non-active mappers were lack of knowledge about how the tool operates. This was due to lack of good training materials before actual mapping activities which would have enabled mappers get equipped with skills and knowledge of how GMM tool works.

Lack of internet access was another major demotivating factor that was slowing down slum mapping process. For example 96% of active mappers cited this as one of the problems that was affecting slum mapping activities since internet connection was slow, unreliable and of low bandwidth.

Similarly, GMM slum mapping could have been very effective and efficient if mappers were free from political interference. According to the results of this study, political interference instilled fear in both mappers and the

local communities who are the custodians of local knowledge. Slum dwellers for example, took slum mapping as government`s move to evict them so that their land is sold to rich developers. As a result, residents had fears and were not receptive. On the other hand, politicians were telling slum dwellers that any mapping activities taking place in the slums were meant to gather information so that evictions could be executed. In view of this, mappers were under threat from the residents because they were regarded as government agents conducting surveys meant for effecting evictions and land grabbing. This can accumulatively lead into stakeholders shunning from collaborative slum mapping. This means that political support is very important in slum mapping because politician being very influential people in the community, can effectively sensitise local communities on the importance of participating in or supporting slum mapping/upgrading programmes. Government which also has the mandate to administer land can also ensure security of slum dwellers by collaborating with other stakeholders in slum mapping.

Apart from political interference, the study also revealed that voluntarism was demotivating a lot of GMM mappers. In this case, the general feeling of most mappers was that time spent on GMM mapping could be spent on income generating activities, hence devoting less time on slum mapping. Although, the research revealed that a lot of stakeholders were willing to participate in slum mapping with GMM, the demotivating factors have accumulative effects of lowering the morale of GMM mappers which subsequently adversely affecting the quality of slum maps.

Furthermore, from the above discussion, it is clear that effectiveness of GMM slum mapping and level of quality of maps produced are among the factors affected by the commitment of GMM mappers. The findings of this research revealed that many stakeholders are willing to continue taking part in slum mapping. But the level of commitment varies because of various actors. For example, 44%f from FGDs showed commitment to slum mapping quarterly with 25% (experience mappers) devoting 10+ hours per week for slum mapping.

Finally, on how much time stakeholders were actually spending on collaborative slum mapping, the results showed that 50% were spending between less than 1 hour and 5 hours per week while mappers with prior knowledge in surveying were spending between 6-10 hours per week. It has to be noted that the times mentioned above were spend only on slum mapping. GMM mappers were also mapping other features using the tool that were not slums and this study could not establish exact number of hours per week. It was only the spending of 5 hours per day once every three months in a year those GMM mappers spent on slum mapping.

It can be concluded that these demotivating factors could have a potentially detrimental effect on the quality of slum map data while at the same time damaging the collaborative spirit of GMM tool in the slum mapping community. From these findings it is very clear that the problems that could demote stakeholders are not necessarily caused by the GMM tool itself, are to do with the environment in which slum mapping takes place. It is therefore to also ensure that the general environment in which slum mapping takes is conducive and receptive so that maps produced are of good quality.

5.5. Current status in quality of web-based collaborative slum mapping in Kampala.

In this research, assessing the current status in quality of web-based collaborative slum mapping was looked at using various elements such as stakeholders` understanding of a slum as Payne (1977) points out that the first step in solving a problem is to define it correctly so as to be able to quantify, locate, plan and take action as necessary. It also looked into how mappers learnt about GMM tool, when they started slum mapping, knowledge of existence of slum policy, and GMM moderation records.

The study has revealed that all the stakeholders knew the definition of a slum and there were no differences in the way different groups i.e. experienced, less experienced, non-active mappers and slum dwellers and local community leaders, defined a slum in the context of Uganda. The definition and characteristics of a slum are listed under Section 4.6.2. There was an agreement on the definition to what UN Habitat (2003) defines a slum as a group of individuals living under the same roof lacking one or more of the following conditions: access to improved water, affordable price, available to household members without being subject to extreme efforts, access to improved sanitation, sufficient living area, durability of housing and security of tenure.

In addition to the above, quality of slum maps also depends on the experience of mappers. Based on FGDs, the study revealed that 60% of mappers and 66.7% according to the online survey responses, learnt about the GMM tool through a friend followed by 17.1% who learnt about the GMM tool through internet. Those who learnt about the GMM tool through Google accounted for 11.4% in FGDs while PPGIS.net and Linkedin in online surveys responses accounted for 11.1% each. Therefore, the findings have revealed that the most common means through which stakeholders were learning about the tool was trough a friend. Although this mode accounts for higher percentages in both cases, the mode has a potential of being selective as other interested people may be left out if other means of informing the general public about the tool are not advanced. It was interesting to note that despite GMM mappers working on internet, all web-based modes of identifying stakeholders such as internet, Linkedin and PPGIS.net accounted for a total of 44.4% with Twitter and Facebook recording 0%.

Not only how mappers learnt about the GMM tool is crucial to determining the quality of slum maps but also the experience of the GMM mappers which can be assessed based on the date mappers started participating in slum mapping using GMM. Although GMM slum mapping is newly introduced, the findings revealed that a lot of stakeholders are willing to do collaborative slum mapping. From the result presented in Figure 35, majority of GMM mappers have been participating in slum mapping since May, 2011. 76.9% accounted for mappers who started slum mapping in2011 and 11.5% started using GMM in 2009 and 2010 respective. Based on the online surveys, 100% of mappers started participating in slum mapping in 2011. The results showed that only 23% of the mappers interviewed had previous knowledge of GMM tool by the time GMM slum mapping was introduced.

5.6. Assessing the Quality of slum maps

Assessment of quality of slum maps produced using GMM has been done following two procedures. The first one is by analysing the mappers using their moderation track records. From this analysis, the research has revealed that edits by GMM mappers had the highest percentage of approvals and very small percentage of the rejections (See Table 7). The findings indicate that 50% of mappers had a 100% perfect record with 80% scoring above 97% and above approved. Of the total 73,679 edits, only less than 1% was rejected. This means that GMM mappers were accurate hence the map data could be trusted after having undergone moderation process and later approved by Google super mappers. Only accurately mapped slum features are published for public consumption. Although this analysis shows a very high percentage of approved edits, the approach may not be enough to conclude that the slum map data generated was of high quality. As Kerle (2011) argues that this approach may not meet all traditional cartographic benchmarks, but results have indicated high geometric accuracy.

Therefore, the second procedure used to assess the quality of slum map data was by analysing the number of people engaged in contributing and editing of a particular feature. This according to according to (Raymond, 2001), p. 19) as cited in Haklay et. al, (2010) is known as "Linus Law". For mapping, this law can be translated into the number of contributors that worked in a given area. The rationale behind this is that if there only one contributor in an area, he or she might inadvertently introduce some errors for example forgetting positioning a feature in the wrong location. However several contributors might notice inaccuracies subsequently making the quality map because when there are more contributors, inaccuracies are easily identified. The quality of slum maps can be improved through the collaborative contribution of multiple contributors (Haklay, 2010). The more contributors there are, the more likely it is that they will identify the feature in their correct positions. Evaluating the quality of slum maps through the history of GMM edits, the findings have revealed that moderation component ensures accuracy and error correction so that features in slum settlements are mapped accurately. The history shows all of the editing history of a particular feature particularly how many times the features has undergone changes and finally whether or not the change was approved. Such history of edits (Refer to Table 8) shows how many times a feature has been corrected to ensure that quality maps are generated. For example Katanga Slum boundary has undergone 16 changes over time with 6 contributors.

All in all, the findings of this study show that each feature mapped in slums undergo a moderation process to ensure the quality of slum map data by ascertaining accurate of the geometry and the attributes assigned to each mapped feature in the slums. It can therefore be concluded that slum maps generated using GMM are accurate and of good quality following the process they go through before being published for use.

This research also assessed the potential use of slum map data. Findings of the study have shown that slum maps data can be used in emergency responses in times of natural disasters in which relief agencies can use slum maps to respond to natural disasters. For example, data on place names and road names generated via GMM can help

humanitarian aid organizations community to coordinate humanitarian responses to major crises and disasters like floods, fire, hunger and earthquakes. The study has also revealed that slum maps can be used by local or municipal authorities to track and locate businesses within slum settlements to collect revenue for the development of the city. It can also be used for development control demolishing illegal structures developed on encroached or protected land. For universities and research institutions, slum map data can help them come up with better urban planning theories and models which can help in the improvement of urban life especially the poor living conditions of the slum dwellers.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

6.1.1 Background

The main objective of this study was to determine the effectiveness of collaborative slum mapping for the production of spatial data. Four sub objectives were defined from the main objective: (1) To compare and review different web-based collaborative mapping methods and tools (2) To analyze the users` requirements for GMM slum maps (3) To identify factors that lead to, or prevent potential stakeholder participation in collaborative slum mapping with GMM (4) To assess the current status of quality of web-based collaborative mapping in Kampala. In order to address these objectives, research questions were defined. Initially, the chapter discusses conclusions of the study with respect to research questions and then proposes a collaborative slum mapping approach. Finally, recommendations are made for the improvement of collaborative slum mapping using GMM and further research study.

6.1.2 Objective 1: To compare and review different web-based collaborative mapping methods and tools

Under this objective, four questions were raised and these were: (1) What tools are currently available for collaborative slum mapping? (2) Who introduced the tools and why? (3) How do the tools operate? (4) What are the strengths and limitations of the tools?

Web-based collaborative mapping methods and tools discussed in this study i.e. Ushahidi, Wikimapia, OSM and GMM. There effective use depends on the users` knowledge of the tools and how much they are involved in the in the collaborative mapping processes. Since all of them are crowdsourcing mapping methods, their success and effectiveness therefore depends very much on the level of involvement of expert knowledge of local citizens as community members are the custodians of local knowledge necessary for slum mapping. These collaborative methods can be used in conjunction with other tools. For example, data collected and generated through Ushahidi can be integrated into GMM to help the slum mapping process and that KML layer of road networks produced by OSM can be used as a background layer or reference points in GMM slum mapping. .In all these tools, data collection relies local knowledge of individual citizens,

OSM does not have any content restrictions on tags that be assigned to points, lines or polygons. One can use any tags provided "the values" are verifiable (*http://www.openstreetmap.com*). GMM on the other hand does not contain "slum" as a specific category for digitizing which makes it a bit difficult to map some of the features commonly found in slums but are not catered for in the present category setup. Ushahidi, unlike other methods, only map point features and not polygons.

6.1.3 Objective 2: To analyze the users` requirements for GMM slum maps

Under this objective, the following questions were formulated and these were: (1) Who are the potential users of slum mapping? (2) What ways do the interests of users of slum maps differ? (3) How often should slum mapping take place?" and (4) How does the spatial and temporal scale required affect the uses of slum maps?

As discussed in Section 4.4.2 and outlined in Table 5, slum map data has various potential users such as local communities, CBOs, NGOs, government, international organizations, local municipal authorities, business entities and slum dwellers themselves. In Table 5 for example, 40% were interested in uses that had direct relationship with shelter and housing issues and that different users are interested in different areas. Local communities use slum data for mapping, lobbying for lands and funding for the improvement of their housing conditions and also for land sharing. The study showed that there was great demand for slum map data from different institutions and individuals. But this demand is not met, due to lack of quality and up-to-date information since most of slums are not mapped.

The study showed that collaborative slum mapping can be conducted quarterly if it is done by organized mapping groups and once a week if done individually. What is important in both cases is to ensure involvement of expert knowledge of local citizens in the mapping process; in order to produce accurate slum maps and of good quality.

The spatial and temporal scale which is required also affects the use of slum maps because maps are mapped at two different levels. These are small spatial scale and large spatial scale of the satellite imagery used. At small spatial scale, only few features such as roads, rivers, bridges, open spaces and buildings can be mapped while detailed slum mapping is done at large scales. Slum map data cannot be useful if detailed mapping is not done. Finally, the time that it takes for edits to be approved also affects the use of the slum maps since, users cannot use the maps until they are published. This means, Google determines when the map can be used. This may have accumulative effects of discouraging various stakeholders from participating in collaborative slum mapping and using its map products.

6.1.4 Objective 3: To identify factors that lead to, or prevent potential stakeholder participation in collaborative slum mapping with GMM

Six questions were raised under this objective: (1) What are the enabling and disenabling factors for participation in collaborative mapping? (2) What are the concerns local communities have in the use of GMM for slum mapping? (3) What motivates mappers to become part of collaborative slum mapping? (4) How much committed are the GMM mappers to continue contributing to collaborative slum mapping? (5) How much time do the stakeholders spend on collaborative mapping? (6) How much time are they willing to spend for collaborative mapping?

Training of stakeholders on the operation of the GMM tool conducive political environment, maximum support from all GM stakeholders, personal knowledge of the poor living conditions in slums and organizing mapping competitions are some of the factors that motivated stakeholders to continue participating in collaborative slum mapping.

Local communities on the other hand, have fears that they don`t get enough technical support from the experienced mappers to enable them know how the tool works so that they ably participate in collaborative slum mapping processes. Also, any slum mapping was regarded as governments move to evict the slum dwellers from their land. This can be resolved by involving the local communities at every level of the collaborative slum mapping to promote the spirit of ownership. Furthermore, involvement of government in GMS slum mapping processes could also help resolve this problem because government can provide guarantees not to demolish structures until all necessary procedures are followed. Mapping of slums on voluntary basis was also demotivating stakeholders from participating in collaborative slum mapping.

Time spent on collaborative slum mapping depends on attributes about the individual mappers such as experience, knowledge of the tool and involvement of local knowledge and the type of work one is doing. It depends on such factors as accessibility to internet connection, size of slums and density of features to be mapped. Despite demotivating factors, a lot of stakeholders are willing to do collaborative slum and devote time to it. For example, majority opted for doing collaborative slum mapping weekly (over 50%), quarterly (44%).

6.1.5 Objective 4: To assess the current status of quality of web-based collaborative slum mapping in Kampala

Four questions were raised in order to answer this objective. These questions were (1) What is the current status in the quality of slum mapping in Kampala? (2) How often is collaborative slum mapping being carried out? (3) What are/could the maps be used for? and (4) What criteria are used to identify stakeholders for collaborative slum mapping?

Mapping slum using the GMM tool can generate quality slum map data because it relies on local knowledge which plays a key role in the mapping process. The moderation process which is part of GMM mapping process was found to be one of the ways to ensure accuracy of the maps and error collection. In the end ensuring that quality maps are produced. Therefore, a lot slum maps and different mapped features undergo a number of changes before being published for public use. This ensures that quality slum maps are prepared.

Since majority of mappers learnt about the GMM tool through a friend, it is important to consider other means of making GMM known to a lot of people and attract many mappers to ensure that most slums are mapped. This will ensure that demand for slum data as seen in users` various interests is satisfied, subsequently achieving the ultimate goal of improving the poor conditions of slum settlements.

6.2 Proposed Collaborative Slum Mapping Using GMM

On the basis of the findings of this study, the following collaborative slum mapping approach is proposed to ensure effective slum mapping process. This approach will ensure that the GMM tool is effective because more stakeholders will be well equipped with skills and knowledge on how the toll operates. The proposed approach will also deal with the problem of lack of internet connection which the study revealed as one of the factors that demotivate mappers and accumulatively lead to poor quality of slum maps.

In Figure 39 below, the proposed approach has two elements. In addition to the current online slum mapping, the study also proposes the offline platform where GMM mappers can edit or add features when internet connection is not available and plugin later to upload the mapped features onto the tool. This proposal is based on one of the findings of this research that lack of internet access was preventing stakeholders from participating in slum mapping.

Similarly, training of stakeholders on how the tool works is added in the approach as one of the important steps. This is because many people were unable to participate in collaborative slum mapping because they didn't know how the tool functions. There could also be improvements made in the interface that allow new categories to be formulated e.g. slum boundary and perhaps also to create user defined groups to enable quick switches to be made between frequently used items.

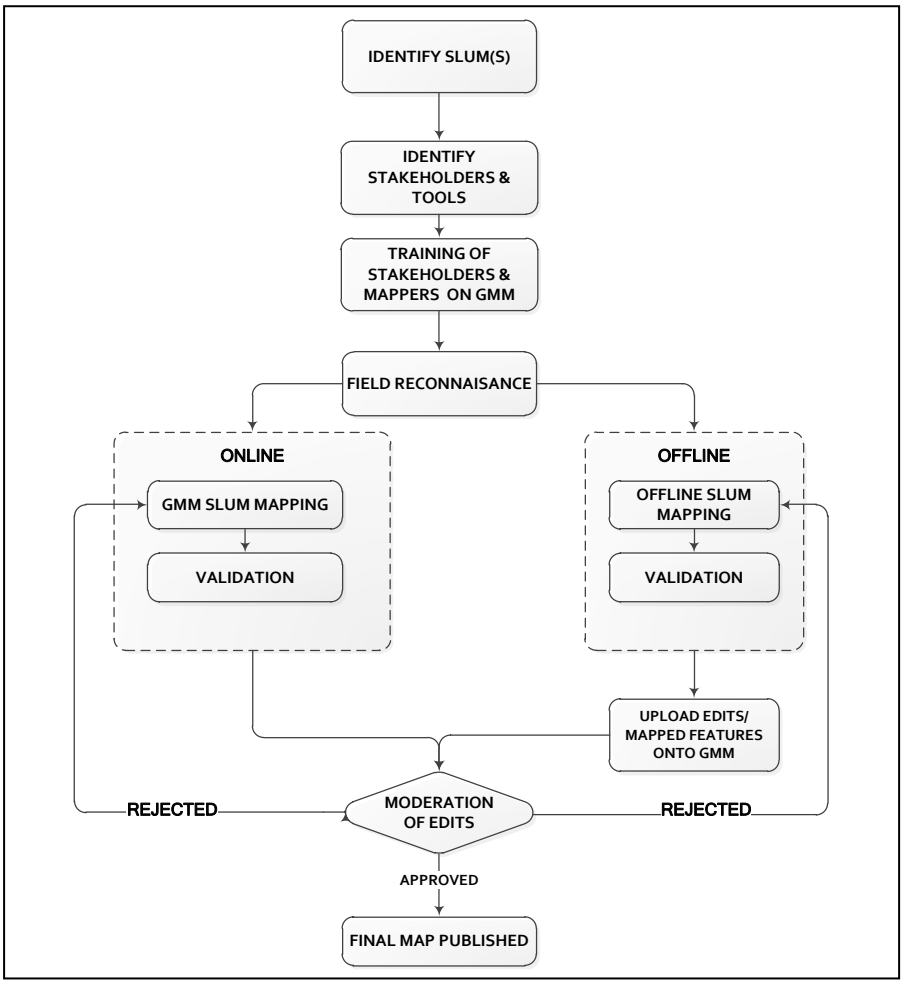


Figure 39: Proposed Collaborative Slum Mapping Approach using GMM

The above proposed collaborative slum mapping procedure is set to address a number of problems GMM mappers face. These are unreliable and slow internet connexion, lack of support by the local community and government, lack of knowledge about the tool due to inadequate training and possibilities of mapping features on wrong positions. The proposed approach will also encourage the use of other collaborative mapping tools and in the process ensuring continuation of slum mapping process.

First, in addition to the current status where majority of stakeholders (60% in FGDs and 66.7% in online survey respectively) learnt about GMM through a friend, identification of stakeholders and tools; and training of stakeholders is set to deal with the problem of lack of knowledge of the GMM tool and minimizing the resistance by the slum dwellers. This can be done through sensitizing the local community about the importance of local participation in slum mapping. Once local communities are well aware of the collaborative mapping with GMM, they will get encouraged and be part of the process, in so doing minimizing resistance by the local communities. The training will equip stakeholders with skills and knowledge about how GMM tool operates. This in turn will encourage mappers to continue participating in slum mapping. Since slum dwellers listen to their local leaders more, the training should target local community leaders who will in turn train their fellow residents.

Although Field reconnaissance stage is already there and this research proposes the intensification of this step it will help mappers to familiarise themselves with the areas to be mapped. With the above step well organized with full participation of local communities, threats of evictions, non-receptiveness of local community members can be avoided. On the other hand, field reconnaissance, to some extent can improve the accuracy of mapped features

One of the main features of this mapping procedure is the offline mapping part. It is proposed that Google should introduce an offline slum mapping platform that should be used when there is no internet connection, with a plug in so that contributions can be uploaded once internet connection is available. This component will solve the problem of failure to map slum due to internet connection problems. At the same it will also encourage many stakeholders to participate as lack of internet connection may not be an excuse.

In each path, online or offline, another step f validation is proposed. Validation in this case can be done in steps. First is feedback from mappers and second field visits to do ground check particularly for small objects to ensure that features are correctly mapped. Other collaborative mapping tools like GPS can be used at this point. This will help to update the slums and then revise them by adding features that might have been left ut before, or editing features where necessary. Girres et. al(2010) argue that contributors are more focussed on capturing attractive objects which are most useful to their interests.

All in all the above collaborative mapping procedure is proposed to improve on the slum mapping with the GMM tool.

6.3 Limitations of the study

This research had the following challenges:

1) Unavailability of some of active GMM mappers due to busy schedule.
2) Lack of willingness by some key informants. These did not want to be interviewed citing reasons that they were doing slum mapping voluntarily. This delayed the whole process as the researcher had to look for other informants.
3) In some cases, participants were reluctant to talk about slum mapping because in Kampala City, slum mapping is regarded as a way of grabbing land and evicting the poor by government. So such fears of eviction led to the reluctance of many participants
4) Collecting data from government offices or departments proved difficult due to bureaucratic set ups. It required a very long and slow process for approval for the release of data to be granted. Some of the data could still not be collected because of this and in some cases where permission was granted, it was not possible to get the data as officers keeping the data were not available,
5) Heavy rains particularly during the second week forced the researcher to re-schedule focus group meetings and interviews as participants could not travel to the agreed venues on time.
6) There was too much political interference in issues to do with slum mapping and this instilled fear in the people especially slum dwellers who were told not to take seriously any one mapping slum settlements as they were believed to be collecting data in order to evict the residents

6.4 Recommendations

Based on the findings of this research, the following suggestions are made to encourage greater stakeholder participation in collaborative slum mapping using GMM in order to ensure effective use of GMM tool and production of quality slum map data.

1) As part of the deliberate effort to attract stakeholders to participate in collaborative slum mapping, GMM should be introduced in primary, secondary schools and university education curricula. This approach will help many people learnt about the tool and at the same serving an effective way of sensitizing the general public about GMM tool and importance of mapping their settlements collaboratively. The focus here should be instilling the skills and knowledge on how the GMM tool operates

2) Increased efforts should be made to counter the wrong perception about slum mapping through community meetings and involvement of many stakeholders. These efforts should be complimented by organized visits to slum settlements by local community leaders through NGOS, CBOs. After such visits, the selected stakeholders should be required to report back through community meetings. The important messages should be clarifying any issues regarding evictions and importance of mapping slums to the improvement of the living conditions.

3) As part of helping mappers deal with the problem of internet connection access, Google should consider introducing an offline GMM platform where stakeholders can map or edit features and the plugin so that changes made can be uploaded on the GMM tool once internet connection is available.

4) Google should update satellite imageries for cities in developing countries as most of them have very old imageries that do not represent the true picture on the ground.

5) Google should introduce into GMM tool a separate feature class called "Slum Area" and should provide fields for slums feature attributes such as:
   (a) Name of Slum Area
   (b) Size of the slum area (km^2 or ha)
   (c) Estimated population
   (d) Year of data
   (e) Tenure Security
   (f) % o with adequate water supply
   (g) 5 with adequate sanitation
   (h) % overcrowded (more than 3 persons/room)
   (i) % of poor quality house materials
   (j) Hazard : Floods, Landslide, Fire, Earthquake, Power lines

6) Further research work should be conducted on assessing the quality of slum map data using completeness and geometrical accuracy procedures.

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Appendix 1: Online Survey Questionnaire

1. Title [ ]
2. Sex [ ]
3. Your personal details
   - Name [ ]
   - Company [ ]
   - City/Town [ ]
   - State/Province [ ]
   - Country [ ]
   - Email address [ ]

Please type your occupation
[ ]

4. Since when have you been participating in slum mapping using GMM?
   - [ ] May 2011
   - [ ] June 2011
   - [ ] July 2011
   - [ ] August 2011
   - [ ] September 2011
   - [ ] October 2011
5. How did you learn about slum mapping with Google Map maker?
   - [ ] Newspaper advert
   - [ ] Through the internet
   - [ ] Via a friend/Workmate
   - [ ] Twitter
   - [ ] Facebook
   - [ ] Linkedin
   - [ ] PPGIS.net

   Other (please specify)
   [ ]
6. What slum features do you actually map?
   - [ ] Slum boundaries
   - [ ] Buildings/houses
   - [ ] Roads
   - [ ] Railways
   - [ ] Rivers/streams
   - [ ] Open/public spaces
   - [ ] Forests
   - [ ] Water points
   - [ ] Schools/hospitals
   - [ ] Commercial areas

   Other (please specify)
   [ ]
7. Who are you partnering with in the mapping of slums using Google Map Maker?
   - [ ] Nobody
   - [ ] Residents/slum dwellers
   - [ ] CBOs
   - [ ] NGOs
   - [ ] Int. organizations
   - [ ] Government depts.
   - [ ] Local authorities
   - [ ] Universities & research Institutions
   - [ ] Businesses/Utility Companies

   Other (please specify)
   [ ]
8. What other collaborative or participatory mapping tools are you using for slum mapping?
   [ ]
9. How often do you do slum mapping?
   - [ ] Once a week
   - [ ] Twice a week
   - [ ] More than thrice/wk
   - [ ] Once a month
   - [ ] Twice a month
   - [ ] Once a year
   - [ ] Twice a year
   - [ ] Quarterly
10. How much time (hours) do you spend on slum mapping per week?
    - [ ] Less than 1 hour
    - [ ] 1 hour
    - [ ] 2 hours
    - [ ] 2-5 hours

[ ] 6 hours 6-10 hrs
[ ] 10+ hours

11. How much time are you willing to devote to slum mapping per week?
    [ ] Less than 1 hour
    [ ] 2 hours
    [ ] 3-5 hours
    [ ] 6-10 hours
    [ ] 10+ hours

12. What follow-up approaches if any do you apply to ensure effective slum mapping process?
13. Do you receive any form of feedback from anyone while doing slum mapping?
    [ ]

14. What is the nature of the feedback if any?
    [ ]
15. Is the feedback useful?
    [ ] Yes [ ] No

16. How? Explain you answer to Q17 above
    [ ]
17. Do you benefit from other types of feedback? Please give details
    [ ]

18. Who uses the maps that you produce with Google Map Maker? (select as many options as possible)
    [ ] Unknown
    [ ] National Government
    [ ] Local Government
    [ ] International Organization
    [ ] Residents/Slum Dwellers
    [ ] Research institutions
    universities
    [ ] UN HABITAT
    [ ] Cities Alliance
    [ ] Utility companies /businesses
    [ ] Urban Planners/Urban managers
    [ ] Google
    Other (please specify)
    [ ]

19. What problems do you face when carrying out mapping of slums?
    [ ]

20. How do you address the problems that you have mentioned above?
    [ ]

21. Are there any slum settlements in your city where mapping is restricted?
    [ ] Yes [ ] NO

22. If YES, please explain your answer
    [ ]

23. Explain whether the community agrees with what has been mapped through this collaborative approach
    {]
24. Do you have any advice or suggestions to make slum mapping with Google Map Maker easier, more effective or more useful?
    [ ]

Thank you very much for your time to answer these questions.

Appendix 2: Key_Informant Interview Questionnaire

QUESTIONNAIRE

Name of Interviewer: [……]
Date of Interview: [……] Place of Interview: [……]
Time: [……. To ……]

Details of the Interviewee:
Title: […….]
Name of Interviewee: [……] Sex: [……] Occupation: [……]

Q1. How do you define a slum?
Q2. Which parishes in the City of Kampala have slums and names of slums?
Q3. What is your role in as far as mapping of slum areas is concerned?
Q4. When you are mapping slums what information do you put on the maps?
Q5. Or do you use maps prepared by others in your day- to-day operations?
Q6. If *NO* why? And If *YES*, how do you use the map?
Q7. Do you have any policy on slums (either written or unwritten) in Kampala that guide growth, upgrading or mapping of the slums?
Q8. What problems do you face when executing your duties in the slum settlements?
Q9. How do you resolve these problems?
Q10. How do handle the issue of evictions in the slums in the City of Kampala?
Q11. Who do you work with when carrying out mapping/planning of slum settlements?
Q12. Do you think it is important to use maps when dealing with slums upgrading programmes?

Appendix 3 : GMM Showing tracks created by My Tracks

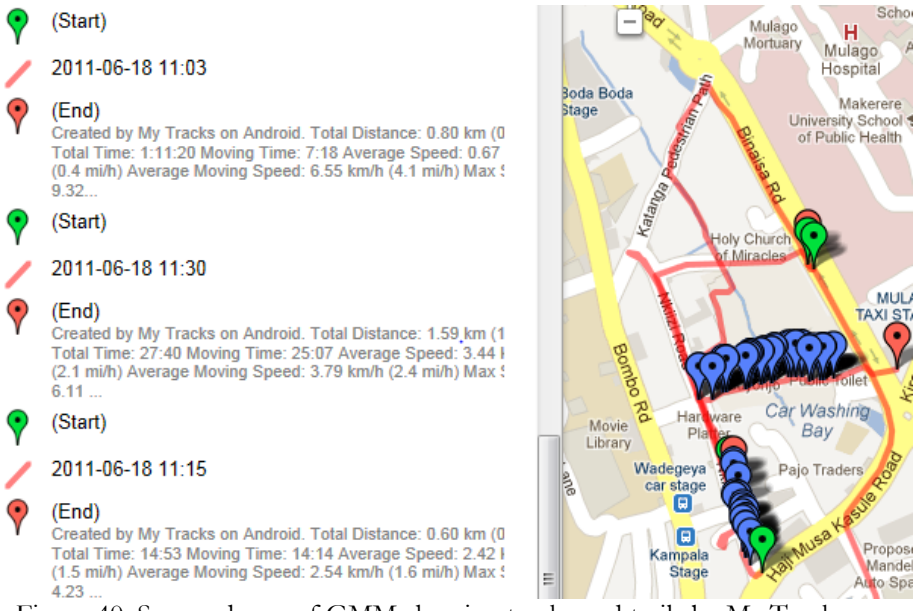

Figure 40: Screen dump of GMM showing tracks and trails by My Tracks
Source: GMM 2012)