ARDHI UNIVERSITY

APPLICATION OF CROWDSOURCED CADASTRAL DATA IN TANZANIA

A Case Study of Kunduchi Ward

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APPLICATION OF CROWDSOURCED CADASTRAL DATA IN TANZANIA

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A Dissertation Submitted to the Department of Geospatial Sciences and Technology in Partial Fulfilment of the Requirements for the Award of Science in Geomatics (BSc. GM) of Ardhi University

Certification

The undersigned certify that they have read and hereby recommend for acceptance by Ardhi University a research proposal titled **"Application of Crowdsourced Cadastral Data in Tanzania"** for university examination.

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I, MLAWA EDGAR hereby declare that, the contents of this dissertation are the results of my own findings through my study and investigation, and to the best of my knowledge they have not been presented anywhere else as a dissertation for diploma, degree or any similar academic award in any institution of higher learning.

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Dedication

I sincerely dedicate this dissertation to myself and nobody else rather than my lovely mother Elizabeth Anderson for all her efforts to ensure I have a proper educational carrier.

Abstract

Crowdsourcing involves obtaining work, information, or opinions from a large group of people who submit their data via the internet, social media and smartphones applications. Crowdsourced cadastral survey which is also known as volunteered geographical information is the way in which ordinary people can create digital spatial data and maps, individually and collectively. This survey is mainly for providing additional information to general base maps information. It allows users to create their own content by location of events and certain features which are not present on the available maps.

Also, this research used questionnaire method which was aimed at residents who live at Kunduchi ward in Kinondoni municipal. Most of the respondents who were involved in the questionnaire method had ideas of tackling the questions that were brought to them, simply because this method of data collection reduces bias. It included uniform question presentation and no middle-man bias. Literature review was one of the secondary data collection method used in this study to which the information available rely on published and unpublished documents from books of related topics, journals, thesis from the government and non-government observation's related to the topic.

The aim of this research was to access the use of crowdsourced methodology in as many cadastral projects in can Tanzania which was based on the findings and discussions that answer the entire research questions of this research. After data collection and analysis of the findings it discovered that people still rely on the traditional way of accessing or measuring land for the purpose of first and systematic registration and this is simply because of the residents themselves not being ready to accept the use of this new method and also specifying that their lack of knowledge and understanding of such as method plays a big part as a barrier to its application in the country.

Keywords: Cadastral Survey, Crowdsourcing, Crowdsourcing Cadastral Data, Volunteered geographical information, Tanzania.

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Acronyms

ARCGIS	Aeronautical Reconnaissance Coverage Geographical Information System
BIM	Building Information Modeling
CAD	Computer-aided Design
CORS	Continuous Operating Reference Station
ESRI	Environmental System Research Institute
FFP	Fit for Purpose
GPS	Global Positioning System
NCMA	National Cadastral and Mapping Agency
OSM	Open Street Maps
RRR	Rights, Restrictions and Responsibilities
SMD	Survey and Mapping Director
VGI	Volunteered Geographical Information

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

It is of great importance to introducing voluntary people or citizen participation for data collection for a systematic first registration has been followed and well investigated for some time now in terms of technical quality as well as methodology. Recent researches and investigation have shown that crowdsourced methodology may improve the efficiency of cadastral surveying and the process of adjudication of property owners and their parcels by significantly reducing compilation times, costs and errors from people. Depending on the methodologies followed, the geometric, thematic and topological quality of the crowdsourced data may vary significantly. Many have studied the potential for implementing crowdsourced approach in cadastral data collection, however, not much investigation has been done on how to improve the quality of such crowdsourced surveys. This research aims at providing new and concrete methods on how to employ crowdsourced technique by adding any available and relevant geospatial and descriptive information that may help participants to locate parcels or areas correctly to be used by people, citizens and informants for the crowdsourced cadastral surveys. Crowdsourced land information also known as volunteered geographical information (VGI) is the way in which ordinary citizens can create digital spatial data and maps, individually and collectively. Crowdsourcing is mainly used to provide additional information to general base map information. Crowdsourcing technology allows users to create their own content by marking locations of events and certain features which are not in these maps. Information provided by crowdsourcing has contributed to more up-to-date information sources in several sectors. According to (Heipke, 2010) crowdsourcing is about people using and creating their own maps, sharing location information with friends and visitors through the knowledge they have of place with the use of open-source maps API and affordable navigation devices. A decade ago, volunteered geographical information (VGI) was identified as a new source of information that would blur the traditional boundary between producers and the consumers of data (Goodchild & Glennon, 2010). This form of information has been recognized by multiple names, including crowdsourced geospatial data (Goodchild, 2007) and user-generated geographical content (Fast & Rinner, 2014) to name but a few. The belief that VGI is contributed by the public, some contributors with little experience and expertise of geospatial data, might have contributed to the perception of the unreliability of this data source. Such issues have impeded the adoption of

crowdsourced geospatial data in several projects. While one can argue the importance of the individuals and their levels of expertise based on the concepts of "the wisdom of the crowd" and the collective decision, some questioned the representativeness, i.e. the structure of the crowd and "power of the tiles", in many crowdsourcing projects (Leszczynski & Elwood, 2015). There is a global effort to develop methods and tools in order to reduce the required costs and simplify the procedures so that those countries that do not yet have a complete cadaster will develop reliable systems as fast as possible to improve the global sustainable prosperity. Therefore, new technologies are introduced for the compilation of cadastral mapping, the increased owner's participation and the potential use of m-services in the field. Owners participation in the cadastral mapping may be upgraded to the level that owners and other local citizens may undertake certain tasks that traditionally were in the responsibility of the state agency and/or the cadastral surveyors. This activity is usually mentioned as "crowdsourcing" in land administration. Crowdsourcing is a type of participatory online activity in which and individual, an institution, a non-profit organization, or a company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task of variable complexity and modularity; estelles-Arollas and Gonzales-landron-de-Guevara 2012. An interesting example of crowdsourcing in mapping is the project of the National Map Corps of United Geological Services(USGS), which encourages citizens to record and collect data by adding new features and correcting existing data for The National Map database about structures such as schools, colleges/universities, fire stations, police departments, hospitals, ambulance service, prisons, government buildings, ports, post, public sights and notable buildings and cemeteries(U.S. Geological Survey 2015).

1.2 Statement of the problem

Tanzania as one of the developing countries, a large percent of their trusted local citizens and land owners are not well familiar with cadastral aspects. Traditionally, landowners indicate on-site the boundaries of their parcels to their land surveyor for the compilation of the cadastral survey. In many other cases, trusted local citizens, too, provide useful historic information for the adjudication of unknown landowners and the exact boundaries of these parcels, and the results have shown that many participants have difficulty in identifying the land parcels (location, shape, and size) on the base-map correctly causing delays, extra time and cost. The potential for introducing voluntary citizens participation, combined with mobile services for cadastral data

collection for a systematic first registration has been thoroughly investigated and even implemented in some official projects. This data collection procedure can technically be accomplished safely, the ongoing cadastral survey projects in Tanzania do follow the participatory procedure of allowing the non-professionals, right holders to digitize parcel boundaries through crowdsourcing methodology. The purpose of this paper is to present a concrete methodology that supports a modern approach for cadastral surveys in Tanzania and also to improve the quality of such crowdsourced cadastral data, by adding to the base-map any available and relevant geospatial and descriptive information that may help the participants to correctly identify their land parcels.

1.3 Objectives

1.3.1 Main objective

The aim of the study is to analyze the response of people or citizens on the introduction of crowdsourced cadastral surveying in Tanzania. Since crowdsourcing is a digital way of performing cadastral survey therefore peoples view on the move from their analogue way to a new system is to be taken into consideration.

1.3.2 Specific objectives

i. To explore the roles of crowdsourced cadastral surveying in Tanzania.
ii. To analyze the importance of crowdsourcing method to local citizens of Tanzania.
iii. To analyze the usability of crowdsourced method in cadastral projects in Tanzania.

1.4 Significance of the research.

i. The emphasized adoption of the crowdsourced data methodology to cadastre will ensure the addition of important and missing geospatial features on the base-map which people use as their reference points to locate land parcels and locations.
ii. Insurance of correct locating of points and parcels by non-professionals leading to removal, reduction of errors.
iii. Saving of time and cost by project professionals due to quick information's they can get in the internet uploaded by trusted local citizens, rather than going on field.
iv. Since a large part of the country hasn't been full covered in terms of cadastral measurements, the introduction of crowdsourcing methodology in cadastres will speed up complete full nationwide coverage in developing economies like Tanzania along with relevant social issues.

1.5 Beneficiaries and expected users.

    i.   With the knowledge of the research, students from Ardhi university and other colleagues from different institutions can benefit from the above study, they can as well undergo more researches about crowdsourcing methodology.

    ii.   Since crowdsourcing is a participatory approach, then landowners, settlers and other trusted local citizens can positively gain knowledge through the research.

    iii.   Different professionals and experts such as land surveyors, Town planners and Architectures are likely to get more information's and data from the research.

    iv.   Land administration and management officers.

1.6 Scope and limitations

The study is mainly concentrated on providing methods on how to introduce and implement the application of crowdsourced method (sometimes termed as VGI) of obtaining data for different cadastral projects in Tanzania.

1.7 Research question.

What are the roles of crowdsourced cadastral survey to the Tanzanian society?

What can Tanzania gain by the use of crowdsourcing cadastral survey to different cadastral projects?

Considering the fact that Tanzania is one of the developing countries, can this method be applicable in the country?

CHAPTER TWO

LITERATURE REVIEW

This chapter contains the reviews of the main concepts about this research mostly based on cadastral survey and knowledge about crowdsourcing which are explained in details for more understanding.

2.1 Overview on cadastral survey

Cadastral Surveying concept was introduced in Tanzania by the German colonial administration, which formed the Department of Surveying and Agriculture in 1893. British followed the footsteps of the German administration. Initially cadastral surveys were used for the alienation of land to European settlers. Currently, the cadastral surveying system is administratively placed in the Ministry of Lands as the other related disciplines (Land Use/Physical Planning, Land Registration & Titling, Management and Valuation). A ministerial organ that administers cadastral surveys in Tanzania is the Surveys and Mapping Division (SMD) (Silayo, 1997)

Cadastral surveying is the sub-field of cadastre and surveying that specializes in the establishment and re-establishment of real property boundaries. It involves the physical delineation of property boundaries and determination of dimensions, areas and certain rights associated with properties. This is regardless of whether they are on land, water or defined by natural or artificial features. It is an important component of the legal creation of properties. A cadastral surveyor must apply both the spatial-measurement principles of general surveying and legal principles such as respect of neighboring titles (Mango, 2015).

The British government which was ruling Tanzania from 1919-1961 from the Department of land and survey in 1920 in which the department was given task of resurveying the properties which was owned by German. The British government introduces the system for planned town ship survey by which control was established first by traverse and the corner of the blocks set out plan data was coordinated.

Therefore, cadastral survey is the process by which information about land parcel was collected for the purpose of describing the boundaries of the land parcels, the information collected is used also for recovery and restoration of lost boundaries. The geometric description information is collected which describes the spatial location, size and shape of the land parcels. The land parcel is the basic unit in cadastral, each parcel is given the unique parcel number and address which

together with dimension are shown in a cadastral survey plan. Boundary lines for the adjacent parcels are defined by a set of beacons or iron pins in concrete (IPC).

The process of cadastral is carried out under the legal framework therefore the process of cadastral is called legal survey, cadastral survey work operated under the basic law od land Act No 4 of 1999 which state that the granted right of occupancy shall be issued on land that has been surveyed [section 22(1)]. Village lands are not a subject of a granted right of occupancy and are therefore not a subject of a survey as presented here. The principle legislation that regulates the technical operations of cadastral surveys in Tanzania is the Land Survey Ordinance, Cap 390 of 1956.

2.1.1 Cadastral system

Cadastral system is a parcel-based land information system comprising a land registration system and a cadastral survey and/or mapping system which provides large scale maps of land parcels. The maps are additionally necessary for planning, land management, administration, provision of infrastructures, raising land tax, land development and so much more.

Cadastral system has its functions, the following are some of the basic functions of cadastral system.

i.   Foremost it should be designed to serve the needs of the country, other functions are

ii.   To support land registration and improve access to land.

iii.   To support secure land tenure and property rights

iv.   To support land regularization. Example, formalization of land tenure

v.   To facilitate efficient and accessible land and property markets

vi.   To support development of land information systems; these promote access and exchange of land information about land rights

vii.   To support long term sustainable economic development, land management and environmental protection.

viii.   To support increasingly agricultural productivity

ix.   To be a source of political stability and social justice

There are processes that guide cadastral system, the following are the main cadastral process;

i.   Adjudication of rights on land

ii.   Demarcation, subdivision of land parcels in order to provide the basis of clear identification and recording of ownership rights

iii.   Transfer of rights in land

2.1.2 Components of cadastral system

i.   The cadastre

Conventionally it is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries (Hessen) and usually supported by large scale maps. A public listing in which all land parcels of a country of a defined area stored. Information content is land parcel, location, size, use and value (FIG, 1995).

Cadastre is the land parcel-based information system, which is up to date and contain record of interests in Land, rights, restriction and responsibilities and usually includes a geometric description of land parcels linked to other records describing the nature of interests and ownership or control of the interests in land and often the value of the land parcel and its improvement (Silayo, 1997). The information supplied by cadastre is about location, size, improvement of the land, people who own interest invested in the land and nature of interest. cadastre may be classified as,

i.   Fiscal cadastre, which is carried out for the purpose of rising revenue through land taxation.

ii.   Legal cadastre, that provide data necessary for land transaction, shows precise boundaries of land parcels, identifies legal ownership and describes the rights and show records of the properties invested in the land.

iii.   Multipurpose cadastre which contain the same information as fiscal and legal cadastre.

The Components of a Cadastre

i.   A record of interests in land; This is a descriptive part of the cadastre i.e. a register, which contains physical attributes (identifier, location, area, use) and abstract attributes (data for tax, proprietor and reference to the land register) of the parcel.

ii.   A graphical description (large scale maps) of the land parcels linked to other records which describe the nature of the rights or interests in the respective land parcels.

iii.   Implementation of the cadastre is the responsibility of the land surveyor

iv.   The contents of the records include parcel number, name of parcel owner, type of land use, location and size of parcel

The maps have from historical times been used as a means to identify land parcels for establishment or transfer of rights in land

ii.   Land registration

Land registration is any of various systems by which matters concerning ownership, possession, or other rights in land are formally recorded (usually with a government agency or department) to provide evidence of title, facilitate transactions, and prevent unlawful disposal. The information recorded and the protection provided by land registration varies widely by jurisdiction. Cadastral systems and land registration are both types of land recording and complement each other (Tanzania, 1999).

2.1.2 Application of cadastral surveying

i.   Cadastral survey is used in providing a solution to land disputes by ascertaining positions of boundaries during demarcation, adjudication and boundary restoration.

ii.   Supply land information needed for land use planning, land development control, land administration, land policy formulation and land reform.

iii.   Land registration. Cadastral surveys provide info needed for unique identification and accurate geographic locating of land parcels.

iv.   Land parcel creation and or definition.

2.1.3 Demarcation surveying

Demarcation is the operation that legally establishes boundaries between properties. This can be done out of court or it can be imposed by the courts in case of owner disputes. Property is demarcated by local, natural features of land either trees, streams or rocks and relatively permanent human structures such as walls, bridges and monuments (Tanzania, 1999). This survey involves the following,

i.   A process of physically marking boundaries of blocks of land parcels on the ground to indicate their limits. It often involves: block setting out, and marking block corners & sometimes where the block boundary meets other features (river, shoreline, road, railway) by temporary boundary markers (wooden pegs or pins).

ii.   bush clearing along block boundary lines, to ensure inter-visibility between corner points. Caution, you are required to observe highest degree of carefulness, responsibility and judgment during fieldwork to avoid conflicts that may rise due to e.g. cutting down standing crops, valuable trees and shrubs unnecessarily replacing pegs with permanent boundary markers: Beacons & IPC.

iii.   So, a survey whose aim is to demarcate and record the position of boundaries of land is what we call cadastral survey.

2.1.4 Duties and role of cadastral surveyor

One of the primary roles of the land surveyor is to determine the boundary of real property on the ground. That boundary has already been established and described in legal documents and official plans and maps prepared by attorneys, engineers, and other land surveyors. The corners of the property will either have been monumented by a prior surveyor, or monumented by the surveyor hired to perform a survey of a new boundary which has been agreed upon by adjoining land owners (Tanzania, 1957).

2.2 Crowdsourcing

Crowdsourcing is simply obtaining work, information, or opinions from a large group of people who submit their data via the internet, social media and smartphones applications. People involved in crowdsourcing sometimes work as paid freelancers, while others perform small tasks voluntarily. It allows companies to farm out work to people anywhere in the country or around the world, as the result, crowdsourcing lets business tap into a vast array of skills and expertise without incurring the normal overhead costs of in-house employees (Schenk & Claude, 2009).

2.2.1 Crowdsourced cadastral survey.

Crowdsourced survey which is also known as volunteered geographical information is the way in which ordinary people can create digital spatial data and maps, individually and collectively. This survey is mainly for providing additional information to general base maps information. It allows users to create their own content by location of events and certain features which are not present on the available maps. The information provided by this survey has contributed to more up-to-date information sources in several sectors (Apostolopoulos, 2018). Traditional cadastral surveys usually do not include the completion of both 2D and 3D cadastral registration preventing the well-function of property markets in several countries. Especially in cases of less-developed regions, time and costs for the 3D cadastral data collection are prohibitive. In recent years, crowdsourced data have claimed a place as a reliable cadastral data source, empowering their role in the process for the initial implementation of 2D and 3D cadastre, in both the developed and developing countries. The active participation of right holders in cadastral surveys, who know better the boundaries and location of their properties, can minimize their time and costs and more important it can eliminate the gross errors. Until now, the majority of research in this field, bases the

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identification and delimitation of 3D crowdsourced cadastral objects, on existed 2D cadastral maps, orthoimages and architectural floor plans. Right holders are responsible to deliver all the necessary (geometric and descriptive) proprietary information into the cadastral system, utilizing modern technological developments. (Vucic *et al*., 2015) presents an interesting crowdsourced approach for 3D cadastral data acquisition. The user is invited to submit information concerning the property height, the reference point and the surface relation, through a mobile device. The inserted data are combined with existed 2D official information about the property's premises, enabling the partly establishment of 3D cadastre and its' visualization. (Ellul *et al*., 2016) propose a web-based crowdsourced approach for the identification and declaration of the situations in which the land and property ownership situations belongs to. The contributor selects his/her situation from several groups presenting different types of land ownership, sketched by the research team (Kingsley, 2007). A different approach is proposed by (Gkeli *et al*., 2018), they designed a cost-effective technical framework for the acquisition of 3D cadastral data and the visualization of the real properties, as block models (LoD1), both above and below the land surface. A prototype mobile application able to process the inserted geometric data and provide the block models of the declared properties was developed. The application aims to automatically produce 3D building models through the digitization of property units 2D boundaries on the available base-map. A similar but optimized approach is presented in (Gkeli *et al*., 2019). The mobile application is upgraded by enriching its functionalities, while the methodology is enhanced by upgrading the role of team leaders in the whole registration process. However, in the absence of an accurate base-map, other approaches should be followed. As alternatives, the utilization of the smartphone's GPS sensor, with an accuracy of a few meters, or the utilization of external support GNSS (Global Navigation Satellite System) tools and resources, achieving high positioning accuracy, is proposed from some researchers (Moerdijk *et al*., 2018)

2.2.2 Crowdsourcing techniques in Land Administration.

The new era in LAS and the need to embed crowdsourcing techniques in its design is very recent. McLaren, 2011 did research on LAS and crowdsourcing techniques with the sudden expansion of smartphones, focusing on unmapped areas and the great number of unregistered parcels worldwide. His findings showed that only 25% of land parcels have been formally registered in LAS (McLaren, 2011). Due to these two main controversial aspects, the universal trend has been towards a Public Participation Geographic Information System which "is a field of research that,

among other things, focuses on the use of GIS by non-experts and occasional users" (Haklay & Tobón, 2003) and empowers GIS users to use technology purposefully to capture their local knowledge and advance their goals (Talen, 2000). It is also remarkable that the number of megacities has risen from two in 1950 to twenty in 2005 while seventeen of them are located in the world's less developed regions (Doytsher *et al*., 2010). More than 1.1 billion people live in slums, which are located in unregistered parcels (McLaren, 2011). It is clear that procedures should be made more efficient and the cost should be reduced through the involvement of individuals. As Adlington (2011) has underlined in the East Central Asia region, land reform and the land registration program has been completed by people without formal training in cadastral surveying. The project was guided by surveyors who were open to help without being wedded to traditional methods and high levels of accuracy. It is clear that society's needs for easily edited and inexpensive maps which can be produced in short time has forced VGI in various fields. Land management, which mainly applies land information to land resources (UNECE, 2005), can flourish with the aid of VGI. The main question that is posed in this research, taking into consideration all the above perspectives on technology and potential scenarios, is whether VGI and crowdsourcing techniques more generally can be incorporated in cadastral surveys and to what extent. The testing of the results is done through the Hellenic Cadastre project, which is a well-known, long-lasting project. The idea of incorporating VGI into the cadastral procedure is based on the power of locality and the participation of citizens in land planning as active parts of society.

2.2.3 Crowdsourced cadastral survey in Greece.

Greece is an EU country that does not have a complete cadaster for all of its territory. The compilation of the cadaster is considered to be an urgent issue not only because cadaster is an important governance tool, but also because it is the right tool to secure land tenure and ensure access to credit for the poor and middle-income households leading to the economic recovery of the Greeks. Current procedures for the compilation of the Hellenic Cadastral are time and cost consuming, an issue that Greeks cannot afford easily. The fundamental and innovative principle of the current technical specifications for the Hellenic Cadaster, as adopted in 1995, is the emphasis on a clear specification of the requirements for the final product rather than those for the method to be used for its production; this principle was in contradiction with all traditional technical specifications applied for other topographic surveying works in Greece at that time (e.g., the basic law for survey works, various ministerial decisions, etc.). This early international innovation of

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the Hellenic Cadaster has inspired the "fit-for-purpose" methodology published by FIG. The National Cadastral and Mapping Agency (NCMA) of Greece selected the required accuracy and the content of the final cadastral diagrams (for urban areas the RMSxy is 0.71m and for rural areas the RMSxy is 1.41m), entrusting to the contractor (private cadastral company) the responsibility for the choice of the methods and the tools that he/she would use to reach the desired result. The NCMA though requires to be informed about the tools and the selected methods, and in certain cases a ratification may be needed, so that possible errors will be avoided and a unified quality of the products will be achieved. Since a high accuracy and/or an increase in the amount of information to be included in the cadastral diagrams may demand the use of advanced tools and methods and may therefore result in increases in costs, the NCMA has to determine carefully what is really required in order to avoid superfluous work and its consequent costs. It is therefore derived that through the original specifications of the Hellenic Cadaster a kind of fit-for-purpose (FFP) approach is encouraged to be adopted for this project utilizing the active participation of the right holders. Therefore it can be said that the Hellenic Cadaster is actually a product of a "fit-for-purpose" methodology, in terms of tools and methods used.

Initially Greece used a traditional way of locating parcels on site and when participants were asked in Greece to identify their land parcels from a distance and not in the field several gross location errors appeared that have caused long delays and extra costs for the project. Since, the ongoing Hellenic cadastral project follows a modern participatory procedure allows non-professionals/right holders to digitize parcel boundaries through crowdsourcing methodology, they had to have a way to overcome such problems, the Hellenic National Mapping and Cadastral Agency (NMCA) has taken the following actions

(a) A number of e-services were developed,

(b) Advanced base maps, made by professionals, that now include additional geospatial information (e.g., points of interest, street names) are offered to the participants,

(c) Several automated controls, such as system checks of the submitted data through the declaration process, and provision of a list of errors to ensure the elimination of such in the data collection process from a distance, were introduced. Already to January 2020, more than 750,000 participants have submitted an online declaration (1.1 million declarations in total); this number may well justify the term 'crowdsourced cadastral surveys. Severe researches focused on

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improving the proposed model for crowdsourced cadastral surveying methodology in Greece. For this, the authors investigate further the progress achieved in the Hellenic cadastral project in this field.

2.2.4 Application of crowdsourcing

    i.   Urban and transit planning are prime areas for crowdsourcing. For example, from 2008 to 2009, a crowdsourcing project for transit planning in Salt Lake City was created to test the public participation process.

    ii.   Crowdsourcing allows businesses to submit problems on which contributors can work on topics such as science, manufacturing, biotech, and medicine optionally with monetary rewards for successful solutions (Sarasua *et al*., 2012).

    iii.   Crowdsourcing systems provided researchers with the ability to gather large amounts of data, and helped researchers to collect data from populations and demographics they may not have access to locally

    iv.   Researchers have used crowdsourcing systems such as Amazon Mechanical Turk or Cloud Research to aid their research projects by crowdsourcing some aspects of the research process, such as data collection, parsing, and evaluation to the public. Notable examples include using the crowd to create speech and language databases, to conduct user studies and to run behavioral science surveys and experiments (Callison-Burch & Dredze, 2010).

2.3 Mapping of crowdsourced cadastral data

Mapping is simply the act or process of making maps. Mapping applies to any set: a collection of objects, such as all whole numbers, all the points on a line, or any other in a circle. This is the geometric description of cadastral land units. The basic requirement of cadastral mapping is to provide a sufficient specification of the location of a land unit (or object). An index (i.e. a spatial framework) that is based on the earth's surface is necessary for this purpose. Aerial photographs provide suitable indices for cadastral mapping in many countries because land units can be identified by reference to terrestrial feature's using simple photo interpretation methods. Land object definitions without any reference to the earth's surface can use other means to meet the demands of providing evidence of the location of land objects. Any sort of geo-reference that is recognized by a community will meet the demands of specifying a land object.

2.3.1 Types of maps

    i.   Cadastral maps

A cadastral map is a map which provides detailed information about real property within a specific area. Example, it might be a map of a village which shows the boundaries of all of the parcels and sometimes the available features. Cadastral maps are produced by joining together individual cadastral plans. A cadastral map is a general land administrative tool which has no real legislative basis. It is often created on the demand and therefore not necessarily up-to-date. These maps are maintained by the government and they are a matter of public record for anyone who seeks and wants to see them (Kain, 1992).

ii.   Thematic maps

These are the types pf maps that portray the geographic pattern of a particular subject matter (theme) in a geographic area. This usually involves the use of map symbols to visualize selected properties of geographic features that are not naturally visible, such as temperature, language, or population. these are types of maps which portray the geographical pattern of a particular subject matter in a geographical area. In this, they contrast with general reference maps, which focus on the location (more than the properties) of a diverse set of physical features, such as rivers, roads, and buildings. Alternative names have been suggested for this class, such as special subject or special-purpose maps, statistical maps, or distribution maps, but these have generally fallen out of common usage (Petchenik, 1979).

iii.   Topographic maps

These are the types of maps characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation), but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map (Kent, 2009).

iv.   General reference maps

These are simple maps showing important physical features in an area. Their main purpose is to summarize the landscape to aid discovery of locations. They are usually easy to read and understand. Most of the early mapping of the earth falls into this group.

CHAPTER THREE

METHODOLOGY

This chapter discusses research methodology by outlining the research design, study area, study population, sample size, sampling strategy, data type and source, data gathering methods, data analysis, and data presentation. The reason for selecting this type of design was due to the fact that it allows studying different groups of respondents at one point of time. Under this study, in view of theoretical and empirical literature. Then, it describes model specification; definition and measurement of the variables that model used; describes the estimations techniques; states hypotheses of the study; explains the data sources; lastly presents the data analysis and method employed by the study.

3.1 Study Area

Kunduchi is an administrative ward in the Kinondoni district of the Dar es Salaam Region of Tanzania, which is the most populated district in the country with an estimation of 1,775,049 inhabitants. According to the 2012 census, the ward has a total population of 75,016. Kunduchi, near its long beach, has a number of hotels including Kunduchi Beach Hotel, Wet' n Wild, Ununio beach with active night life. Local people depend on sea fishing.

As many other areas, Kunduchi is one among the wards where regularization and formalization has never been conducted making the local citizens there not aware of the adjudication process and some areas not planned or given first hand registration systems. Consider figure and table 3.1 below showing the study area and its description used in this research.
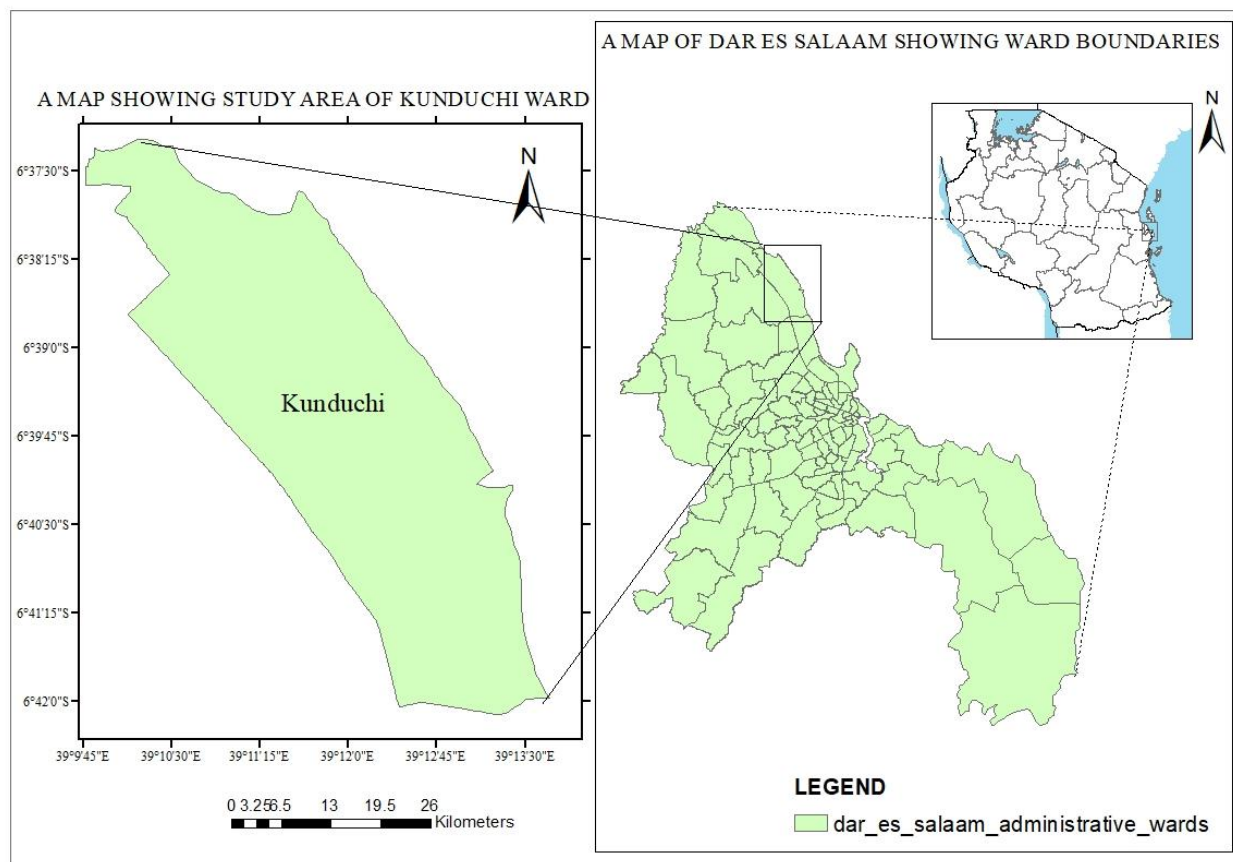
Figure 3. 1 Map showing the study area

Table 3. 1 Description of The Study Area

COUNTRY	TANZANIA
REGION	DAR ES SALAAM
DISTRICT	KINONDONI
POPULATION	75,016 (2012 CENSUS)
COORDINATES	6º40'S 39º13'E
TIME ZONE	UTC+3(EAT)
AREA CODE	022

Source: Field work 2023

Authors illustration

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3.2 Research design.

According to studies a research design is specification of methods and procedures for acquiring information needed. It is the over-all operational pattern or framework of the project that stipulates information to be collected from source and procedures (ibid). Research design is important because it prepares proper framework within which the research work was actually carried out. Research design acts as a blue print for the conduct of the whole research project. It introduces efficiency in investigation and generates confidence in the final outcome of the study (Rwegeshora & Rwegeshora, 2006). Research design gives proper direction and time-table to research activity, it keeps adequate check on the research work and ensures its completion within certain time limit and keeps the whole research project on the right track. The study adapted a cross sectional research design. Cross sectional research design is conducted where subjects are assessed at a single time in their lives (Babbie, 1990). Cross-sectional is fast and can study a large number of patients at little cost or effort. It adds that, cross sectional is useful where there are resource constraints like labor, personnel, time, fund and transport as it is the case in the study. Thus, the study used this kind of design, because it is mostly used for research, which based for academic purposes. Based on the above explanation the study used both qualitative and quantitative approaches.

3.3 Sampling Design and Sample Size.

3.3.1 Sampling Design.

Sampling is a process of selecting population to be studied in order to make inference about the whole population. The sample therefore gathered data that is representative of all adults' residents living on the surveyed area, not just focusing on the household head or the knowledgeable individual. This is critical given that tenure security may vary within the household and that the goal is to look at the views of most residents. Throughout the survey, individuals aged 18 years and above are referred to as adults. This is the age where most Tanzanians start their own living and allowed to make their own decisions and own possessions including land and other dwellings.

    I.   Simple random sampling.

This method is considered the most effective method of sampling than any other method. In this method, representatives of different groups are studied and included in the orbit of study Simple random sampling method was used in the selection of residents for household survey. Most resident within the selected area of Kunduchi ward was qualified to be questioned.

II.   Purposive sampling.

In this kind of sampling a researcher chooses a person basing on some characteristics of his or her interest or judgements. Kunduchi ward in Kinondoni municipal was selected purposely as it is one of the wards on which residents are migrating to, with a consideration that it is in one of the most populated municipals in Tanzania.

3.3.2 Sample Size

A sample is a subset of a population used to represent the entire group of a whole population (Barlett, 2001). The sample size is defined as the number of observations used for determining the estimations of a given population, the measure of the number of individual samples used in an experiment. Described sample size as one of the important features in any empirical research with an aim of making inferences about a population from the samples. Thus, the sample size was calculated from household at kunduchi ward, these exact households were considered as the population size on which the sample size should be computed. The sample size is an important feature of any empirical study which the goal is to make inferences about a population. Thus, the sample size which was 100 was calculated from house hold in Kunduchi ward, these households was considered as the population size in which the sample size should be computed from Streets in Kunduchi. The reason of involving different types people in this study was ensure more data were collected in looking the contributions of cadastral surveys (maps) for human settlement development in Kunduchi at Kinondoni Municipal Council.

3.4 Data Collection Methods.

Data is a collection of facts, such as values or measurements. Data can be both qualitative or quantitative. Qualitative data is a descriptive information while qualitative data represents numerical information. These are methods that play part in helping with collection of some facts about the research and also indicating the types of techniques and tools that will be used to collection of data.

3.4.1 Primary Data Collection

This type of data collection involves obtaining of data from primary data source (Rwegeshora, 2006). Primary data sources are original sources which a researcher directly collects from the field and that have not been previously collected before. This kind of data are the ones collected for the first time. In this research, the main methods will be questionnaires and survey method which will be used to collect data.

- Household survey

Household surveys are questionnaires that are given to a sample of households in a population. Their primary advantage is to provide considerable discretion to the interviewer about the information requested of respondents. Their major drawbacks are that information provided by respondents is often inaccurate (response error), and, in many cases, the information requested is not provided at all (nonresponse problem). Another problem is that because household wealth is extremely skewed, the very rich (the so-called upper tail of the distribution) are often considerably underrepresented in random samples.

3.4.2 Secondary Data Collection.

Secondary data refers to data that is collected by someone other than the primary user. Secondary data analysis can save time that would otherwise be spent collecting data and, particularly in the case of quantitative data, can provide larger and higher-quality databases that would be unfeasible for any individual researcher to collect on their own (Babbie, 1990). Thus, a researcher has done data collection from previous reports and dissertation. Secondary data sources include reports, articles, censuses, dissertations and other existing documents. Secondary data help to prove what obtained in primary data so that it can increase accuracy of the study.

- Literature review

This is one of the secondary data collection method that this research is based on, and the information available rely on published and unpublished documents from books of related topics, journals, thesis from the government and non-government observation's related to the topic.

3.5 Data Collection Tools.

Data collection is a process of preparing and collecting data for the purpose of obtaining information to keep on record and get reality about a certain matter (Human, 1991). Sometimes it helps to make decisions about important issues. There are several data collection methods include experiments, observations, documentation, interview and questionnaire. This study adopted only used questionnaire data collection method.

3.5.1 Questionnaire.

The term "questionnaire" refers to an instrument for the collection of data, usually in written form, consisting open/closed questions and other enquiries requiring a response from subjects. This questionnaire method was aimed at residents who live at Kunduchi ward in Kinondoni municipal. Most of the respondents who were involved in the questionnaire method had ideas of tackling the

questions that were brought to them, simply because this method of data collection reduces bias. It included uniform question presentation and no middle-man bias.

The following are the types of questionnaires used in the collection of data.

    I.   Open-ended questions

This gives the respondents the ability to respond in their own words. It does not limit respondents on how to answer their questions and it might lead to the results obtained to be out of the subject required.

    II.   Close-ended or fixed alternative questions

This allows the respondents to choose one of the given alternatives. Closed ended questionnaire may include Dichotomous questions and Multiple Questions. This is the type of questionnaire which was used to collect data and get information from residents at Kunduchi ward. This type of questionnaire was preferred to be used simply because it lets respondent answer the questions within the required topic limit.

3.6 Reliability and Validity of Data

3.6.1 Reliability of data.

Reliability is a measure of degree to which a different researcher if applying the same procedure as a previous researcher in repeating and not replicating the same case the findings and conclusion will be consistent. Test-retest reliability is a measure of reliability obtained by administering the same test twice over a period of time to a group of individuals. The study was reliable because all groups of people were involved in the study mostly resident or ordinary people as well as local leaders of the selected ward and municipal. The aim or doing reliability check is to minimize errors and biases in a research. In order to achieve reliability, this research used the tactic of documenting the research procedures as among the tactics suggested by (Yin, 2009) to achieve reliability. The research demonstrated the procedures used in data collection methods. That is by using in-depth interviews and a voice recorder whereby all the interviews were recorded orally and also in writings (Rwegeshora & Rwegeshora, 2006).

3.6.2 Validity of data.

Validity refers to the degree to which a study accurately reflects or assesses the specific concept that the research is attempting to measure. Validity in research is important because it can help

determine what types of tests to use, and help to make sure researchers are using methods that are not only ethical, and cost-effective, but also a method that truly measures the 1dea or construct in question. However, this study was valid since the researcher adopted triangulation of data collection methods/tools. Triangulation is a powerful technique that facilitates validation of data through cross verification from more than two sources. In particular it refers to the application and combination of several research methodologies in the study of the same phenomenon (Babbie, 1990)**.** The purpose of triangulation in research is to increase the validity of the results.

3.7 Data Processing and Analysis.

Data processing refers to the collection and translation of a data set into valuable and usable information. It includes data collection, data input and the processing. The data in this research were collected in both qualitative and quantitative data. Qualitative data this described the quality and characteristics of the respondents, it included their educational status, age and gender. Quantitative data described variables such as for how long they lived in the area, sizes of their plots or land.

Analysis refers to the computation of certain measure along with searching for pattern of relationship that exists among data groups (Kothari, 1990). Data analysis as the process of testing the research question, applying statistical techniques to evaluate data.

Quantitative data were organized and sorted for analysis. Microsoft excel software was used for analysis, also after the data were presented in tables, pie charts and histograms.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents study findings and discussion. In this chapter both primary and secondary data collected during the fieldwork (Chapter 3) are discussed. Both qualitative and quantitative methods have been using statistical and spatial analysis methods. The chapter is based on the explanations of the result coming from the community on how crowdsourced cadastral data can be applied, play roles and be of great importance on various cadastral projects in Tanzania.

4.2 Socio demographic characteristics.

This are known as the characteristics of the respondents at Kunduchi ward, these involves spatial data directly from the field. The table 4.1 below shows the characteristics of the respondents.

Table 4. 1 Socio demographic characteristics.

No.	Variables	Ordinary People	
1	**Sex**	N	%
	Male	62	62
	Female	38	38
2	**Age Group**		
	18-25	13	13
	26-35	26	26
	36-45	29	29
	46-55	22	22
	56 and above	10	10
3	**Education Level**		
	No formal education	2	2
	Primary education	18	18
	Secondary education	33	33
	Post-secondary education	34	34
	Other forms	13	13

Source: Field work 2023

Authors illustration

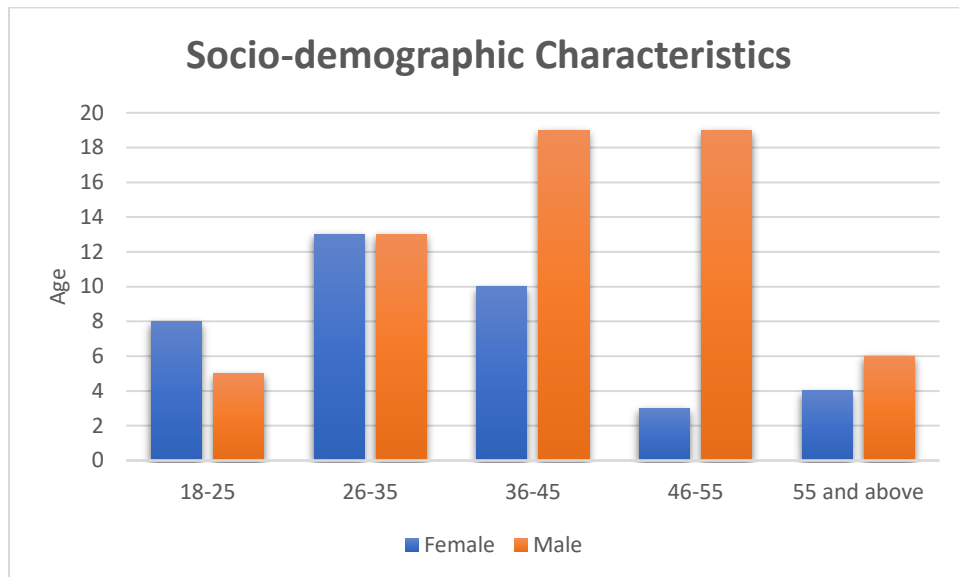Consider figure 4.1 showing socio demographic characteristics of Kunduchi residents.

Figure 4. 1 Socio demographic characteristics

The findings imply that 13% are aged between 18 and 25, 26% are aged between 26 to 35, 29% are aged between 36 to 45, 22% are aged between 46 to 55, and finally 10% are aged from 56 and above. These results imply most of the residents in Kunduchi are adults aged between 36 to 45. Figure 4.2 shows the educational status of Kunduchi residents
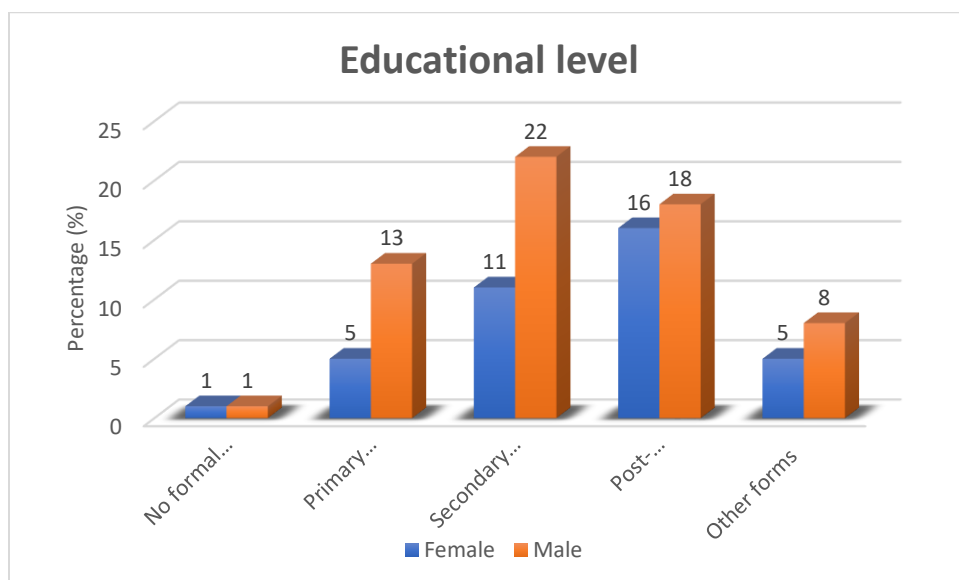

Figure 4. 2 Educational level of respondents

The response also shows that only 2% of the Kunduchi residents are illiterate therefore most of the residents have formal awareness, and thus this helped to simplify work of collecting data for the research.

4.3 Crowdsourced cadastral surveying knowledge in Kunduchi ward, Kinondoni municipal.

Examining the awareness on crowdsourced cadastral survey in both surveyed and unsurvey areas. Respondents were asked to express their knowledge on crowdsourcing cadastral survey. Whereas 100 residents were involved on the questioning. Figure 4.3 shows knowledge on crowdsourcing survey among Kunduchi residents.
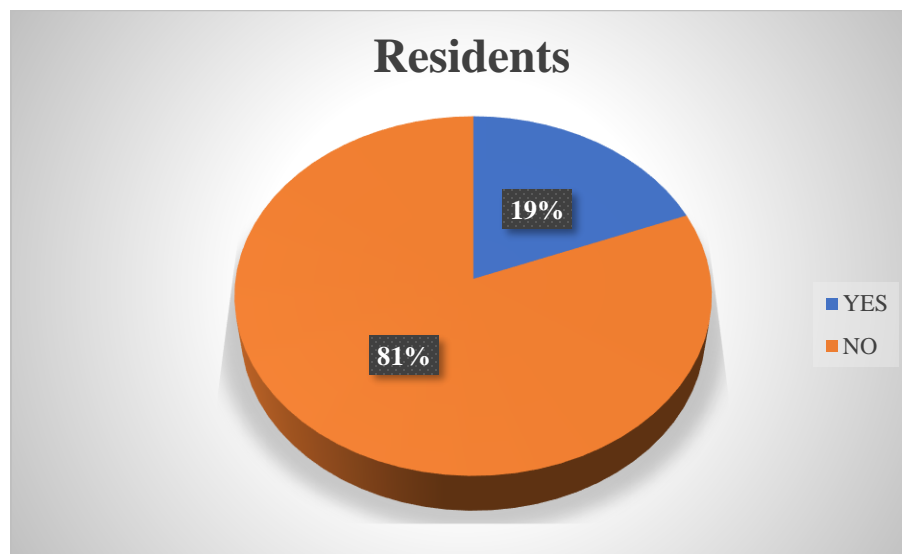

Figure 4. 3 Pie chart showing knowledge of residents on crowdsourced cadastral survey

The above results imply that our country Tanzania has not made enough efforts in educating residents especially the youth in cadastral survey matters. The 81% of the residents who had no idea with crowdsourced cadastral issues most them were of initial or middle educational level but the remaining percent of residents were form higher educational level. These findings prove that it will need the government to apply so much efforts if they need people to cope with the advancement of cadastral activities in this country.

4.4 The participation on crowdsourcing cadastral activity of residents at Kunduchi ward.

This study aims at finding out the number of residents who fully participated on crowdsourced survey project or activity and if they are well aware of its procedure to its completion. The respondent's answers were summarized in the figure 4.4.
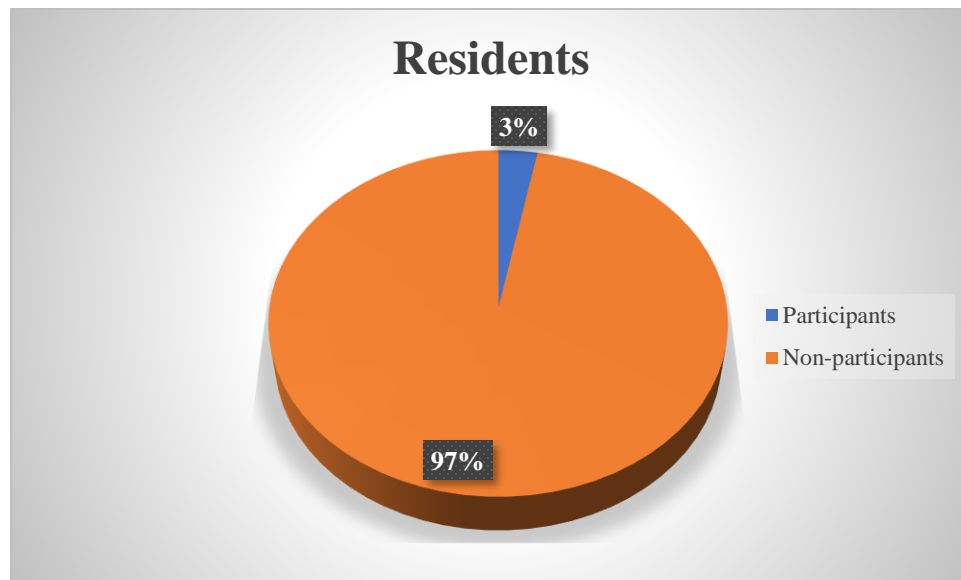

Figure 4. 4 Pie chart showing the participation on crowdsourced activity

The figure above show that only 3% of residents participated in a crowdsourced cadastral activity while 97% of them have never been in any crowdsourced cadastral activity, this means only 3 residents out of 100 have done so. The fact that only 3% of residents out of 100% have ever participated in any crowdsourced activity explains why there is no large land coverage measurement in Tanzania especially to the Kunduchi residents. If more people could have participated and involve much in crowdsourced activity land coverage issues could have been fastened.

4.5 The roles and importance of crowdsourced cadastral data to the residents of Kunduchi ward.

This study aims on the impact of crowdsourced cadastral survey; thus, the researcher asked the residents to give their views on why crowdsourced cadastral data should be involved on different cadastral projects. The following figure 4.5 shows the roles and importance of crowdsourced cadastral data to Kunduchi residents.
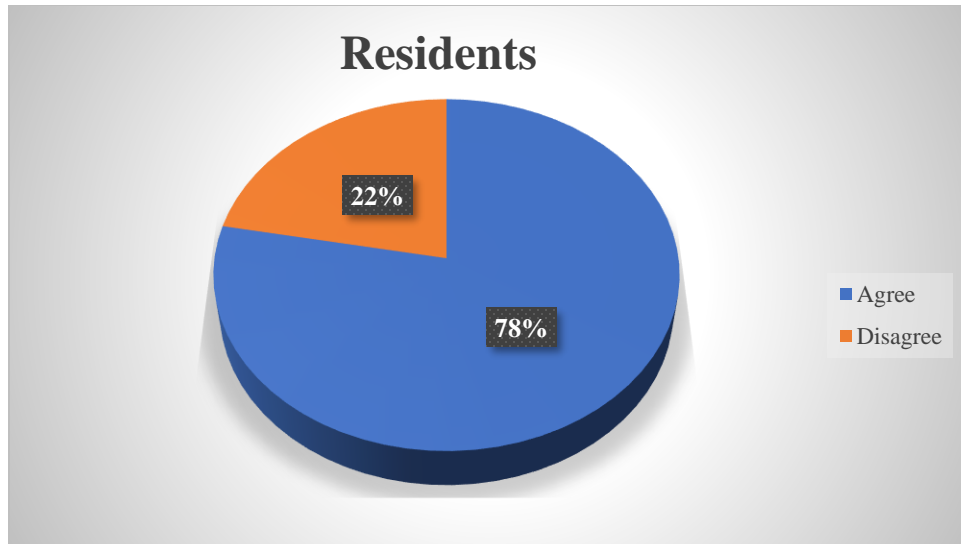
Figure 4. 5 Pie chart showing the roles and importance of crowdsourced cadastral data

The above results imply that 78% of Kunduchi residents agree that the use of crowdsourced cadastral data is important and its role is quite useful in completing different cadastral projects. The large percent of residents argue that the use of crowdsourced cadastral data can play part in Insuring of correct locating of points and parcels by non-professionals leading to removal, reduction of errors and also saving of time and cost by project professionals due to quick information's they can get in the internet uploaded by trusted local citizens, rather than going on field.

4.6 The applicability of crowdsourced cadastral data in Tanzania.

This study aims at analyzing the use of crowdsourcing in Tanzania, but first taking the consideration on the answers of residents at Kunduchi, whereas the results are shown in figure 4.6.
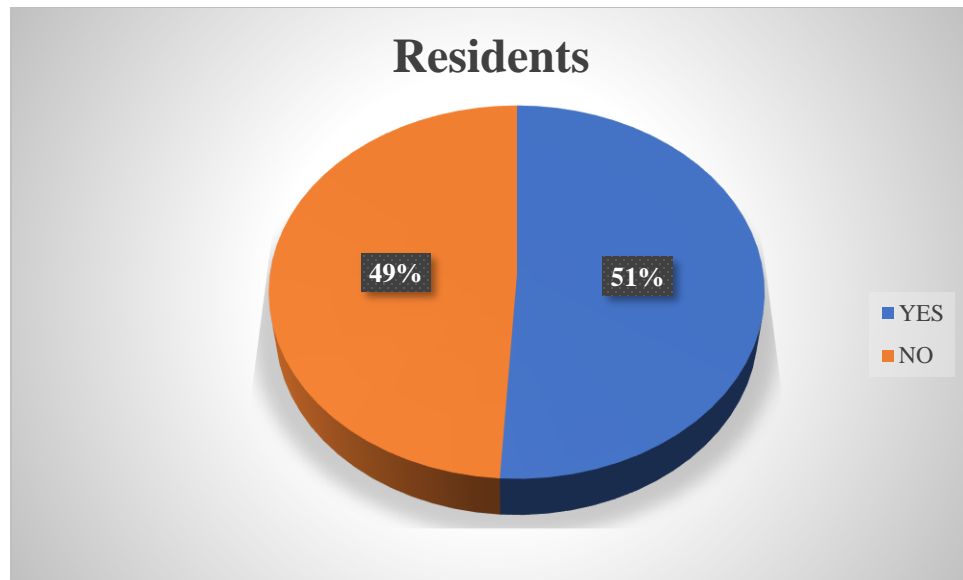
Figure 4. 6 Pie chart showing response on the use of crowdsourced method

The above figure show that 51% of Kunduchi residents think that crowdsourced cadastral data can be used in Tanzania while 49% of them deny its use and say it's impossible to be used in Tanzania. The small percent of the residents that denied the application of the above method argue that there are many factors that can lead to its fail, the main factor being the lack of knowledge on crowdsourced cadastral survey. However, this factor is not an issue to residents with post and high education level, to them poor science and technology comes first on the factors to let down the application of crowdsourced cadastral data. This shows the difference in views and understanding between the two groups of residents.

4.7 Major setbacks on the use of crowdsourced cadastral method.

Despite the fact that a large percent of residents agree that crowdsourced cadastral data can be applicable in Tanzania, they also had their say on the difficulty on the initializing on the method. Table 4.2 shows and illustrates the major setbacks that can hinder the use of the new crowdsourced methodology.

Table 4. 2 Major setbacks on the crowdsourced cadastral method

No.	Possible setbacks to its application	% response
1	Lack of knowledge about crowdsourced cadastral survey	47%
2	Insufficient funds	4%
3	Poor science and technology	17%
4	Unpleasant citizen participation	32%

Source: Field work 2023

Authors illustration

Lack of knowledge about crowdsourced cadastral survey came first as the major setback to the use of crowdsourced method, however, residents of Kunduchi came up with the solution to it arguing that this problem could be resolved if the government can or will increase their efforts in educational sectors like schools and other public services. The use of complicated software's such as AutoCAD can also be a burden to people. Also, implication of policies regarding land and its use and measurement could increase knowledge to its people.

Poor science and technology, most of the resident argued that people lack usable tools to the method such as smartphones, iPads, laptops and others even miss e-mail accounts therefore it will be hard for them to cope with the new method which involve the use of such electronic tools, this fact comes into play with the economic status of the country arguing that most people are not financially fit.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The aim of this research was to access the use of crowdsourced methodology in as many cadastral projects in can Tanzania which was based on the findings and discussions that answer the entire research questions of this research. After data collection and analysis of the findings it discovered that people still rely on the traditional way of accessing or measuring land for the purpose of first and systematic registration and this is simply because of the residents themselves not being ready to accept the use of this new method and also specifying that their lack of knowledge and understanding of such as method plays a big part as a barrier to its application in the country.

On exploring the roles and importance of crowdsourcing methodology the research adhere that the use of the new method is vulnerable in our country since by employing this method it can help participants to avoid possible errors in the declaration submission phase and to increase quality of the final product and also when his method is combined mapping drone and photogrammetry can control and ensure faster ways or serving the needs of land coverage. Also this new crowdsourced methodology has proved its importance to residents of Kunduchi by avoiding gross location errors and improve the efficiency of non-professionals in identifying the right parcel location on the base map, the proposed methodology introduces the compilation of an advanced base map enriched with more information such as road, settlement and river names, green areas, points of interest, urban blocks, road and river network, obvious land parcel boundaries, building footprints, etc. That will make the location process for non-professionals even easier. The crowdsourcing methodology proves itself important by ensuring urban and transit planning and by helping researchers with large data collection from populations and demographics they may not have access to locally.

On analyzing the usability of the crowdsourced method in cadastral projects, some skilled and educated personnel who are well aware of the new method argue that the method cannot be part of cadastral projects in Tanzania simply because there is poor science and technology in the country, so people miss the necessary tools that are needed to its completion, tools such as tablets, personal computers, smartphones and emails are being a problem to most people are processed by the few and mostly wealth people. However, Non-professionals involved in the proposed methodology are usually the right holders or local residents that know the area and the history of tenure. A large number of non-professionals is involved in the process but only for: (a) a specific

task and (b) a relatively short time of commitment. A team of trained volunteers may undertake this task. Such a task requires longer commitment and training of a small group of volunteers. This stage will satisfy an FFP approach. In addition, the proposed methodology suggests enriching the base map with all relevant pre-existing geospatial information derived from officially ratified projects. Also, during data collection and analysis, it was discovered that the government should make much emphasize of employing new and modern methods of executing cadastral survey in regularization and adjudication from the traditional on.

5.2 Recommendation

Based on the analysis of the research findings, this study gives out the following recommendations. The application of crowdsourced cadastral survey should employ the use of BIM data as input to 3D crowdsourced cadastral surveying. This new urban reality though, requires the establishment of modern 3D LAS to protect and secure property Rights, Restrictions and Responsibilities (RRRs) within the three-dimensional environment. In the meantime, many cities, regardless of the progress in establishing good land administration systems, are mapped in 3D at various levels of detail and have complex buildings designed, constructed and managed by Building Information Modeling (BIM). Linking cadastral information to the 3D digital representations of the man-made environment could be a promising approach in order to define, declare and visualize the complex 3D cadastral space units.

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APPENDICES

Appendix I – Questionnaire

QUESTIONS TO RESIDENTS AT KUNDUCHI, DAR ES SALAAM.

These questions are for academic purpose only and are meant to collect information on cadastral surveying in kunduchi residents.

(put a tick at your respective choice in each section)

A. Characteristics of respondents.

Age of the respondent………………

Gender

☐ Male

☐ Female

Educational status

☐ No formal education

☐ Primary education

☐ Secondary education

☐ Post-secondary education

☐ Other form

B. Cadastral and crowdsourcing surveying knowledge and understanding.

1. Are you familiar with cadastral survey?

☐ Yes

☐ No

2. Have you ever heard of crowdsourced cadastral survey?

☐ Yes

☐ No

3. With your point of view, do you find cadastral survey practices and land measurement of any importance in Tanzania?

☐ Yes

☐ No

4. Do you think crowdsourced cadastral data can be practiced in Tanzania?

☐ Yes

☐ No

5. With consideration of Tanzania, what can be the major setbacks to the application of crowdsourced methodology in its society.

☐ Lack of knowledge about crowdsourced cadastral survey

☐ Insufficient funds

☐ Poor science and technology

☐ Unpleasant citizen participation

6. Do you agree that the government of Tanzania make has made enough effort to ensure measuring of people's land and property for proper land registration?

☐ Strongly agree

☐ Agree

☐ Not sure

☐ Disagree

☐ Strongly disagree

7. In your opinion, should we employ the new crowdsourced methodology in Tanzania, or keep up with the traditional way of going to sites and locating land parcels.

   ☐ Yes, we should

   ☐ No, we should not

   ☐ I'm not sure

8. Since crowdsourcing is a participatory approach, do you think its use can be cost and time effective?

   ☐ Yes

   ☐ No

9. What should be done to make to ensure there is improvement of quality of crowdsourced cadastral surveying data and ensure its successful application in Tanzania?

   ☐ Educate and introduce crowdsourcing survey to citizens, schools and private sectors.

   ☐ Government should implement policies and emphasize the use of crowdsourced survey.

10. The information about crowdsourcing is obtained from the people this includes residential citizens, teenagers, adults and people with different educational level, do you think information obtained from crowdsourcing can be a better and reliable source of information for cadastral practice in Tanzania?

    ☐ Yes, crowdsourcing can be a reliable source.

    ☐ No, we cannot rely on crowdsourcing.