14-02-02

# Assessing the Use of Orthoimages for Rural Cadastral Surveying and Mapping: A Case of Benishangul-Gumuz, Ethiopia

Dilnesa, Fentahun

# BAHIR DAR UNIVERSITY

# INISTITUTE OF LAND ADMINISTRATION

**LAND ADMINISTRATION AND MANAGEMENT POSTGRADUATE PROGRAM**

**THE THESIS ON:**

**ASSESSING THE USE OF ORTHOIMAGES FOR RURAL CADASTRAL SURVEYING AND MAPPING IN BENISHANGUL-GUMUZ REGION, ETHIOPIA**

**BY: DILNESA FENTAHUN ALEM**

**ADVISOR: Dr. GEBEYEHU BELAY**

**OCTOBER, 2017**

**BAHIR DAR**

# ASSESSING THE USE OF ORTHOIMAGES FOR RURAL CADASTRAL SURVEYING AND MAPPING: A CASE OF BENISHANGUL-GUMUZ, ETHIOPIA

*By:*

*Dilnesa Fentahun Alem*

*Thesis submitted to Bahir Dar University, the Institution of Land Administration in partial fulfillment of the requirements for the degree of Master of Science in Land Administration and Management.*

*Advisor:*

*Dr. Gebeyehu Belay*

## STUDENT'S DECLARATION

This Thesis is my original work and has not been presented for a Degree in any other University.

Signature: ___________________ Date: __________________

Name: Dilnesa Fentahun Alem ID No. ………………………..

**Supervisors:**

This proposal has been submitted for review with our approval as University supervisors:

1. Signature: ___________________ Date: _____________________

Prof. /Dr _________________________________________________(Advisor)

Department _______________________________________________

BDU, Institute of land administration

2. Signature: ___________________ Date: ________________________

Prof. /Dr ___________________________________________________

Department __________________________________________________

BDU, Institute of land administration

**DISCLAIMER**

**This document describes work undertaken as part of a programme of study at the institution of land administration of the Bahir Dar University. All views and opinions expressed therein remains the sole responsibility of the author, and do not necessarily represents those of the institute.**

## ACKNOWLEDGEMENTS

This research would never have become visible without the contribution of many people to whom I have the pleasure of expressing my appreciation and gratitude.

First, I would like to express my sincere and deepest thankfulness to my advisor, Dr. Gebeyehu Belay for your unlimited support, critical comments, and continuous discussions were very invaluable and inspiring in the process of the proposal writing research task and thesis writing. Dr. Berhanu Kefale, your valuable advice, encouragement and commitment to the ideas of my MSc are greatly appreciated.

I am thankful to the experts of the Woreda. Without their acceptance and contribution to share their time, primary data collection would not have possible. I thank them very much for providing information and openly answering my questions. My appreciation extends to those farmers and Kebele land administration committees who were most helpful in the data collection.

To my family, to my mom and dad for your immeasurable love and support, to my brother Eyasu, and my sisters Rahel, Kidist, and Feven who were always supporting my decisions. Thank you very much. Hope each of you is proud of me.

Special thanks for my friends Yared, Kemal and Atenkut, my best friends. Thank you very much.

Sincerely,

Dilnesa

## ***DEDICATION***

*This thesis is dedicated to the reason of every achievement, every single try and second of my life.*

***......My family!***

*You are the reason of every breath and I hope to make you always proud. I adore and love you!*

*Yours Dilly*

***ABSTRACT***

*In the past two decades a huge effort has been given to the land administration sector and many goals have already been achieved through first-stage rural land registration and certification in Ethiopia. However, the first-stage certification had limitations with respect to the maintenance and updating of land registration records. Therefore, the government of Ethiopia is committed to undertake the systematic 2nd level certification of all rural land. From the several different methods of land surveying that have been tested the use of orthophotos/images has been found as the most suitable method for mass-scale 2nd level certification of rural land in Ethiopia. Ortho-rectified aerial photography or satellite imagery can be a useful tool in the demarcation and digitization of land boundaries. However, it is rarely sufficient in its own right regarding shadows from trees, houses and clouds which can make it difficult to see details and other surveying methods must be augmented. The principle objective of the study is to assess the use and applicability of orthoimages base procedures for parcel boundary surveying and mapping in order to achieving a maximum efficiency of parcel map production. The methodology is described in terms of per-fieldwork, fieldwork, and post-fieldwork considerations. One of the significant observations of the study is a suitable, flexible, and reliable technical procedure certainly significant. It was revealed that 72% of the respondents replied that the procedures to produce field maps were tedious and unsuitable. The comparisons shows that 39% from (0.01-0.09)ha and 46% from (0.10-0.25)ha. can be derived with a difference in terms of area respectively. Despite the fact that some tape and hand held GPS measurements and scaling on field maps has augmented due to the invisible boundaries in the field map and in the ground. From the above findings it's clear that that institutional strength needs an emphasis in terms of technical and operational efficiencies of rural cadastral mapping in order to achieve efficient parcel map production. Eventually, there needs to be a comprehensive handover and maintenance of cadastral dataset at Woreda, zonal and regional level.*



***Keywords:*** *Operational manual, Orthoimage, Field map, Land registration, Cadastral surveying and Cadastral mapping.*

# TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

## ACRONYMS

| | |
|---|---|
| BGRS | Benishangul-Gumuz Regional State |
| CSA | Central Statistics Authority |
| EFLAUB | Environment, Forest, Land Administration and Use Bureau |
| EFLAUO | Environment, Forest, Land Administration and Use Office |
| FDRE | Federal Democratic Republic of Ethiopia |
| KLAC | Kebele Land Administration Committee |
| LAS | Land Administration System |
| MoA | Ministry of Agriculture |
| REILA | Responsible and Innovative Land Administration |
| GIS | Geographic Information System |
| GPS | Global positioning system |
| HRSI | High resolution satellite imagery |

# 1. INTRODUCTION

## 1.1. Background

Ethiopia has implemented one of the largest, fastest and least expensive second level land registration and certification reforms in Africa (Deininger et al, 2008). While there is some variation in how land registration and certification has been implemented across, and even within, regions in Ethiopia, the broad-scale first-stage land registration and certification involved the registration and demarcation of land plots using simple local technologies that required little training. The main sources for determining plot boundaries are field markings, in conjunction with the memories of the neighbors whose farm plots border those owned by the households in question. Measuring tapes and ropes used to measure the farm plots (MOA, 2013a). However, the first-stage certification had limitations with respect to the maintenance and updating of land registration records. Ethiopia has begun piloting and introducing a second-stage land registration and certification in selected districts in the highland regions. The new registration and certification system involves registering the precise geographical locations and sizes of individual farm plots using technologies such as GPS, satellite imagery or orthography. Farmers receive plot and holding level certificates with maps rather than a household-level certificate. The aim is that the second-stage land registration and certification effort will enhance tenure security, the maintenance and updating of records, and land management (MOA, 2013a).

In this regard, the most important technical aspects to deal with where the way parcels identification and boundaries determination are practiced. In most cases, this involves cadastral surveying (with or without coordinates in a national geodetic network). The result can be in the form of a cadastral index map, but different methods do exist. In many cases, some use is made of topography (from existing topographic maps, aerial photography or satellite imagery) where features like hedges, fences, ditches or specially erected monuments used as boundary markers. The way this work has carried out in a country depends to some extent on the legislation that is in force, but it is also influenced greatly by the technology that is available at a given moment in time. Sometimes the official demands on the work could not be met using the technology available, but in other cases better and more efficient methods –made possible by new technology–are hindered by the (survey) regulations (Zevenbergen & Bennett, 2015).

Ortho-rectified aerial photography can be a useful tool in the demarcation and digitization of land boundaries. However, it is rarely sufficient in its own right and other survey and mapping methods needed to complete the task. According to the India planning commission land administration modernization report, recent micro-pilot study in Shadnagar Mandal of Andhra Pradesh trialed the use of orthophotos and compared it results achieved with electronic total stations. Comparisons between results showed that 33% of line measurements agreed within permissible limits; 52% revealed 2-3 meter differences and the remaining lines differed because of human errors (in fixing the boundaries in either the use of orthophotos and the total station). Most of this latter category could probably be reduce with improved training in both methods of measurement.

In Norway, the cadastre for rural areas based upon mapping from orthophotos, performed in a twenty-year period starting in 1960. The method was highly inaccurate, but many of these maps are still part of the cadastre covering rural Norway. These maps are now causing several property disputes (Mjøs & Sevatdal, 2011).

The Government of Ethiopia is committed to undertake the systematic 2$^{nd}$ level certification of all rural land. In the past two decades, a huge effort has been given to the land administration sector and many goals have already been achieved through 1st level land registration and certification. From the several different methods of land surveying that have been tested the use of orthophotos from aerial photographs and satellite images has been found as the most suitable method for mass-scale certification of rural land (REILA, 2016). The use of orthophotos for surveying land parcel boundaries has been applied in several countries, such as Rwanda, which was visited by Ethiopian land administration and surveying experts and decision makers. To test the suitability of the method in Ethiopia it has been successfully apply in five regions (Amhara, Tigray, SNNP, Oromia and Benishangul-Gumuz). Based on the practical experiences in the use of the method in Rwanda and in the imagery trials within Ethiopia the operations manual is developed for imagery-based systematic 2nd level rural land registration program in Ethiopia.

In Benishangul Gumuz Regional State a systematic 2nd level rural land registration and certification operations are being implemented by using 'Ortho-rectified' aerial photography and high-resolution satellite imagery as a map base**.** An operational manual has been developing by Responsible and Innovative Land Administration (REILA) project. It is used as the basis for rural cadastral procedure in Ethiopia.

The operational manual used as a guideline in the region, with regard to demarcation states that the demarcation of land would be based on, features visible both in the field map and in reality (REILA, 2016). In marking of boundaries, the landholders will use boundary markers commonly used in the adjudication areas including boundary tracks, footpaths, ditches, fences, trees, plants and stones. However, the current practice revealed that some parts of boundaries either are not visible on the field map, are newly demarcated (e.g. when boundaries are changed to allow for public access) or are obscured by overhead vegetation. In very rare situations, it might be impossible to demarcate a parcel corner even by using repeated measurement tapes, due to the absence of nearby objects that are visible in the image. This might be the case e.g. in densely forested areas. This obviously degrades the quality of both the land registration and the cadastral maps. Consequently, this study seeks to assess the technical competitions of using orthoimages for rural cadastral surveying and mapping. Therefore, this paper gives an overview of imagery based systematic 2nd level rural land registration and certification practices, and presents a synthesis of its achievements, problems and challenges encountered in its implementation and indicates the future direction and perspectives set by the government in establishing a sustainable, efficient and transparent land administration system in the country.

## 1.2. Statement of the problem

Internationally, Orthophotos is a well-recognized alternative method of determining rural land boundaries where there are existing physical boundaries and a method of 'general-boundaries'. However, they can also assist when there are some physical boundaries or identifiable features from which there is a known distance relationship to the boundary where there is a system of 'Fixed-boundaries'. In such cases, other forms of measurement must augment orthophotos.

The use of orthophotos from aerial photo or high-resolution satellite imagery does provide a level of detail that is appropriate for the demarcation and digitization of most rural cadastral boundaries. As for orthophotos, the use of high-res satellite imagery would need to augmented by other survey and mapping methods where boundaries are not clear on images (insufficient detail or detail obscured by overhanging vegetation or structures).

There are however several challenges concerning the use of satellite images. Especially, shadows from e.g. trees, houses and clouds which can make it difficult to see details in the image. If a large tree covers the border of a land parcel, it will be difficult to see the exact border corner. Corlazzoli & Fernandez (2004) found that the accuracy of a satellite image depends directly on the type and amount of vegetation cover in the study area, the size and shape of the property and the topography of the area.

Another challenge is that landscapes with complex terrain relief can influence the accuracy of the 'Ortho-rectification' of satellite images in a negative direction, while landscapes with less terrain relief are easier to handle this is due to terrain distortions of the uncorrected satellite image (Wang & Ellis, 2005). Another challenge concerning the use of satellite images for land registration is that legal boundaries cannot be determined without extensive reality of the ground. In situations where a parcel boundary has been surveyed directly from the satellite image in the office, a follow-up is needed to confirm with the holders and neighbors whether the boundaries are correct (Ahn & Song, 2011). However most areas of the region is covered by deep and vast forests and on meadow, wet, or grassland features. This land cover characteristics obviously contribute a negative impact on the orthophoto and satellite images. To this end: therefore, in Benishangul Gumuz Region by using aerial photos and satellite images as tools for rural land parcel boundary demarcation and digitization based on, ground surveying methods are undertaken over the last five years since July, 2013 up to now for eighteen kebeles of the region. Now, however, there has been no study to assess rehearses of using orthoimages for parcel boundary surveying and mapping. The study will contribute to fill this gap by evaluating the exercise in eighteen kebeles of the region.

## 1.3. Objectives

### 1.3.1. General objective

The overall objective of the study is to assess the usage of imagery based rural cadastral surveying and mapping in order to achieving a maximum efficiency for parcel map production.

### 1.3.2. Specific objectives

The study is designed to address the following specific objectives:

- To investigate the procedure for demarcation, geo-referencing and digitizing processes of rural land parcel boundaries using orthoimages.
- To examine the appropriate scale of field maps.
- To apply and explain the application and usages of orthoimages in combination with different ground survey methods when boundary features are not visible.
- To analyze the efficiency of parcel map production.

## 1.4. Research questions

At this stage, the major research question is focuses on the application and usage of orthoimages for rural land boundary demarcation and its combination with ground survey methods and also the efficiency of parcel mapping.

1. Is the procedure developed to produce parcel maps using orthophotos suitable?
2. What is the appropriate scale for the field map production? Moreover, how should the scale be determined?
3. What types of ground survey measurement methods applied in the absence of nearby objects visible in the image due to deep forest and grasslands without features?
4. What are the potential improvements for effective parcel mapping for imagery based approach?

## 1.5. Significance of the study

Recently, imagery based rural second level registration has selected as the main cadastral mapping method in Benishangul-Gumuz region. Therefore, this study assessed the using of satellite imagery 'Orthophotos' for rural cadastral surveying and mapping implementation in order to achieve effective parcel map production and sustainable land administration system in the study area. By doing so, the research results would contribute as a reference literature in the field of study, and can be also important for policy and decision maker if the need arises to take any relevant mitigation measures.

## 1.6. Scope and limitation of the study

The study was conducted at Komishiga-26 Kebele, Assosa Woreda, Benishangul-Gumuz Regional State, Ethiopia. The rationale on selection of the study area is the proximity to Assosa city and the imagery-based land registration was undertaking when the research was conducted. In addition to this the selected kebeles do have better access to infrastructure that may ease the field work. In this study there are limitations on investigating orthoimages with regard to cost, accuracy and time aspects of rural land registration and certification in required depth because of the lack of budget, time and other resources.

## 1.7. Thesis structure

The provisional thesis structure consists of:

**Chapter 1:** Introduction-articulates the background of the study and justifications of the problems, including the research problem, research objectives, research questions, and limitation of the study.

**Chapter 2:** Literature review-is a chapter where we refer to other works related to the main concepts of research.

**Chapter 3:** Research methods-explain in detail, the profile of the study area, the methods are used for data collection, data gathering and data analysis.

**Chapter 4:** Result and discussion-give firstly information about the participators and then articulates their opinion about the procedures and evaluate the professional opinions based on the required elements. Moreover, a comparison of data is done regarding both methods. In the end, discussion of the thesis

**Chapter 5:** Conclusion and recommendations-covers for objectives and in the end lessons learned and future recommendation.

# 2. LITERATURE REVIEWS

## 2.1. Concepts of land administration

Land administration is a term used regularly in close relation to land registration and cadaster (Twaroch & Muggenhuber, 1997). It is quite a wide term which encompasses land registration, cadaster and more. It could be defined as follows: *"Land administration is the operational component of land tenure; land administration provides the mechanisms for allocating and enforcing rights and restrictions concerning land. Land administrative functions include regulating land development and use, gathering revenue from the land (through sale, leasing, and taxation), controlling land transactions, and providing information about the land. These functions are accomplished, in part, through the development of specific systems responsible for boundary delimitation and spatial organization of settlements, land registration, land valuation, and information management activities"* (McLaughlin & Nichols, 1989: 77-86).

Land administration can also be described as "the process whereby land and information about land may be efficiently managed". It includes the provision of "information identifying those people who have interests in real estate; information about those interests e.g. nature and duration of rights, restrictions and responsibilities; information about the parcel, e.g. location, size, improvements, value" (MOLA, 1996).

Land administration system contains, on one hand, the database containing spatially referenced land data, and on the other hand the procedures and techniques for systematic collection, updating, processing, and distribution of the data to the end users in an efficient manner. The elements of technical perspective play important roles in different processes of LAS including system development, data management (capture, maintenance, access), and process designing. All these elements are most important to improve the efficiency of LAS by considering the pace of changing technology and social needs of a society

The quality of cadastral data largely depends on processes (both legal and technical) or methodologies and standards used for acquiring, structuring, and updating changes of ownership data and spatial division of property units. While establishing land information systems (LIS), cadastral datasets are normally digitized using the available cadastral maps and land registers where the cadastral maps show spatial data set such as shape, size, boundary, and location of land parcels on the ground while the non-spatial data set including; ownership, rights, area, and other relevant information are maintained in the land registers.

The theoretical and practical developments in technologies such as different remote sensing satellite images and geographical information systems (GIS) including database management concepts can improve the quality, cost effectiveness, performance and maintainability of LASs (Aleksic et al., 2005). The adoption of these technologies provides enormous opportunities to share land related information in a more easy way than the old fashioned technologies/methods in which the information is managed and shared through manual records and procedures

## 2.2. Basics of cadaster and land registration

Land registration can be described as "the process of recording legally recognized interests (ownership and/or use) in land" (McLaughlin & Nichols, 1989: 81). The term 'registration' refers to an active process, whereby the result should be called a 'register' and an organization doing this a 'registry'. Land registration usually refers to a predominantly legal registration, where one can see who (supposedly) owns some real property. It usually contains all relevant legal documents regarding real property. The term is more or less used exclusively in the Anglo-Saxon world, although the Middle European 'Grundbuch' refers to virtually the same concept.

In some cases land registration is exclusively used for 'registration of title' A closely related topic can be found in cadasters, which in a similar way could be described as "an official record of information about land parcels, including details of their bounds, tenure, use, and value" (McLaughlin & Nichols, 1989: 81-82). It usually refers to a predominantly technical registration, which contains information on where a property lies, what its boundaries are and how large it is. The use of the term cadaster has been mainly found in continental

Europe, where it has shifting meanings. In much of the Anglo-Saxon world the term was virtually unused, although the term cadastral surveys have been in use for the surveying of property boundaries. The term is being promoted at the international level by the FIG in 'The FIG Statement on the Cadaster', which contains the following description:

*"A Cadaster is normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyance), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection"* (FIG, 1995).

The different applications of the cadaster given in the last sentence are also referred to as the fiscal, juridical (or legal) and multi-purpose cadaster (e.g. Dale & McLaughlin, 1988: 13, McLaughlin & Nichols 1989: 82). The term 'multi-purpose cadaster' means about the same as the term 'land information system' (LIS). A juridical cadaster, which serves as a legally recognized record of land tenure, is closely related to land registration.

A cadaster usually consists of two parts; a geographic part ('map' or 'plan') and a descriptive part ('register' or 'indexes'). The relation between the two is of the utmost importance, and usually arranged through a so-called 'parcel identifier'. All of this will be discussed later in this report it is often mentioned that the roots of cadasters have to be found with the taxation of real properties (e.g. Larsson, 1991: 21, & Simpson 1976: 111). Without wanting to dismiss the numerous (small scale) activities that had already taken place before, the major development in introducing cadasters (with maps) took place in the early 19th century. In 1807 Napoleon I, Emperor of France, instituted the cadaster in France and all the areas which at that time were under his rule (most of the South and West of continental Europe).

In 1817 Francis I, Emperor of Austria, introduced a much improved cadaster for the whole Austrian-Hungarian Empire, which at that time covered most of Central Europe.

This use of cadastral identification in land registration has been both used to enhance deeds registration and to facilitate the change from a deed to a title registration system (Larsson, 1991: 25-26). On the other hand the cadaster can be kept much more up-to-date when the information on land transactions through land registration is made readily available; therefore, it is essential to consider land registration and cadaster together. They should at least cooperate and work closely together, something which is unfortunately not the case in many countries. Experts expressed that "there is a strong need to integrate and rationalize land title registry and cadastral systems" (UN, 1996a: 28). but very often historically grown situations and the vested power structures based on those prevent the merger of the two organizations involved; Land registration and cadaster make up an important part of 'land administration'. Land administration can be described as "the process whereby land and information about land are efficiently managed," (MOLA, 1996). Land administration deals with the ownership, use and value of land.

With regard to land registration cadastral and non-cadastral countries can be distinguished, which have had clear differences in the history and development of land registration. Nevertheless it was attempted to come to clear definitions in the Commission 7 Opening Address at the 1990 FIG Congress by Henssen and Williamson. They gave the following definitions, which can be better understood in relation to the figure.

'Land registration' is a process of official recording of rights in land through deeds or title (on properties). It means that there is an official record (the land register) of rights on land or of deeds concerning changes in the legal situation of defined units of land. It gives an answer to the question **"who"** and **"how".**

'Cadaster' is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. Such properties are systematically identified by means of some separate designation. The outlines or boundaries of the property and the parcel identifier are normally shown on large scale maps which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel. It gives an answer to the questions **"where"** and **"how much".** Therefore, the definition of 'cadaster' has adopted in this research because cadaster used to operate together all the registration of legal rights associated with the parcel.

**Figure 2.1: Historical evolution of land registration**

### 2.2.1. Cadastral maps and registers

A cadaster consists of cadastral maps and cadastral registers. The cadastral map is an essential component of a cadaster. It is a legal and spatial document showing positions of boundaries of cadastral parcel. Cadastral maps are maintained by authorized cadastral (geodetic) engineers; the cadastral map includes (1) parcel (and property) boundaries, (2) easements, and (3) a unique parcel identifier. It may also include buildings and other boundaries that delimit administrative areas (e.g. Cadastral zones, governmental, planning and postal districts), land use zones (e.g. forest, agriculture), and utility networks (e.g. roads, railway lines), as well as textual descriptions, such as street names, building numbers etc. (Williamson, 1996).

The second component, cadastral register include non-spatial or attribute information regarding the cadastral parcels, such as address records, surface area, land use, official value, taxpayer and/or right holders.

### 2.2.2. Cadastral parcel

The cadastral parcel is the basic unit of a cadaster. In some countries, cadastral unit also includes sub-parcels which are division of cadastral parcel based on official land use or value for taxation purposes (e.g., France, Hungary) INSPIRE fig. 2.1, (Dale & McLaughlin, 1999). The cadastral parcel is regarded as a closed polygon on the surface of the Earth in unique ownership and with homogeneous real property rights. In reality, of course, a parcel extends both upwards and downwards, being a volume rather than an area.

**Figure 2.2: Cadastral parcel and property right**

### 2.2.3. Cadastral boundary

The international Federation of Surveyors described a cadaster as “a parcel based and up-to-date land information system containing a record of interests in land” –where a parcel, according to Dale & McLaughlin (1988) is “a continuous area or volume of land within which unique, homogenous interests are recognized”. Varieties of cadasters can be identified, usually based on their purpose. The variety of cadaster determines the type of land tenures represented in a cadaster.

Establishment of a cadaster system constitutes adjudication, demarcation, surveying and recording as its operational components (Henssen, 2010). Parcel boundaries could be natural or artificial, and can be represented either by visible features on the ground, or by lines on a map, or by coordinate (FIG, 1995). Zevenbergen (2009) described a boundary as a discontinuity line on which the right of one party begins and the other ends. According to Dale & Mclaughlin (1988) linear features like fences and hedges served as parcel boundaries in rural areas. They allow the use of cheaper photogrammetric approaches of survey: parcel boundaries are visible from the air. Such visible boundaries are appropriate for many purposes in land management and land information system (Zevenbergen & Bennett, 2015).

Unlike fixed boundaries, the emphasis of general boundary approaches mainly lays on the right of individuals rather than the special accuracy of the boundary: The accuracy can actually be modified in future depending on the purposes, but still need to be recognized legally in cadastre (Bennett et al., 2010). On the issue of using natural boundaries for land administration, according to Yesmaw (2016) identified perception (who perceived its existence?), purpose (what is its purpose?), presence (what is its nature on the ground?), point in time (when does it exist?) and presentation (how is it represented graphically and textually?) as elements to use natural boundaries. It is also stated that the presentation element needs definition of datum, scale, data type, and divide type for better data integration. In line with vein, Navratil (2011) the accuracy which must be applied depends on the purpose, the cost and time of realization of a project or a product. To strengthen this idea, Bogaerts & Zevenbergen (2001) noted that as fixed boundaries are costly, introducing general boundaries for the establishing of cadastral system is worthwhile. Particularly, for most rural and semi-urban areas in countries of sub-Saharan Africa, Enemark et al., (2014) suggested general boundary approach. A cadastral parcel is uniquely defined by its boundaries. A boundary could either be the physical objects or an imaginary line marking the division between two cadastral parcels (FIG & UN, 1999).

#### 2.2.3.1. Fixed boundaries

The legal boundary points agreed by the all parties are marked with marks, and precisely surveyed. Their locations are represented through coordinates connected to national or local geodetic frames. Any lost boundary points can be recovered from original measurements. Fixed boundaries refer to legal boundaries drawn on cadastral maps. E.g. wooden pegs, iron bars, or concrete marks (point features).

#### 2.2.3.2. General boundaries

The legal boundary points are remained undefined. Natural or man-made visible features are used for identification approximate location of legal boundaries. E.g. fences or hedges (linear features) wall, ditch, and edge of wadi. An important disadvantage of general boundaries is that it does not supply the parties with the level of confidence to the precise spatial extent of their properties that more specifically, in French the process is called *constatation* defined boundaries do (Dale & Mclaughlin, 1988: 31). Furthermore the terrain and the land use patterns have to be such that they allow for general boundaries. The average English countryside with walls and hedges or the Dutch polders with many ditches are well tuned towards use of such a system. This is different for areas where most boundaries are invisible lines, ill-defined on the ground or crop-lines and other non-permanent features, as reported with respect to Cyprus. This led an official from the Cyprus Department of Lands and Surveys to say “that the nature of boundaries in Cyprus does not permit the system of ‘General boundaries’ to operate” (Roussos, 1993: 106).

## 2.3. Methods of cadastral surveying and mapping

Land registration for land management purposes requires cadastral surveying and mapping. Cadastral surveying and mapping includes the procedures to demarcate and identify boundaries of parcels allocated to different users with some kind of right, for instance the right to use the parcel for a specified purpose. The boundaries are surveyed in the field and described on the map. A cadaster itself is a description of systematically organized land parcels in an area describing individual land parcels/ properties. This description is made through maps and land registers where the maps show shape, size, and location of the land parcels on ground while the ownership, rights, area, and other information is maintained in the land registers. A substantial amount of the land administration activity is of a technical nature (UN-ECE, 2005).

According to Dale et al., (1988) three sets of complimentary techniques of cadastral surveying are common: field/ground surveying, photogrammetry, and remote sensing; all of which are concerned with the discovery, recording, and presentation of spatially referenced data: Generally, cadastral surveying techniques can be divided in to direct and indirect techniques. In case of direct technique, the relative position of points is located first on the ground, and the distance and angles are then measured using surveying instruments. Coordinates of location and areas for each land parcels are computed using mathematical formulae. On the other hand, in case of indirect technique, the surveyors use aerial photographs or satellite images to delineate parcel boundaries and the polygons are then digitized in a second step (Corlazzoli & Fernandez, 2004).

## 2.4. An integrated approach for cadastral mapping

The existing cadastral surveying techniques as discussed in the above section are based on independent theories and practices on surveying, photogrammetry and remote sensing. Since all these theories are developed and implemented in an independent manner, they are not able to acquire data efficiently at the required level of accuracy with low cost specifically for the cadastral purposes (Konecny, 2002). There is a need to integrate these different techniques for acquiring cadastral information to update the existing cadastral data and (re)produce cadastral maps in an efficient manner.

An integrated approach seeks to collect cadastral data and survey cadastral boundaries in an efficient manner as compared to these different techniques. This also helps to update the existing old cadastral maps and produce new data as per users' needs. The integration of these techniques depends upon the purpose of cadastral surveying i.e. whether it is carried out for the first time registration or for the maintenance of existing cadastral boundaries.

According to Larsson (1991) demarcation is a question that includes both legal and technical aspects. In general, the type of procedure and the existing boundary system are of great importance in selecting a system of demarcation. Unfortunately, however, selection of both survey and demarcation methods is often based on technical perfection instead of more important factors, such as available resources, the need to rapidly implement the title registration system, and the degree to which most boundaries are visible on the ground.

Larsson defines two different procedures for demarcation. The first method entails fixing precise boundary positions on the ground in the presence of the parties. ''If a boundary dispute arises, the boundary is determined by an officer or a court, but includes a right of appeal''. After the positions of the boundaries are fixed, they are permanently marked. This method is generally, but not necessarily, combined with accurate ground surveying or large-scale aerial surveying with pre-marking. In the second method, the boundaries are determined based on ground features that are noted either from aerial photos or ground surveys. These boundaries are not fixed legally, nor are they physically marked unless the parties insist.

The second method is much cheaper and faster in most cases. Often, adjoining landowners will agree on the size and shape of their parcel of property, but are unable to agree on the actual boundary. The first method may invite lengthy and unnecessary disputes. The method chosen should depend on the accuracy demanded or desired by landowners. Owners of large, inexpensive, rural plots are less likely to be concerned about accuracy or physical demarcation than owners of small, high-value, urban plots.

Several other intermediate methods of demarcation exist. It is the practice of some countries to determine, but not to permanently demarcate, boundaries with the landowners present. Instead, physical features such as low ridges, footpaths, and field limits are accepted as sufficient demarcation.

The main purpose of land registration surveying is to record, with some accuracy, the location of parcel boundaries so that disputed or uncertain boundaries can be redefined. Such surveys, however, also provide other benefits, including providing a basis for producing maps that assist in land administration (Dale & McLaughlin, 1999). Survey methods range from very simple and less expensive to very complex, detailed, and expensive. The choice among surveying and mapping methods generally involves balancing costs and accuracy. As mentioned above, this choice is too often driven by what is technically possible, rather than what is economical and necessary to provide the desired benefits. Considering the degree of accuracy required for land title registration, Larsson states: "It must be admitted that most of the benefits of cadastre/ land-registration systems can be achieved even with rather low mapping standards. Even simple large-scale maps make possible the identification of the plot on the ground and thus secure the connection to the land". In fact, excessive precision can have a detrimental effect by creating dispute and conflict where none previously existed and resulting in extra costs and delays.

In recent decades, the use of photogrammetric surveys and other types of aerial pictures has increased the number and types of survey methods available. Several factors must be considered when deciding whether to use aerial pictures. First, making a survey with the help of aerial pictures is typically economical only when fairly large areas can be treated at the same time; that is, when a cadastral survey is done systematically area by area. Second, the usefulness of aerial pictures depends on topography, cover of vegetation, and the types of boundaries (Larsson, 1991). Hilly areas require more sophisticated and expensive photogrammetric methods that eliminate errors due to altitude differences. Heavy vegetation cover renders certain boundaries invisible, making it necessary to at least supplement the aerial photography with a ground survey (Dale & McLaughlin, 1999). If the boundaries are not visible from the air, pre-marking or a ground survey must be used. In general, the use of aerial pictures is most advantageous in open country with small, irregular fields having physical boundaries. Much of the agricultural land in Asia, in particular, fits these conditions and as such, aerial pictures are a feasible option for much of the cadastral surveying. Aerial pictures are also likely to be feasible in rural areas with large, regular fields having physical boundaries. Third, the cost of aerial survey relative to ground survey depends on the wages paid. If wages are low, as they are even for technical specialists in most developing countries, ground surveys may be cost-competitive (Dale & McLaughlin, 1999).

In sum, because balancing the advantages of greater accuracy against higher costs and available resources is a matter of judgment, a flexible attitude is necessary in less-developed countries like Ethiopia. The required accuracy should never be determined primarily by standards used in more developed countries or by a desire for technical perfection.

## 2.5. Rural cadastral situation in Ethiopia

The FDRE Rural Land Administration and Use Proclamation, No. 456/2005section II 6(2), states that:

*"Rural land holdings ... shall be measured by the competent authority and shall be given cadastral maps showing their boundaries".*

During the past decades, Ethiopia has made impressive progress in registering rural land rights at low cost, mostly without surveying and mapping the boundaries only by issuing land holding certificates "Green Books" which is called 1st level registration. This is now being enhanced by a '2nd level' registration process to survey and map the land parcel boundaries. During the past five years, the REILA project has implemented trials in five Ethiopian Regions (see map on the next page), which have mapped land parcel boundaries using orthophotos based on aerial photographs (Oromiya and SNNP Regions) or satellite images (Amhara, Tigray and Benishangul-Gumuz Regions). These trials have shown that the surveying and mapping methodology is effective, low cost and sustainable. The work is now being scaled-up on a countrywide basis, by REILA and other donors such as DfID (UK) (Shewakena & David, 2015).

In Benishangul-Gumuz Region, land registration is still in its early stages; an estimated 1,000,000 rural land parcels need to be surveyed and registered. The legal basis for rural land holding in the region is "Proclamation No. 85/2010, Benishangul-Gumuz Regional State Rural Land Administration and Use Proclamation". The Proclamation in article-25 states about land measurement that:

*"Rural land given users in holding privately or in group, held for common usage by the community of an area, or forestry development, or conserved for any other similar activities shall be measured and the map shall be prepared by the authority in traditional way or modern tool. Because of this, a special system of enumeration shall be designed and implemented to clearly understand each land. The sign that indicate the boundary shall also be made on the land".*

The imagery-based systematic 2nd level rural land registration is being implemented now by the Bureau of Forest, Environment, Land Administration and Use (BoFELAU) Woreda officials with support from BoFELAU Region and Zone offices with the support of the REILA project-according to the BoFELAU report the implementation progress of the program is listed below:

**Table 2.1: second registration status in B.G**

| Zone | Woreda | operational Kebeles | Parcels Demarcated | Parcels Digitized | Parcels Certificate issued |
|---|---|---|---|---|---|
| **Assosa** | Bambasi | 6 | 14,871 | 14,689 | 5,501 |
| | Assosa | 4 | 7,573 | 7,573 | 3,634 |
| **Meteke** | Bullen | 3 | 4,719 | 4,719 | 1,494 |
| | Pawe | 2 | 11,637 | 11,595 | 1,121 |
| **Kamashi** | BeloJiganfoy | 1 | 2,358 | 2,358 | 0 |
| | Kamashi | 1 | 1,141 | 810 | 0 |
| **Total** | **6** | **17** | **42,299** | **41,744** | **11,750** |

**Source- BoFELAU weekly report, 2017**

## 2.6. Technical implementation of imagery based rural cadaster

The research will focus on the technical part of the imagery-based parcel boundary surveying and mapping practices. However, to give the full picture of the implementation of the second level registration in the study areas and based on the 'Operations Manual' the major steps are listed here.

In the *preparatory phase* activities that form the basis of the certification should be conducted. These include:

- Selection of a Kebele (sub-district) where the 2nd registration will be performed.
- Training of trainers and operation managers.
- Recruitment and training of contractual staff.
- Strengthen/establish and train Kebele Land Administration Committee members.
- Verify the current extents of the Kebele boundary.

- Settle as many conflicting interests/disputes as possible.
- Perform procurement and setting up of all the necessary equipment and materials.
- Public Information and Awareness (PIA).
- Arrangement of transportation facilities.
- Preparing and printing of field maps and different field registration forms.

The *field work* can be divided into two separate parts:

- Surveying and mapping of the land parcel boundaries.
- Adjudication - identification, assessment, and verification of the legal holders, the legal rights and encumbrances for each parcel.

The following are the major activities performed at the *office level*:

Scan and geo-reference the printed out field maps including parcel borders demarcated with a pen.

- Digitize parcel boundaries.
- Construct and fill in the parcel attribute table.
- Scan all existing records and field registration forms.
- Perform quality control of all the information.
- Print out the information for Public Display.
- Make corrections of the information following the Public Display.
- Produce a map for each parcel.
- Prepare for the transition to the maintenance phase,
- Updated easily.

### 2.6.1. Image acquisition and preparation

Satellite and aerial image techniques are comparatively inexpensive and accurate, easy to teach and have seen a rapid development the recent years. The accuracy and resolution of the imagery have been drastically improved the recent years, and are suitable for rural cadastral mapping nowadays. For these reasons, imagery based rural second level registration was selected as the main as the most suitable method for mass-scale certification of rural land in Ethiopia. One source is Satellite images that are normally ordered from a digital image provider 'Digital Globe' (Thomas, 2016).

The acquired digital images for the demarcation must have a resolution of not more than 0.5 cm and must be Ortho-rectified and properly georeferenced, it is clearly stated in the 'operational manual' that the acquired images should be verified and certified by EMA. When the Regional offices have received Ortho-rectified images, an area to be mapped has to be selected. In the B.G case, this is normally a Kebele (sub-district). The approximate boundaries of the selected Kebele then have to be obtained; normally this can be found in files delivered by CSA. These are used to select the parts of the images that will be printed out. By using the approximate boundary of the selected Kebele, imagery is made available for the field map production.

### 2.6.2. Field work

Since the technical aspects are the focus of this paper, the field work is only briefly described. The prerequisites are the following: Field work must be consisting of using four teams of four people each in each Kebele has to be in place,

1) A surveyor (to draw the boundaries on the field map).
2) A field registrar (to register all parcel attributes (land holder name, parcel ID etc.).
3) A team leader (to control the acquired field data and to plan the team activities and write reports), and
4) A Land Administration Committee member, who is the legal representative from the Kebele.

Equipment has to be available, consisting of a selection of field maps (covering the area to be visited the coming days), field registration forms, clipboards, bags, stationery, 50 m measurement tape, ruler and a handheld GPS. A means of transportation (normally a car) also has to be available.

### I. Demarcation

'Demarcation of land' is normally completed at the same time as 'adjudication/verification and recording of details' and the 'General boundaries' principles will be applied to demarcation and adjudication in rural and peri-urban areas. Surveyors will simply mark parcel boundaries as identified on the ground and image onto the field map and give each land parcel a unique identification number.

Before any demarcation work is undertaken in a Woreda/ Kebele registration area, socio-economic baseline data will be compiled. Existing maps (topographic and administrative), a suitable scale (1:5,000 – 1:10,000) of aerial photographs or satellite images will be prepared for overview and planning purposes. The scale of the planning maps should be adapted to the size of the Kebele.

**General steps**

1) The parcel boundaries will be drawn on the field map using the pencil. The parcel will then get a unique identification number (UPIN) by the field team (normally by the surveyor). The UPIN will also be written on the field map inside the parcel boundaries. If a new parcel number is given, it is the smallest unused number in an interval that is given to each team before each working day. The intervals are specified so that there is no risk of duplication. Sequence gaps caused by intervals that are not completed are allowed though. If a team finishes an interval, a new one is given to them before they continue.
2) Demarcation of land will be based on features visible both in the field map and in reality. In marking of boundaries the holders will use boundary markers commonly used in the adjudication areas including boundary tracks, footpaths, ditches, fences, trees, plants and stones.
3) Some tape measurements and scaling on the ground will be necessary in order to mark parts of boundaries that either are not visible on the field map, are newly demarcated (e.g. when boundaries are changed to allow for public access) or are obscured by overhead vegetation. If measurements have to be made in slopes, the surveyor has to re-calculate the slope distance to horizontal by using simple techniques,

e.g. using ratios between objects measured on the ground and in the field map or by holding the tape horizontal and measure the distance in intervals. With a ruler, the correct distance can then be used to draw the object on the correct place in the image.

4) It is important that all measurements have to be controlled. This is done by measuring the distance from the demarcated point to another object that is visible in the field map. The distance on the ground should then be confirmed by the distance on the field map (measured with the ruler).
5) In very rare situations, it might be impossible to demarcate a parcel corner even by using repeated measurement tapes, due to the absence of nearby objects visible in the image. This might be the case e.g. in densely forested areas. In this case, other techniques (e.g. the use of Total Stations) have to be implemented. This alternative should only be used if there is no other way to get a reasonably accurate position (around the meter), since it is very time- and resource consuming to re-visit a site with the needed equipment. The team leader shall immediately report such situations to the project manager in order to be able to plan the additional terrestrial surveying effectively.
6) If a parcel is found to be impossible to demarcate on the map due to severe disputes or visibility problems, the registration is not performed. If the parcel has no reliable existing ID, a parcel number is reserved for the parcel for the postponed demarcation: This to be able to use consecutive or similar parcel numbering within a certain area. If demarcation is not possible in an area containing several parcels (e.g. covered by a forest), the quantity of parcels affected are determined together with the Land Administration and Use Committee, and an interval covering the expected maximum quantity is reserved for the postponed demarcations.

## II. Demarcation of parcels where the borders cannot be seen in the image

In some cases it is difficult to see the borders in the image and at the same time identify the features on the ground. If this only concerns one or two of the border corners, it can simply be solved by using the measurement tape from the other corners or some other identifiable objects. However, if it concerns most or all of the points, it is a big problem. This situation mainly occurs in some specific types of locations; in deep and vast forests and on meadow-, wet-, or grasslands with very few features in the image and on the ground.

No additional equipment is needed compared to the normal situation. Just make sure that there is access to a measurement tape, a ruler and a handheld GPS; first, the handheld GPS should be calibrated. If we use them within the coming 30 minutes, we can reduce the absolute error to less than 3 meters in normal situations. After this, the satellite movement in the sky will create new constellations which will slowly increase the error.

1) **If the measurements are performed in a cropland or meadows,** the following procedure could be used. Mark all parcel corners that are visible in the image and confirmed on the ground. For the remaining corners that we cannot see in the image, and where the visibility around the parcel is good;
   a) Find two objects in the field map that are sharp and clearly defined both in the image and on the ground. Preferably it should be objects on the ground with a clear sky visibility (bridges, flagpole foundations, footpath crossings etc.).
   b) The objects should preferably be in the same field map, but if it is not to be found, a neighboring field map will be OK.
   c) Start the handheld GPS and keep it on for at least 10 minutes before the measurements. This is because the position sometimes fluctuates initially when the GPS is turned on. It does not matter if it started on the site of the measurements, so it can be turned on e.g. during the walk to the parcel area to save time.
   d) Measure the object for at least 10 minutes. If the GPS has an averaging function it should be used.
   e) Plot the coordinates in the field map (using a ruler to get the exact position) and draw a GPS correction line between the plotted point and the real location of the object. They normally differ with 1-5 meters.
   f) Repeat the process on the second object and check that the GPS correction lines have a similar size and direction. If not, repeat the measurements for the points.
   g) The distance will normally have accuracy below the meter. As displayed in the figure below;

**Figure 2.3: Measurements in meadows**

The direction will also be below the meter due to the rule of the proportion of triangles (if the distance 1-3 is more than four times the border distance 1-2). The GPS (corrected for the coordinate system shift) is assumed to have accuracy around 5m. Together, this should give point accuracy below the meter if all parts of the process are done properly.

2) **If the measurements are performed in a dense forest**, the following procedure could be used.

a) To find a starting point for the border measurement, choose method in the following priority order:

- ~ If possible, start from a border corner that is visible in the image and on the ground.
- ~ If this is not to be found, start anywhere on a straight border line at a place that you can identify in the image (e.g. a boulder), and treat it as a border corner.
- ~ If e.g. a footpath (with reasonably clear sky for the GPS measurement) is crossing the border we can see it in the image, but we do not know in the image where on the footpath the border is crossing it. To solve this, measure with the GPS where the footpath is crossing the border: Find the place in the map by adding the measured GPS correction line to the GPS coordinates and plot that place on the map as a help point. From the help point you find the closest distance to the footpath and put the point there, since we know that the GPS measurement took place on the footpath.
- ~ If even this is impossible to do, try to locate a place that is in the sightline of one of the borders with an identifiable feature. This will be our first help point (H1 in the figure below).
- ~ If you only find an open place (without features) in the line of sight, use the GPS technique (including the GPS corrections) to mark a help point there.

**Figure 2.4: Measurements in a dense forest**

A help point H1 is marked in an open space in the line of sight along the chosen border.

b) To demarcate the next point, the priority order is as follows:
   - ~ Find the parcel corner (B) on the ground and in the image (see figure 2.5 below).
   - ~ If it is not visible, find a detail along the border that is visible in the image. The detail should be as far away as possible from the first point to minimize the angular error in our traverse.
   - ~ If no point could be found along the border, continue in the line of sight to find a feature that is visible in the image.
   - ~ If no feature is found, use the GPS and plot a help point (H2 in the figure below) somewhere along the border or behind it (following the line of sight). Remember to add the GPS correction line to the plotted point. The location should be on a straight line, as far as practically possible from the first border corner (that we already demarcated), but preferably within "measurement tape distance" from the second border corner.

c) If you start from a help point behind the first parcel corner, measure the distance between the help on the ground with the measurement tape. Then measure the distance to the second border point (as long as the border line is straight).

d) If a second help point was used, also measure the distance from that to the second border point as a control.

e) Now use the measured distances, the help point(s) and a ruler to plot the parcel corners.

**Figure 2.5: Plotting the parcel corners using the measurements and help points**

f) Since the method uses GPS measurements where the errors are not minimized by the proportion of triangles, it is especially important to check the loop misclosure by checking the distance between the first and last point on the ground and in the image.

3) **If a parcel is situated on a plain,** several hundred meters from any reference point, a starting parcel corner point could be established by the following method:
   a) Determine the GPS correction line by measuring with handheld GPS on defined details as described before.
   b) Find three additional reference objects that are well spread around the parcel and easily identifiable on the image as well as on the ground. House corners or poles are suitable objects. They do not need to be measured with the GPS.
   c) Put one person or object on the reference points if they are not clearly identifiable.
   d) Put a person or object on the selected parcel corner.
   e) Estimate the distance from the parcel to the object A. Try to find a place which is at least double that distance, but on the other side of the parcel (this to keep the error down by using the proportion of triangles principle). Now walk so that the parcel corner and the reference object A in in the exact line of sight.
   f) Measure the point with handheld GPS, apply the determined GPS correction line and plot the help point 1 on the field map.
   g) Repeat the process for reference point B and C to create help point 2 and 3.
   h) Draw help lines (light pressure and with a pencil so that they can be erased later) with a ruler between the point pairs A-1, B-2 and C-3.

i) The three lines will now form a small triangle, normally with the corners 2-3 meters from each other. Plot a point in the center of the triangle. This is now the plotted and corrected parcel corner, which can be used as a reference for other corners. Erase the help lines to finish the process.

**Figure 2.6: Plotting of parcel corner without using measurement tape**

### 2.6.3. Data processing

In principle Field registration Forms and Sketched Field Maps shall be recognized and stored in systematic archives.

- Field officers shall hand over the registration forms and sketched field maps to the Woreda Land Registration Expert / Data Encoder.
- The Data Encoder has to verify that information has been collected as per the desired format and standards (number documents, quality and contents).
- The Data Encoder shall create a filing and storage system.

#### I. Scanning and Georeferencing

When the field maps are delivered to the office, they are first scanned with an appropriate scanner. All scanning is to be done in A4 or A3 format, black and white, or color (if stamps or signatures are in blue ink), density of 300 dpi and output format, PDF. To reference the scanned image, the Georeferencing function in QGIS is used. To perform this, nine evenly distributed grid crosses from the printed coordinate grid are selected. The comparatively high number of points is chosen to ensure that any gross error is easily detected, and to be able to find local deformations in the map (e.g. due to folding damages). Each grid cross is zoomed in and digitized, followed by the entering of the grid cross coordinates, which are printed in the margins of the field maps.

### II. Digitizing

If the referencing quality is acceptable, the digitizing of the parcels can start. A polygon layer with a predefined attribute table is created for the purpose of gathering the parcel information. The digitizing is done by choosing the polygon tool and then carefully clicking on each border corner that is demarcated with a pen in the field. For curved borders a sufficient number of points are digitized to represent the boundary well.

Office data processing of the attribute and map data collected in the field work, resulting in georeferenced and digitized parcel boundaries and attribute data in a Quantum GIS database. Map and attribute data is linked for each parcel by a five digit Unique Parcel Identification Number (UPIN).

### III. Quality control

The processing of large amounts of land related data presents challenges in ensuring that data quality is maintained at all parts of the data processing. This means that rigorous quality control procedures are required. The QC procedures are often the first to be abandoned (or cut back), when delivery targets are putting pressure on production staff and managers to deliver ion time. This must not be allowed to happen; poor data quality will lead to a reduction in confidence from land holders, which in turn will damage the whole land registration process (Shewakena & David, 2015).

During the digitizing, it is very important to make a regular quality control. During the trials, the quality control was sometimes made at the end, with an enormous error editing list as the result. To find the errors and learn from the mistakes (not to repeat them) is much easier if the quality control is done regularly from the beginning. The regular quality controls performed are the following:

~ Checking of georeferencing accuracy, which in practice means to check the printed grid lines on a scanned and georeferenced field map compared to a "perfect" reference grid generated in QGIS.

~ Topology checking, searching for gaps, overlaps and invalid geometries (a parcel border crossing itself).

~ Validation of geometry (e.g. finding two or more points that have the same coordinates in a parcel).

~ Search for duplicate parcel IDs.

~ Searching for outliers in an attribute column (e.g. a date that is in the future, green book numbers with less than 7 digits etc.).

# 3. RESEARCH METHODS

Having providing the theoretical setting for the work, this chapter articulates the necessary steps needed to answer the research questions. It gives a complete notion on how the research study stems from the selection of the study, the collection of data, up to analysis of the data in a manner to achieve a relevant result and communicate findings. The research design explains rationales how will the process of research make possible all steps and with specific justifications why specific methods selected.

## 3.1. Study area

Ethiopia has nine administrative regions with two charter cities. During the past five years imagery based 2nd level land registration is implemented in five regions of the country including Benishangul-Gumuz region, the region is located in the northwestern part of the country between 09º17`--12º06`North latitude and 34º10`--37º04` East longitude, covering about 4.6% total area of the Country. Administratively, the Region divided into three zones (Namely: Metekel-zone, Assosa-zone and Kemashi-zone) and has 20 Woreda and 475 Kebeles.

Despite the fact that a registration was done still a lot of woredas are in the process of imagery based systematic 2nd level rural land registration. In this regard, it considered a highly suitable location for testing the quality assessment of parcel map production. The study area selected purposively through Assosa-Zuria Woredas, where the process of 2nd level systematic rural land registration is recently undertaking. The Kebele has almost flat terrain and covers an area of about 5,368,000 $m^2$. The upper left scene co-ordinates and lower left scene coordinates are 68°29’11’’ E, 11°05’95’’N, and 68°67’33’’E, 11°09’42’’N respectively. Generally the study area was chosen for its diverse set of ground features, data availability and proximity to Assosa and also it is the place where the imagery based systematic 2nd level rural land registration program has carried out.

**Figure 3.1: The study area**

## 3.2. Research design

This study employs the scientific research process of conducting research. The scientific process is described in figure-3.2 as a process consisting of series of actions necessary to carry out research, and the desired sequencing of the steps.

Two kind of literature is going to be examined for this research to be well acquainted with the problem. These two kinds are conceptual literature and empirical literature. Conceptual literature will help to study about theories and concepts of related field. Empirical literature will help review previous studies of related subject. This research designed taking into consideration the order in which the research objectives are outlined. It takes three main stages; Pre field work, field work and post field work as can be seen in (Figure 3.2).

**Figure 3.2: Research design and methods**

## 3.3. Methodology

In this section of the thesis are described the methods used in the three phases of the research, before fieldwork, in fieldwork and after fieldwork. The methods used for data collection and data analysis with a precise description why was selected this method and what was the result expected from applying each of the methods in this research.

### 3.3.1. Pre-fieldwork phase

In this phase of work, information is collected. Form different literature sources including books, papers, governmental reports, operation manual and previous studies conducted in the same field. From the literature review, the study area, the research problem, questions, and methodology were defined. And before any activity field observation will be adjusted and carried out. During field observation camera will be used to take photo records respectively. This was helped the researcher to have some knowledge before entering in to detail data collection. The researcher employed a team having three experts who were working in the office of environment, forest and land administration at Assosa-Woreda for parcel survey data collection.

### 3.3.2. Fieldwork-phase

During the fieldwork, collaboration with Bureau of Forest, Environment, Land Administration and Use (BoFELAU) made possible an interaction with users of the system and dealing with data collection in Woreda or Kebele level. Meanwhile, the application of using orthoimages for rural parcel map production was tested with users in an area where the imagery-based systematic 2$^{nd}$ level rural land registration was taking place, in Komishiga-26 Kebele. After the test, through semi-structured interviews, information about the perception of users was gathered. A focus group discussion was carried out with the users where the results of the field testing were discussed. Besides, compassion of data and method was made to assess the required technical efficiencies of implementing the application of orthoimages in practice. This phase focused on the collection of information in order to identify the methods of parcel boundary surveying in combination with orthoimages, user role and perception in order to carry out the boundary surveying and mapping operation. All those elements are required to answer the research questions.

#### 3.3.2.1. Sampling of the case study area

In this research the selected groups were land officials, and land professionals implemented in the cadastral collection process in B.G region, especially in Assosa. The selection was made on judgmental sampling. The people selected for interviews and questionnaires were professionals' of land administration and management, GIS, surveyors and data encoders, and land officers from the regional bureau, zone and Woreda office around 32-35 people that were involved in the collection and registration process.

Selection of the measured parcels was made from the field team which has a graph of daily measurements they need to complete in that area. Meanwhile, the Kebele where the measurement took place was selected because was in the process of systematic second level land registration during field work visit. In total, 28 parcels were tested with in the two field maps in Komishiga-26 Kebele. The field maps tested based on the parcels boundary/ features visibility, includes visible, partially visible and invisible on field map and in the ground respectively were selected.

#### 3.3.2.2. Semi-structured interviews

Semi-structured interviews are preferable to avoid limitations in answers, in this way it is possible to achieve all the information needed. The interaction between the researcher and the responders give the opportunity to explain the questions as well as to retrieve extra information. Likewise, the semi-structured interviews were conducted in order to retrieve the opinions of the respondents without getting affected by other people's opinions inadvertently. The number of semi-structured interviews undertaken was 14. There were interviewed 6 professionals from BoFELAU, 2 experts from Zone, 4 expert from Woreda, and 2 experts working on the REILA project.

The semi-structured interviews were based on the themes based on the research question (Appendix-B). The themes were: imagery-based land registration;image acqusition and preparation; users and their role in land registration; ground surveying methods using orthophotos; spacial data processing and handling, and difficulties that are faced on the second registration;. In some cases, explanations and extra question were done based on the topic or for retrieving extra information.

#### 3.3.2.3. A focus group discussion

After conducting semi-structured interviews, group discussions were undertaken. Though discussions with the users were more productive in providing specific and diverse informtion, the group discussion enabled inclusion of the opinions of people who were not interviewed personally.

Information that was collected from the 2 focus group discussion was: firstly, field team participant's actual involvements and their discontent with existing processes. The second group discussion analyed the office data processing and maintainance of cadastral datasets. The focus group was open to all interested parties that wanted to participate. A presentation where it was explained briefly the research and a deep explanation about the objective. Tested on the field was given. After the comparision of the data and an understanding of the method, the participants were given to me to ask questions and give the opinion about potential implementation. Checklist was prepared to guide focus group discussions. The checklist was targeted at generating relevant information on major issues related to the research objectives.

#### 3.3.2.4. Questionnaires

A questionnaires approach was selected to assist creating and understandings of what the perception of the users towards the methods of boundary surveying and mapping was. Only professionals wereincluded becouse most of the landholders (farmers) could not read and write. In total questionnaires carried out were 32. Where 12 from field data collectors, 4 from data encoder, 6 from woeda experts, 8 from regional bureau and other 2 from zone supervisor. For the content of the questionnaires refer to Appendix-B. The field team questions were based on the experience they had using orthophotos forparcel boundary surveying and mapping.

Quesionnaires gave a broader view of parcel boundary surveying and mapping methodology and the required functions of the program from the user perspective. The perception of the users for the improvements in term of pracel boundary surveying and mapping were part of the questionnaires.

### 3.3.3. Post-fieldwork phase

The post-field phase included the processing of the data. The interviews were analyzed manually using content analysis, whilst descriptive statistics were applied to the field survey and questionnaire datas. The result of this phase are the assessment of orthophotos for parcel boundary surveying methods and the mapping processes and data maintainance also discussed regarding the criterias and methodology used in the operational manual. The last step including developing conclusions, and recmmendations. Content analysis: was the selected method for analysis of semi-structured interviews data that were collected. The method was selected to give the possibility of analyzing the data in an objective fashion. From content analysis were defined the elements land experts addressed and fined necessary for completing cadastral data collection. From the interview the mast specific phrases were quoted in order to show specific opinions of the users regarding the technical and functional concerns of the parcel boundary surveying and mapping and regarding the methodology followed. Descriptive analysis: this method was selected to analyze the results of questionnaires conducted for the assessment of boundary surveying and mapping methods using orthophotos production. This method was selected to summarize data dependent on their content. The contents of the questionnaires were mostly about the technical and functional aspects of fieldwork and office data processing. User that undertakes imagery-based 2$^{nd}$ level land registration in the field and in office provided their perceptions about the program and the actual methodology. The questionnaires made on the group discussion include suggestions about the improvement of the program on the future.

# 4. RESULT AND DISCUSSION

One of the main objectives of the study is to assess the usage of orthoimages for rural land parcel map production, based on procedure for parcel boundary demarcation, scanning, georeferencing, and digitizing processes, the scale of field map production, and the methods of parcel boundary surveying and mapping in combination with orthoimages when boundary features are not visible from the 'operational manual' perspectives of the program. In order to attain this specific objective, parcel data were generated and analyzed through the assessment of experts' perceptions and opinions on rural cadastral mapping using of orthoimages production. To meet this objective primary data from sample parcels was collected from one Kebele (sub-district). The survey gathered qualitative and quantitative data pertaining to parcels boundary surveying and mapping information and for compassion of spatial information with the actual data collection process in the study area. The analysis is based on data from a sample of 28 parcels purposely selected. The sample units were chosen from two field maps using a purposely sampling method. Results and discussions of the studied parcels are discussed below.

## 4.1. Demographic profile of the respondents

Before discussing the results, relevant data were obtained from sample respondents during field survey, according to the experts' survey as it is indicated in (Figure 4.1) below, educational status of the respondents where 3% have second degree, 41% have first degree, 6% have diploma and 50% of the respondents have a certificate.

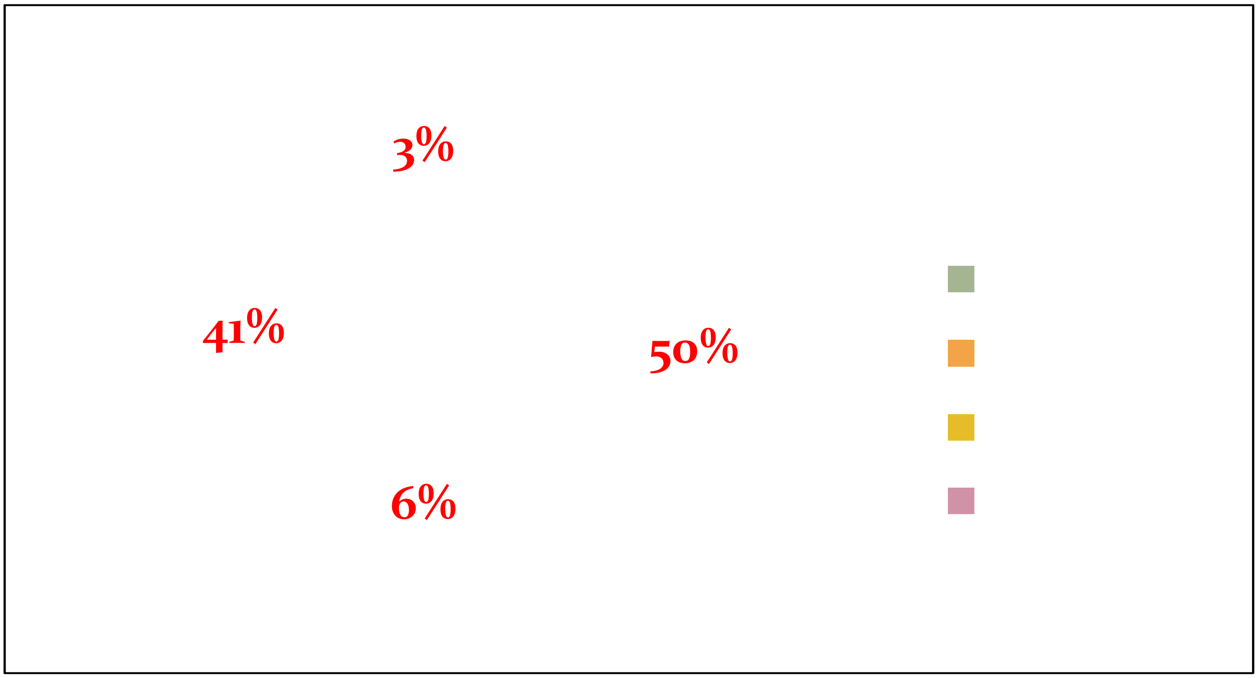


**Figure 4.1: Educational status**

**Figure 4.2: Educational status reviewed**

## 4.2. Procedure of rural cadastral mapping using orthoimages

In order to make possible the examining and evaluating of rural cadastral mapping using orthoimages production and the suitability of the operational procedures in the study area; the data was analyzed from interviews, questionnaires, and group discussion conducted during fieldwork. Referring to materials analyzed from the conducted interviews form the functional and technical methodologies identified to investigate whether procedures of data collection and processing using orthoimages are suitable or not, within this perspective the survey result revealed that 72% of the respondents agreed that it was a tedious and unsuitable procedure to produce and print-out orthoimages/ Field maps and 50% were justified the procedure to demarcate parcel boundary using orthoimages were suitable as it is depicted in (Table-4.1) below.

**Table 4.1: Experts opinion and attitudinal survey**

| SE.NO. | ASSESSMENT TOOLS | RESPONSE | FREQUENCY | % |
|---|---|---|---|---|
| 1 | Field map production | Yes | 9 | 28 % |
| | | No | 23 | 72 % |
| | | Total | 32 | 100% |
| 2 | Parcel boundary demarcation | Yes | 16 | 50% |
| | | No | 16 | 50% |
| | | Total | 32 | 100% |
| 3 | Scanning | Yes | 28 | 88% |
| | | No | 4 | 12% |
| | | Total | 32 | 100% |
| 4 | Geo-referencing | Yes | 16 | 50% |
| | | No | 16 | 50% |
| | | Total | 32 | 100% |
| 5 | Digitizing | Yes | 20 | 63% |
| | | No | 12 | 37% |
| | | Total | 32 | 100% |

**Source: (Survey data, 2009)**

As can be seen from (table-4.1) concerning the tasks of scanning majority of the respondents 88% were justified the procedure to convert analog data into digital data, scanning operation were suitable. In contrast, 50% of the respondents argued that the methodology of geo-referencing was not suitable, therefore, geo-referencing procedures needs emphasis to achieve fast and automated operation. And the majority 63% agreed the procedure of digitizing was suitable.

In order to have an idea for the suitability of procedures developed within functional and technical requirements for the implementation of rural cadastral mapping using orthoimages the data was analyzed from interviews, and questionnaires. The data revealed that 56% of the respondents were agreed suitability of the procedures (figure-4.3).

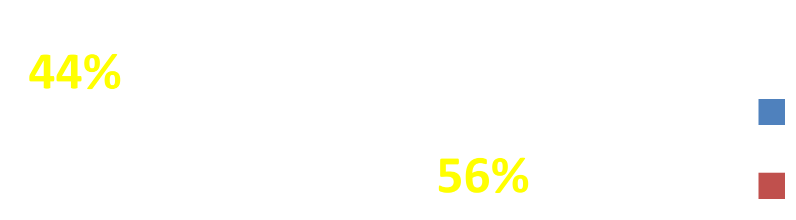


**Figure 4.3: Suitability of orthoimages for parcel map production**

Whereas, 44% of the respondents' response not suitable, mainly the procedures to produce field-maps, the technical complexity of boundary surveying requirements, like boundary demarcation where parcel borders invisible in the image and features are missed in the ground. And the georeferencing tasks are the mentioned difficulties of the operation.

## 4.3. Appropriate scale for field map production

The main objective of this section is to examine the appropriate scale of field maps for imagery base rural cadastral mapping operation. In this regard, respondents were interviewed questions in order to articulate the appropriate scale for field map production. In that case, in order to simplify the surveyed data interpretation responses are summarized and presented in the following (Table-4.2).

**Table 4.2: Experts opinion on field maps scale determination**

| SE. NO. | Measuring tools | Response | Frequency | % |
|---|---|---|---|---|
| **1.** | The scale of field maps currently used | 1: 1000 | 0 | 0 % |
| | | 1: 2000 | 30 | 100 % |
| | | 1: 3000 | 0 | 0 % |
| | | Total | 30 | 100 % |
| **2.** | Weather the scale of field maps suitable for boundary feature identification or not | Ye | 21 | 70 % |
| | | No | 9 | 30 % |
| | | Total | 30 | 100 % |

Source: survey data, 2017

It can be revealed form (Table-4.2) above concerning the question what scale of field maps currently used? Overwhelming respondents (100 %) confirmed that 1:2000m is applied. Furthermore, the suitability of the most commonly used 1:2000m scale of field maps for parcel boundary identification 70% responded that it is suitable whereas 30 % responded the scale of 1:2000m is not suitable for parcel boundary identification. Obviously, the scale of field maps is important for determines the accuracy of parcel map production and also for parcel boundary feature identification. Thus, the appropriate scale determination should be improved to reduce the point positional accuracy of orthophotos and to get the required benefit. The next sub-section deals with the discussion the regional bureau land experts as a key informant concerning the scale determination of field map productions.

A discussion with regional bureau experts was held during the field work. A semi-structured question was used for the discussion. The discussion result is organized as follows.

The regional bureau is responsible to prepare and printout field maps from the approximate boundary of the selected Kebele. To investigate the determination of appropriate scale for field map productions, discussion was held with EFLAU experts at all level. The discussion point was how to fix the appropriate scales of field maps for the Kebele level systematic rural cadastral mapping. Most of the experts are agreed that the appropriate scale of field maps determines based on the ground reality of the selected operational Kebele. However, in another instance the most commonly functional field map scale (normally 1: 2000) is ranked not enough in terms of visibility for the identification and demarcation of parcel boundary. From the discussion it is understood that the determination of appropriate field map scale is a serious problem. Based on the survey results and the field observation, the examiner is intended to conclude that the current field maps scale determination is not appropriately controlled in this particular survey and there needs to be a legal binding to determine the scale of field maps from the regional as well as the national level.

## 4.4. Usage of orthoimages in combination with ground surveying methods

In order to make possible the testing of rural cadastral surveying and mapping using orthoimages in combination with different ground surveying methods when parcel boundary features are not visible in the study area, the actual cadastral data collection was reviewed to show the steps and users involved in cadastral collection process.

The field data collection process using orthoimages /field maps was done in collaboration with the field team and kebele LAC's in the Komisiga-26 Kebele. For collecting parcel boundaries, two field maps was selected based on the sampling criteria mentioned in chapter-three: the field maps (1:2000) scale was printed out from the existed prepared kebeles' field maps. It is required to go around the parcel and parcel boundaries and drawn on the field map using pencil. Demarcation of the parcel boundaries was based on the operational manual procedures mentioned in chapter-two. The visualization of parcels collected during fieldwork is visualized in (figure-4.4).

**Figure 4.4: Map with collected parcels (own creation)**

The steps undertaken for boundary identification, demarcation, scanning, georeferencing and digitizing procedures following from the operational manual were difficult and some complex. The majority of the difficulties were faced during the data collection, due to the neighbors' absence in the field.

### 4.4.1. Cadastral data comparisons

The actual data collection consists on pencil and paper collection method. The process of collection is done by the team of field data (para-surveyor, field recorder team leader, LAC member). The surveyor draws the boundaries over the printed orthophoto, later on; the boundaries are re-drawn with a pen so that the lines can be visible in the scanner. The digitized scans; geo-references and digitizes the parcel boundaries. In the end, the information collected in the field forms is entered manually.

The same procedure was done for comparison purposes. The field maps were scanned, georeferenced and parcels were digitized. For comparison purpose, the digitized parcels were overlapped with the collected parcels (Appendix-A). A comparison, between collected parcels and digitized parcels, about the derivation in area was done. In total 28 parcels from two field maps collected were compared. There were two field maps included for the reason to evaluate parcel borders situated in a plain and grasslands with very few features in the image and on the ground.

Parcel classification with respect to acreage was conducted according to B.G regional land administration and use Directive No-44/2003, Article, 7 small plot size. According to this directive, the minimum area of plot of land, to be provided to one person and cultivable by irrigation and rain shall be 0.1 ha, and 0.25 ha respectively.

**Figure 4.5: Distribution of parcels in the study area with respect to size**

Figure-4.5. shows the percentages of parcels for the change in terms of area per categories. with category A(0.01-0.09)ha, difference, 13 parcels (46%) were found; with a percentage of difference from category B(0.10-0.25)ha, 12 parcels (43%) were found; parcels with difference from category C(0.26-0.99)ha, 2 parcels (7%) were found; parcels with difference from category D (1.00-2.99)ha, were 4% concluding with no parcel with change in area of more than category E(≥3.00)ha.

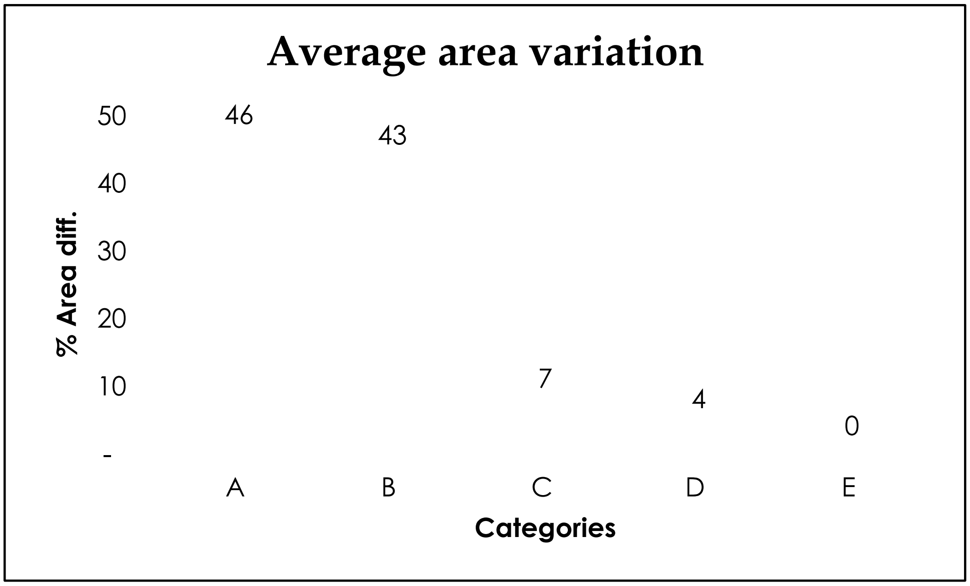


**Figure 4.6: Area variation per category**

From the above figure it can be stated that the differences in the collecting spatial data with both methods are very high. Still there is a different result from the area calculation where the percentage of difference is higher for category A (0.01-0.09) ha, in 13 parcels (46%) and category B (0.10-0.25) ha, in 12 parcels (43%). Further analysis indicated that the smaller the parcel, the greater the error on their areas and vice versa. Similar results have been developed even for comparison of data collected with Total Station and High Resolution Imagery from (Chandrarathne, 2016). This shows that there is a big difference in data from the application of orthoimages. In addition, the data shows that (39 %) and (46 %) of the sample parcels in the study area lays under the category of (0.01-0.09) ha. and (0.10-0.25) ha, respectively. Meanwhile, in the study Kebele (Komishiga-26) the land is only cultivated by rain. Therefore, the examiner is intended to conclude that 85% parcels of the study area lays under 0.25 ha, which denies with the minimum area of land provided to one person, cultivated by rain refers to (Art-7) of the regional land administration and use directive No-44/2003. Furthermore, these statistics shows that the using of orthophotos for rural cadastral mapping have drastic changes from the actual general boundary methods used in the country.

Though, from the legal perspectives of rural boundary the region proclamation article 25 states that:

*"Rural land given users in holding privately or in group, held for common usage by the community of an area, or forestry development, or conserved for any other similar activities shall be measured and the map shall be prepared by the authority in traditional way or modern tool. Because of this, a special system of enumeration shall be designed and implemented to clearly understand each land. The sign that indicate the boundary shall also be made on the land".*

Therefore, legally the fixed boundary principle is stated in the region but practically the principle of general boundary applied.

Most of the boundaries overlap but difference in the area is noticed. The higher differences in the area can be due to different errors affecting the field data collection process as well as office data processes. Differences in shape or boundaries can be caused by terrain, high vegetation, the field track, and density of points. Other errors can be made during the drawing of the boundaries or digitizing process. Further errors are introduced during the georeferencing and digitization of datasets. The amount (dg) of error depends on the cartographic errors, among them the map projection used, digitizer used (Chrisman, 1983). (Kohli & Jenni, 2008). The crucial issue is how to combine the separate error effects. Considering that each error tends to occur as the spatial information is passed from one phase to another in the sequential process, it is therefore sufficient to consider the processes to be independent. Sufficient results of combined geometric errors can be obtained by adding the variances of the distributions by considering the error in source document, georeferencing and vectorization process. All the mentioned errors give the differences in the shape and areas. Apart the differences in spatial information, there were few differences in the methodologies. The majority difference is on the steps followed from collection up to the parcel map data visualization.

### 4.4.2. Usage of ground surveying methods

For the evaluation process of using orthoimages in combination with different ground surveying methods when parcel boundary features were partially as well as fully invisible, the data were analyzed from interviews, questionnaires and group discussion conducted during fieldwork. Referring to the materials analyzed from the conducted interviews can be said that, the parcel boundary demarcation is based on features visible both in the field map and in reality. In some cases that parts of boundaries that either are not visible on the field map or in the ground, some tape measurements and scaling on the ground by , using ratios between objects measured on the ground and in the field map are practiced in the study area. However, if it concerns most or all of the points, due to the absence of nearby objects visible in the image as well in the ground, some hand held GPS measurements and scaling on the field map were implemented. Which is not recommended by the factor of positional accuracy more than five meter and that is the main reason for making a big variation for the comparison of cadastral data overlapped in appendix-A.

## 4.5. Efficiency of parcel map production

From the technical and functional perspectives of the procedures for imagery base parcel map productions the improvements that need are: Parcel boundary surveying methods, when boundary features are:

- Partially invisible,
- Not visible, and
- The scale determination of field maps

The data revealed that there is a big variation on area and position form the cadastral data comparison in order to demarcate parcels where the borders cannot be seen in the image; mainly occurs in some specific types of locations; in deep and vast forests and on meadow, plain, wet, or grasslands with very few features in the image and on the ground.

The improvement to be done were the use and application of orthoimages base procedures in combination with different ground surveying methods are required and need to be taken in consideration. Moreover, due to the absence of nearby objects visible in the image and in the ground an integrated approach for cadastral surveying and mapping techniques are needed for acquiring cadastral data and produce parcel maps in an efficient manner.

With regard to parcel boundary demarcation it is preferable to demarcation of land based on features visible both in the field map and in reality. However, it is very critical to demarcate parcel boundaries when it is difficult to see the borders in the image and at the same time identify the features on the ground. And, that all measurements have to be controlled mainly occurs in some specific types of locations; in deep and vast forests and on meadow-, wet-, or grasslands with very few features in the image and on the ground. Therefore, it could be better by using tape measurements and scaling on the ground in order to mark parts of boundaries that either are not visible on the field map, using ratios between objects measured on the ground and in the field map or by holding the tape horizontal and measure the distance in intervals. With a ruler, the correct distance can then be used to draw the object on the correct place in the image. However, if it concerns most or all of the points, it is a big problem. This situation mainly occurs due to the absence of nearby objects visible in the image. This might be the case e.g. in densely forested areas. In this case, other techniques like-the uses of total stations have to be recommended; in order to get a reasonable accurate position around the meter. Even though, the application of total station and the required accuracy should never be determined primarily by standards used in the region or by a desire for technical perfection.

The field experience showed that field experts suggest an improvement on the scale of field maps to identify the features needed. Despite the point position error of orthoimages map scale 1: 1000 and 1:2000 are ± 42 and ± 182mm respectively. Those data reveal to us the main weakness of the practices of imagery base rural cadastral surveying and mapping which need further improvements in order to be implemented in the study area and broadly in the region.

## 4.6. Discussion

The main objective of this research was to assess the use and applicability of orthoimages based procedures for rural land parcel boundary demarcation to achieving a maximum efficiency for parcel map production.

In parallel with the visual interpretation and quantitative analyses of the applied methods, as outlined in the methodology, land administration professionals were interviewed for their views on the approach, specific methods and the potential for production-level implementation. Hence, institutional arrangement should create conductive atmosphere for the management, administration and use of rural land and the required relationship between the land holder as a customer and the land administration institution as a service giving (Mamimine, 2003). To investigate the capacity of BoEFLAU at all level, discussion was held with BoFELAU staff at regional, zonal and Woreda level. The discussion conducted to understand the differences and improvements in the methods were identified the main difficulties land experts are facing during the systematic second level land registration phase. The first discussion point was how they evaluate EFLAU's strength to provide awareness creation for the rural community about systematic second level land registration. However, the institution is ranked not enough in terms of awareness creation because the overwhelming survey during the discussion reviled the weak public participation, holders as well as neighbors not present during the fieldwork, which causes a conflict and delay of the registration process, and also the kebeles' administrative officers/ leaders and LACs' are mostly not aware about the issue. Another discussion point was the availability of resources at all level such as skilled manpower, finance and transportation. During the discussion it observed that the availability of resources is at its lower stage and unable to satisfy the need. Especially, the problem is very serious at Woreda level, such as; Shortage of Clip board, meter, binder, FRF, Umbrella, bag, scanner, hand held GPS, computer and file cabinets. During the discussion it was observed that the availability of resources is at its lower stage and unable to satisfy the need. This implies that lack of resources at Woreda level can weaken the performance of the Woreda when serving the landholders.

Man power at regional level is quite higher than the next level zone in terms of position and educational background. The number of experts assigned at the zone level at present is less than the required man power. In this particular woreda the position is fulfield. However, there are claims about number of professionals that the position is not directly related with land administration, currently the regional TVET college uniquely trainned rural cadastre and land registration program, and  74 trainnes are graduated at level-III and it is an impressive progress compared with the other regions in the country.

In almost all cases the practitioners agreed that rural boundaries are generally visible from HRSI. However, a specific interview indicated that approximately one out of five parcels has a problem in visibility: the issue of invisible boundaries was one of their concerns about the implementation of (semi) automated boundary-mapping approach. In general, it was also stressed that, with all the constraints, if it is possible to achieve 40 or 50 percent of the missed or misplaced boundaries, they could be fixed by using other methods like measuring tapes, and in most cases when parcel covered in forest and in the grass and border corners far/ beyond to 50 meter in the ground demarcations using a handheld GPS used. Hence, an accuracy (normally 1-2 m) that fits the purpose for rural cadastral mapping merely recommended. While, handheld GPS has a problem with random inaccuracy. During the discussion it is observed that the parcel boundary demarcation is not performed based on the required procedures of the operational manual because of the technical complexity of the operation and the skill gap of the fieldworkers. The issues of training and skill gaps are addressed from the fieldwork up to the office operations of data processing and editing, and emphasis must be given regarding to the application of QGIS. Another main constraints reviled through the discussion was the production of field maps, which is performed at the regional level and not timely provided for the operational Woreda and which causes a delay. Finally, all interviewees underlined the essential need for fast and automated methodology to eliminate the slow going process, and it implies that the requirement of a new tools/procedures to improve the speed of the registration process.

In general the research includes the whole information needed to understand the using of satellite imagery orthoimages for rural cadastral surveying and mapping in the region. What could be done different are the different methodologies used during the research. The suitability of the program was identified better during the field test rather than from literature. The practitioner in itself explains their role and difficulties. A document review and field visit can be done in order to understand the institutions responsibilities before field work and to have an idea. A direct interaction with practitioners makes the information easier to be understood.

# 5. CONCLUSIONS AND RECOMMENDATIONS

In this last chapter of the research are presented conclusions of the author related to the research and future recommendations. The organization of the chapter is done based on sub-objectives order so can be clear and can include all the necessary information to the reader.

## 5.1. Conclusions

The main objective of this research was to assess the use and applicability of orthoimages based procedures for rural land parcel boundary demarcation which determines the efficiency of parcel maps production.

The main issues related to the suitability of orthoimages based operational procedures for rural cadastral surveying and mapping practices, and also the determination of appropriate scale for field map productions have been discussed based on the experts' perception. The research also examined the application and usage of orthoimages in combination with different surveying methods when boundary features not visible, was tested on the field with the purpose to analyze technical requirements. Based on the technical requirements and the practitioners' perception a suggestion is done to improve the procedures of imagery base parcel map production.

**Research sub-objective one:**

*To investigate the procedure for demarcation, geo-referencing and digitizing processes of rural land parcel boundaries using orthoimages production*

Sub-objective one sought to find technical and operational procedures of the imagery base rural cadastral mapping. Imagery-based systematic rural cadastral mapping 'Operational manual' technical requirements were reviewed in combination with experts' interview was done to realize the suitability of the operational methodology. A detailed analyzes were done to understand which of the technical procedures can be critical for rural cadastral surveying and mapping operation.

There were identified five technical and procedural assessment tools: Orthoimage/ field map production, Parcel boundary demarcation, Scanning, Georeferencing, and Digitizing processes. In the process of assessing, was concluded that the technical procedures of scanning and digitizing procedures are easily performed. However, field map production, parcel boundary demarcation and georeferencing procedures are complex to perform on the current method.

The result reveal that a suitable, flexible, and reliable technical procedures certainly significant. It is therefore crucial to review and improve the procedures and capacity building and training with regards to the technical procedures is also essential for land experts at all level regularly.

**Research sub-objective two:**

*To examine the appropriate scale for field map production*

The research objective two was necessary to examine the appropriate scale of field map production.

The findings of the study ascertain that the problems associated with the determination of appropriate scale of field map production. And, the practices are not considering the ground reality of the kebeles. This causes to identify the parcel boundary features difficult, full of inconsistencies, unsuitable and lack of standardization. Although, the point positional errors for scales of orthoimages are various, and also the accuracy of scanning and digitizing operations used for the conversion of analogue to digital form depends on the determination for scales of field maps. It is therefore important to monitor the determination for scale of field map production based on the realization of the operational areas ground features reality.

The results reveal that a scale of 1:1000m could be suitable for boundary feature identification when the ground is covered in deep and vast forests and on meadow, plain, wet, or grasslands.

**Research sub-objective three:**

*To apply and explain the application and using of orthoimages in combination with different ground survey methods when boundary features are not visible*

This research objective sought to understand the applications and practices of using orthoimages in combination with different ground surveying methods with regards to boundary features were not visible.

In order to answer the research objective three, the cadastral data process were needed just five stages: preparation steps, plan data collection, data collection, data processing, and data analysis. In the process of testing, was concluded in the process of parcel boundary demarcation when boundary features are not visible, the technical procedures of the 'operational manual' are not implemented only tape and hand held GPS used as a measurement tools in the current operation of the program.

The analysis of spatial data reveals that there is a big difference. Differences in area and shape of parcels can be caused by the parcel boundary demarcation techniques and other errors can be made during the scanning, georeferencing or digitizing process. In addition, the study shows that the existence of a big gap between what is stated in the procedures, laws and the actual practice on the ground. Most of the parcels in the study area are under the minimum area of land provided to a person stated on the regional directive, and fixed boundary principle is stated on the regional proclamation. Although, in the operational manual it is stated that 'due to the absence of nearby objects visible in the image, in this case the use of total station have to be implemented'. However, practically there is no total station or any ground surveying methods adopted in combination with orthoimages in the study area as well as in the region.

**Research sub-objective four:**

*To analyze the efficiency of parcel map production*

The research objective pursued to analyze the efficiency of parcel map production in order to suggest improvements on the procedures of technical and functional implementation of imagery based systematic rural cadastral mapping in order to achieving a maximum efficiency of parcel map production.

In general, the recent developments of the cadastral mapping process have greatly reduced time and effort needed to produce the cadastral register in the regional Kebele. However, the findings of this research shows the practice and implementation of parcel boundary demarcation when boundary features becomes to be not visible and the scale determination of field map are not found in a good condition. The reason is clear, the operations are not performed based on the operational manual guidelines and the technical as well as operational skill gaps of experts at all level are the main factors concerned and this needs fast response by the concerned bodies. Therefore, emphasis is needed to strengthen the regional, zonal, and Woreda level officers in terms of technical and operational methodologies in order to achieve efficient parcel map production. Eventually, there needs to be a comprehensive handover and maintenance of cadastral dataset at the Woreda, zone and regional level.

## 5.2. Recommendations

The use of satellite images/ orthoimages to support the collection of spatial data for land administration is participatory, produces field evidence, and is relatively easy to process. So, attention should be given to the processing concerns about parcel boundary demarcation technics, scanning images with drawn boundary data on it, georeferencing and digitizing the boundary data, and referring administrative data to spatial units.

Every technique has its own flaws and benefit. To obscure the flaws of one with the benefits of the other would be the best option to overcome any task with high accuracy at minimal cost and similarly an integrated approach of both the techniques can be used to achieve higher accuracy in an economical manner and can even fasten the process. Therefore it is important to appreciate the land registration and certification efforts with whatever limitations. But it should be noted that the benefits that could be derived from land certification can be realized only if they are supported by other enabling conditions. The following issues need to improve the efforts of imagery based land registration and establishing an efficient land administration system in the region.

- There should be awareness creation and public participation.
- Procedures and methodologies of the operational manual have to be revised.
- Parcel boundary surveying methods should be easy, fast, and automated.
- There should be an operational team organized at the regional level in order to support additional terrestrial surveying tasks.
- The quality and efficiency of imagery-based rural cadastral mapping technical operation should be ascertained by higher educational institutes like ILA, BDU as well as there needs to be an involvement of the private land surveying and mapping organization in the future.
- The development of a system of record keeping and archiving of records to ensure that information is protected, development of procedures for handling information and updating records should be the focus of EPLAUA at all levels
- There has to be further rigorous studies about the impacts of land registration and certification. Government could solicit the support of civil society organizations such as NGOs in this endeavor.

## LIST OF REFERENCES

Aleksic, I., Lemmen, C.H.J., Dabass, S. (2005). Technological aspects of land administration systems in the West Balkans. In: FIG Working Week and GSDI 8: From Pharaohs to Geinformatics, 16–21 April, Cairo, p. 17.

Arslanoglu M., & Mekik Ç . (2003). An Investigation On Precision Analysis Of Real Time Kinematic GPS Positions And A Case Study , 9 th. Turkey Survey Scientific and Technical General Assebly, 31 March–4 April 2003, Ankara, Turkey. .

Bennett, R., Kitchingman, A., & Leach, J. (2010). On the nature and utility of natural boundaries for land and marine administration. Land Use Policy, 27(3), 772-779. .

Bogaerts, T., & Zevenbergen, J. (2001). Cadastral systems-alternatives. Computers, Environment and Urban System, 25(4-5), 325-337. .

Burrough PA, Frank AU. (1995). Concepts and paradigms in spatial information: Are current Geographical Information Systems Truly Generic?, Int. J. Geogr. Inf. Syst. 9:101-116. Available online at: http://www.paulbolstad.net/gisbook/introcha.

Ceylan A, Mutluoglu Ö, Günaslan R. (2005). Transformation of /1000 Scaled Cadastral Maps with Cartographic Methods Into Digital Status And Accuracy Analysis. Chamber of Survey and Cadastre Engineers of Turkey, 10 th. Turkey Survey Scientific and Technic.

Clarke. (2003). Getting Started with Geographic Information Systems, Prentice Hall, 4.ed. pp. 340. ISBN: 0-13-046027-3, New Jersey.

Corlazzoli, M., Fernandez, L.O. (n.d.). • *Spot 5 cadastral validation project in Izabal, Guatemala. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 35 (Part 1), 291–296.* 2004.

D., T. (2016). Efficient and fast production of cadastral maps in Ethiopia the world bank - Washington DC,.

Dale, Peter F., McLaughlin, J. (1999). 1999. Land Administration Spatial Information Systems and Geostatistics Series. Oxford University Press, Oxford, p. 169.

Dale, Peter F. and McLaughlin, John D. ((1988)). Land Information Management, An introduction with special reference to cadastral problems in Third World countries, Oxford: Clarendon Press.

Deininger, K., Ali, D. A., Holden, S., & evenbergen, J. . (2008). Rural Land Certification in Ethiopia: Process, Initial Impact, and Implications for Other Africa Countries. World Development, 36(10), 1786-1812. doi: 10.1016/j.worlddev.2007.09.012. In A. D. K..

Eisenbeiss H, Baltavias E, Pateraki M, Zhang L. (2004). Potential of IKONOS and QUICKBIRD Imagery for Accurate 3D Point Positioning, OrthoImage and DSM Generation, XX th ISPRS Congress, 12-23 July, 2004, Istanbul, Turkey.

Enemark, S., Bell, K. C., Lemmen, C., & McLaren, R. ((2014)). Fit-for-Purpose Land Administration. Copenhagen, Denmark: Joint FIG/ World Bank Publication. .

Escobar F, Hunter G, Bishop I, Zerger A. (2008). Introduction to GIS, Department of Geomatics, The University of Melbourne, Available online at: http://www.sli.unimelb.edu.au/gisweb/ (Accessed 02 April 2008).

FIG. (1995). International Federation of Surveyors (FIG), The Statement on the Cadastre, FIG Publication No. 11, Canberra.

FIG and UN. (1999). International Federation of Surveyors (FIG), The Statement on the Cadastre, FIG Publication No. 11, Canberra.

Gürbüz H. (2006). Genel Fotogrametri-I (in Turkish), Türkiye Harita ve Kadastro Mühendisleri Odası, 2006. pp. 154. Ankara.

Hampel, G. (1978). *From Tax-Oriented to Multi-Purpose Cadastres, In: Inter-regional workshop cadastral surveying, mapping and land information (report), Hannover, November 18 - December 20.*

Henssen, J. (2010). Land registration and cadastre system: principles and related issues. Lecture Notes, Master Program in Land Management. TU Munchen, Germany. .

Henssen, J.L.G. and Williamson, I.P. (1990). Land registration, cadastre and its interaction; a world perspective, Proceedings XIX FIG Congress, Commission 7, Paper 701.1, Helsinki 1990, p. 14-43.

Kahveci M., & Yıldız F . (2005). Global Positioning System (GPS): Theory Application (in Turkish). pp.215, ISBN 975-591-203-7, Second Edition, (Ankara: Nobel Publication Delivery), Turkey.

Konecny. (2002). Geoinformation: Remote Sensing Photogrammetry and Geographic Information Systems, 2nd ed. Taylor & Francis, London, p. 248.

Larsson. (1991). Land Registration and Cadastral Systems: tools for land information and management, Harlow (Essex): Longman Scientific and Technical. P-25-26.

Lillesand TM., & Kiefer RW., . (1994). Remote Sensing and Image Interpretation, Third Edition, New York, N.Y., P.750, (Wiley & Sons).

Mamimine, P. (2003). Administration by Consensus: A Quest for Client for Client-centered Institutional Structures for Land Administration in Zimbabwe. Land Reform Existing Opportunities and Obstacles. Zimbabwe, Land Tenure Center. .

McLaughlin, J.D. and Nichols. (1989 ). S.E. Resource Management: The Land Administration and Cadastral Systems Component, In: Surveying and Mapping, No. 2, p. 77-86.

MOA. (2013a). R. In *ural Land Certification and Administration SLM Knowledge Base. Ministry of Agriculture, Ethiopia http://www.slmethiopia.info.et/index.php/aboutus/program-components/rural-land-certification (accessed 15.02.13).*

MOA. (2013b). Development of rural land administration system (Amharic language). Land Administration and Land Use Directorate. Ministry of Agriculture, Ethiopia.

MOLA. (1996). Meeting of Officials on Land Administration, Statement on Land Administration, Geneva, February 26-27, 1996, http://www.sigov.si/mola (visited 20 October 1999) .

Navratil, G. ((2011)). Cadastral boundaries: Benefits of complexity. URISA Journal, 23(1), 19-27. Retrieved from http://www.scopus.com. .

REILA. (2016). Operations manual for imagery based systematic 2nd level land registration of rural areas in Ethiopia. Responsible and Innovative Land Administration project, Ethiopia. .

Roussos, N. C. (1993). Objectives and Technical Issues for the Proposed Cyprus land Information System, In: Computer application to the cadastre and land registration in the Near East, Rome: FAO, p. 102-131.

Shewakena A., & David H.,. (2015). "ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY" The World Bank - Washington DC/USA.

Twaroch, Ch. and Muggenhuber, G. (1997). Evolution of Land Registration and Cadastre; Case study: Austria, In: Lecture material Workshop F, JEC GI, Vienna p. F.3 - F.16.

UN. (1996a). United Nations, Report of the United Nations Interregional Meeting of Experts on the Cadastre, Bogor.

UN-ECE. (2005). Land Administration in the UNECE Region: Development Trends and Main Principles (ECE/HBP/140). United Nations Economic Commission for Europe, New York/Geneva.

Williamson, I. (1996). Cadastral reform - An Australian vision for the 1990s, In: Kadaster in Perspectief (Henssen-Bundel) [Cadastre in Perspective (Henssen-Retirement Book)], Apeldoorn, p. 175-191.

Wolf R. (1974). Elements of Photogrammetry, McGraw-Hill, Kogakusha, Ltd, Japan.

Yesmaw. (n.d.). *Towards Automatic Cadastral Boundary Mapping From Satellite Imagery. MSc. Thesis in Land Administration, Enschede/Netherland . .* 2016.

Yomralıoglu. (2005). Corafi Bilgi Sistemleri Temel Kavramlar ve Uygulamalar (In Turkish), Third Edition, 2005, Trabzon-Turkey (ber Offset pres).

Zevenbergen, J. (2009). Land Administration: To See the Change from Day to Day. Enschede,: International Institute for Geo-Information Science and Earth Observation. .

Zevenbergen, J., & Bennett, R. (2015). The Visible Boundary: More Than Just a Line Between Coordinates. Retrieved from https://www.geotechrwanda2015.com/wp-content/uploads/2015/12/59_Jaap-Zevenbergen_bennett.pdf. .

# APPENDIX-A: Overlap parcels

Map of digitized parcels over the orthophotos(own creation)

## APPENDIX-B: Questionnaires for land experts

These in-depth interview questionnaires are prepared for academic purpose and for the partial fulfillment of MSc program in Land Administration and Management. Your response is highly valued and contributes a lot for the accuracy of the final findings of the study. Therefore, you are kindly requested to fill the interview questionnaires carefully.

***I Thank You in Advance for Your Collaboration!!***

**GENERAL INFORMATION**

1. **Region: ------------** zone: **-------------** woreda: **--------------** kebele: **-------------**
2. **Sex:** A) male B) female
3. **Your institution:**_________________________
4. **Level of Education:** ______________________
5. **Qualification:**__________________________
6. **Your position:** ________________________
7. **Work experience in land related areas:** ______________________

**Questions related to procedures of imagery-based land registration**

**General**

1) What is your opinion about the implementation imagery-based systematic 2nd level rural land registration in the region?
2) Can you please explain about the progress of the program in terms of its coverage in the region?
3) Is there any official guideline or operational manual used to perform the operation?
   A. Yes
   B. No
   C. Other (specify)
4) If your answer is yes, explain about it……………………..
5) Does the program implemented by the qualified professionals?
   A. Yes
   B. No
   C. Other (specify)
6) If your answer is yes, please explain about their roles and responsibilities? ……………………..
7) Does the necessary resources and facilities fulfilled for the program?
   A. Yes
   B. No
   C. Other (specify)

8) Do you think the procedures and methods employed in the current imagery-based land registration process suitable? ………………………………………………………………………………….
9) Can you please explain how to handover and maintenance of imagery-based cadastral data set in your organization?
   - 9.1. Digital cadastral files
   - 9.2. Maps
   - 9.3. Field forms, and
   - 9.4. backup requirements
10) What can be improved to the imagery-based land registration program from your perspective? ……………………………………………………………………………………………………………

**Image acquisition and preparation**

1) How do you acquire the imagery (satellite or aerial) and who approve and certify the imagery?..........................................................................................................................................
2) How does the area/ Kebele selected to be mapped and where does the approximate boundaries obtained?.........................................................................................................................
3) In related to Q2, which organization is responsible to produce Kebele baseline/index map and field map production? ……………………………………………………………………………...
4) How does scale of the field map determined? .......................................................................................
5) What is our opinion about the image preparation/ field map production? ............................

**Parcel boundary demarcation**

1) What kinds of tools and equipment's employed to perform parcel boundary demarcation using orthophotos? ..............................................................................................................
2) Currently what kind of ground surveying methods are employed in combination with orthophotos/ FMs when features;

2.1. Both visible in the FM and in the ground? ……………………………………………………………..

2.2. Either visible in the FM or in the ground? ……………………………………………………………

2.3. Neither visible in the FM nor in the ground? ……………………………………………………….

3) Currently how to demarcate parcel boundary when features are;

3.1. Both visible in the FM and in the ground? ........................................................................................

3.2. Either visible in the FM or in the ground? ……………………………………………………………

3.3. Neither visible in the FM nor in the ground? ………………………………………………………

6) What is our opinion about parcel boundary demarcation and mapping as well as the methods of surveying?………………………………………………………………………………………………………………………

7) How is field maps handle in the field and in office before and after of the daily operation? ……………………………………………………………………………………………………………………….
8) Is there a daily field work report and quality control activity? ……………………………………………………..
9) What are the main challenges during the fieldwork operation? ……………………………………………………

**Office editing**

1. Is field maps scanned properly with the appropriate scanner?
   A. Yes
   B. No
   C. Other (specify)
2. Is the procedure of georeferencing function easily performed?
   A. Yes
   B. No
   C. Other (specify)
3. Is digitizing carefully doing based on each boarder corner demarcated with a pen in the field?
   A. Yes
   B. No
   C. Other (specify)
4. How to perform quality control to avoid gaps, overlaps and invalid parcel geometries? ……………………………………………………………………………………………………………..
5. Is the procedure to printing parcel maps using QGIS suitable?
   A. Yes
   B. No
   C. Other (specify)

<u>**Questions related to individual perception: /**</u> **Orthophotos production**

1) Do you agree current imagery-based land registration is suitable for the country?
   ☐ strongly agree ☐ agree ☐ neutral ☐ disagree ☐ strongly disagree
2) Is the procedure to produce parcel map using orthophotos suitable?
   ☐ Strongly agree ☐ agree ☐ neutral ☐ disagree ☐ strongly disagree
3) The process of field map production from ortho-rectified image is suitable?
   ☐ Strongly agree ☐ agree ☐ neutral ☐ disagree ☐ strongly disagree
4) Do you agree that a resolution of field maps is suitable for rural cadastral mapping?
   ☐ strongly agree ☐ agree ☐ neutral ☐ disagree ☐ strongly disagree
5) Do you agree the scale of field maps suitable for rural cadastral mapping?
   ☐ Strongly agree ☐ agree ☐ neutral ☐ disagree ☐ strongly disagree

**Parcel boundary demarcation**

1) Is the procedure to demarcate parcel boundary using orthophotos suitable?

 Strongly agree  agree  neutral  disagree  strongly disagree

2) Do you agree demarcation of land based on features visible both in the FM and in reality is suitable?

 Strongly agree  agree  neutral  disagree  strongly disagree

3) Do you agree demarcation of land based on features visible either in the FM or in reality is suitable?

 Strongly agree  agree  neutral  disagree  strongly disagree

4) Do you agree demarcation of land based on features neither in the FM nor in reality is suitable?

 Strongly agree  agree  neutral  disagree  strongly disagree

**Office data processing**

1) Do you agree scanning operation is easy to perform?

 Strongly agree  agree  neutral  disagree  strongly disagree

2) Do you agree the georeferencing function is suitable to perform?

 Strongly agree  agree  neutral  disagree  strongly disagree

3) Do you agree the digitizing process using QGIS is easy to perform and user friendly?

 Strongly agree  agree  neutral  disagree  strongly disagree

4) Do you agree the quality control of information at all stage is effectively in your organization?

 Strongly agree  agree  neutral  disagree  strongly disagree

5) Current 2$^{nd}$ level registration system is effective and efficient to perform handover and maintenance cadastral dataset?

 Strongly agree  agree  neutral  disagree  strongly disagree