University of Nairobi

School of Engineering

DEPARTMENT OF GEOSPATIAL AND SPACE TECHNOLOGY

Comparison of UAV Mapping of Settlement Scheme with PIDs/RIMs

A Case study of Nyansiongo Settlement Scheme

By

Jeremiah Omae Omeke

F56/12475/2018

A Project submitted in partial fulfillment for the Degree of Master of Science in Geographic Information Systems, in the Department of Geospatial and Space Technology of the University of Nairobi

August 2020

Declaration of originality

Name of student: **Jeremiah Omae Omeke**

Registration: **F56/12475/2018**

College: **Architecture and Engineering**

Faculty/School/Institute: **School of Engineering**

Department: **Geospatial and Space Technology**

Course Name: Master of Science in Geographic Information Systems

Title of Work: **Comparison of UAV Mapping of Settlement Scheme with PIDs/RIMs**

A Case study of Nyansiongo Settlement Scheme

1) I understand what plagiarism is and I'm aware of the university policy in this regard

2) I declare that this research project is my original work and has not been submitted elsewhere for examination, the award of a degree, or publication. Where other works or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements

3) I have not sought or used the services of any professional agencies to produce this work

4) I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her work

5) I understand that any false claim in respect of this work shall result in disciplinary action in accordance with University of Nairobi anti-plagiarism policy

Signature:

Date:

Turn it in a report summary

STUDENT:

Jeremiah Omae Omeke: SIGNATURE...................................DATE....................................

SUPERVISOR:

Mr. B. M. OKUMU   ……………………..   …………………

                                          Signature   Date

PROJECT_1

Dedication

I dedicate this project to my wife Robi, our daughter Olive as well as my mother Magoma.

Abstract

The study discusses examining the Parcels digitized from RIMs compared with the Parcels derived from the UAV Ortho-rectified images of the same area. Nyansiongo Settlement Scheme has been used as an example to determine the possible variations that exist between the two different techniques of the survey. It comprises of the acquiring of the RIMs maps from the Survey Office, scanning them to obtain the maps in digital format. The scanned RIM is then imported in the ArcGIS environment to be geo-referenced and then digitized. The parcels that were obtained were then used to be compared with UAV-derived imagery of the same area. The UAV derive Imagery was acquired by first, having reconnaissance in the field that is the Nyansiongo settlement scheme.

In the establishment of control points that were to be used by UAV Technology, the Real-Time Kinematic GPS was used. RTK GPS base was used to establish the control points together with the base CORS-Network at Kisii town station RTCM (Radio Technical Commission of Maritime). The flight planning was done with the PIX4D software for the area of study. Then the UAV that is the Phantom UAV was used to take the aerial survey to capture the imagery of the 5cm resolution of the part of the Settlement scheme that was used in the study. The flight altitude or height was 110m and a sufficient overlap of 75% side overlap and 80% forward overlap. The images that were obtained from the UAV were post-processed using UASMaster software that is automated to generate the Ortho-rectified image of the study area. The Ortho-rectified image from the UAV was digitized in ArcGIS software by overlaying it with the scanned and Geo-referenced RIM to determine the boundary line of the parcels. The UAV digitized parcels were referred to as UAV derived parcels while those from RIM were referred to as Digitized RIM parcels. A shift was identified when the two sets of data were overlaid. That is the UAV derived parcels with that of RIM digitized parcels.

 In comparison between the UAV derive parcels with that of RIM digitized parcels a shift in terms of perimeter and area were measured. The shift in the perimeter is 558.31 Meters while as the shift in the area of the same section was 6,080.82Square Meters. This was as a result of the level of technology involved in surveying the same settlement scheme is different. The traditional method used in surveying the settlement scheme involved the use

of aerial photography methods; boundaries are marked on the enlarged photographs. Through Photogrammetric processes, RIMs are generated. The UAV technology is of high accuracy and the imagery obtained from it was 5cm spatial resolution as compared with the conventional methods that were used to generate the RIMs.

Table of Contents

List of Figures

CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 Definition of Settlement Scheme

The settlement scheme refers to the land that has been set aside by the government for citizens mainly to address the issue of landlessness.

1.1.2 History of Settlement Schemes

Historically, settlement schemes in Kenya have been created since 1963 at independence. The farms that were occupied by expatriate settlers were converted to a large program of settlement schemes. For example, the Million Acre Settlement scheme as well as the Kenyan Coastal settlement scheme that was initiated in 1963-1970s. The settlement schemes in the Nyanza region include the following; the low-density settlement scheme or Yeoman settlement scheme, the High-density settlement schemes, and the Sugar settlement schemes. The Low density and High-density settlement schemes are in Gusii land. They include the Nyansiongo settlement scheme, Matutu settlement scheme, Gesima settlement Scheme, and Isoge settlement schemes. The Sugar settlement scheme is in Luo land. For example Nyando, God Abuoro settlement schemes in Kisumu (Wayumba, 2019).

1.1.3 Purpose of the establishment of Settlement Schemes

The goal of the establishment of settlement schemes at independence 1963 in Kenya is to settle displaced persons. Similarly, it was to provide land for landless families and ease population pressure in the native reserves. It also aimed at issuing land to squatters that were present by then in the country. In addition, the settlement schemes were considered as a mechanism of increasing production in agriculture. Alternatively, the settlement schemes were regarded as a method of developing rural areas. The rural areas were developed through optimum utilization of rural and physical developments. Nyansiongo settlement scheme was established to resettle some selected individuals from different communities at independence in 1963. Thus, ease the pressure of land that was prevailing from the two current counties that are Kisii and Nyamira.

Also, it was to provide farmers with development loans to enhance high productivity farming. Equally, the settlement scheme had benefits like boosting the country to have sufficient self-production of food. Further, cash crops like tea from the settlement scheme enabled export to earn foreign exchange to the country. Therefore, as illustrated by (Wayumba, 2013), transforming the farmers from traditional subsistence farming to modern market-oriented producers.

1.1.4 Traditional mapping methods of Settlement Schemes

Different methods were used in surveying the settlement schemes. For example, farm survey, land valuation, land development, measurements of plots, and the provision of conservation services. The farm boundaries were indicated on a scale of 1:50,000 topo-sheets. The measurements of the plots were done by junior surveyors who had minimum training in survey measurements. These junior surveyors used simple types of equipment like chains, compass, and plane tables in demarcating the plot boundaries. The farm owners were encouraged to plant edges of the fences around their farms. After air visible, an aerial survey was done to produce photographs of the settlement areas. In generating preliminary Index Maps, the geometrical errors like tilt and relief of aerial photographs were not corrected.

In order to hasten the land registration processes in Kenya, the use of preliminary Index Diagrams (PIDs) was adopted. Preliminary Index Diagrams (PIDs) were mostly adopted in rural areas. They were easy to produce by the use of simple surveying techniques together with air survey methods. The use of preliminary Index Diagrams (PIDs) was intended to be a temporary measure. Thus, to speed up the pending of land registration as they prepared to have a more accurate document of surveys. These maps were created by land officers using two main methods independently or jointly. The methods are enlargement of aerial photographs and ground survey methods. The preliminary Index Diagrams (PIDs) are generated by undertaking aerial photographs at a scale of 1:12500 or 1:25000 (Siriba et al., 2011).

These photographs are un-rectified and mosaicked. They are enlarged to a scale of 1:2500 or 1:5000. Photo interpreters identify and mark the boundaries of the parcels on the

photographs. An interim map is produced by tracing the marked photographs to be used for registration.

The Registry Index Maps (RIMs) is the main cadastral maps that were prepared for the first registration of land during the adjudication process (Legislature, 2012). During subsequent land subdivisions, they are amended. RIMs are used for identification in the registry the plots on the ground. Similarly, RIMs help to relocate the boundaries of plots in case they are lost. Also, they assist in the effective subdivision of land and also in area calculations of the parcels (Siriba et al., 2011). For every registration district, the RIMs are prepared using ground survey methods.

It is also, divided into registration sections that are identified by unique names. Further, the registration section is subdivided into blocks that are identified by either letters or numbers or both combined. In addition, RIMs have the following information. Location, index, and sheet number, sheet edition, amendment history, plot numbers, and scale. The scale is crucial as there are no dimensions shown on the map for boundaries. The scale is reliable for the map user with the help of a scale ruler to measure distances on the map.

1.1.5 Issues and shortcomings of traditional methods

PIDs are produced from un-rectified photo enlargement manually by the survey of Kenya. The aerial photographs were acquired from aircraft flying at a low altitude of the area that was intended for adjudication. Enlarging aerial photos at a scale of 1:2,500 is then taken to the field for individual boundary demarcation (Ogechi and Odera, 2015). These photographs that are un-rectified, enlarged, marked were returned to the survey office where cartographers transferred every land parcel and attributes onto durafilm that is plastic material. There is the inclusion of parcel area, sheet marginal information, correction of queries to acquire PID product that was used in title processing (Ogechi and Odera, 2015).

The RIMs are generated by either of the two processes that are from an aerial photograph or ground survey. In aerial photography methods, boundaries are marked on the enlarged photographs. Through Photogrammetric processes, RIMs are generated. Similarly, in the ground survey method, an area is allocated by the government. Ground measurements are taken by the surveyors, and then the maps are generated in the survey of Kenya as coordinated from the ground measurements. These maps that are used as cadastral maps are referred to as RIMs.

The issues arising from the use of preliminary Index Diagrams (PIDs) and Registry Index Maps (RIMs) are: The RIMs are not coordinated. But in actual sense, they show the outline of all individual parcels of land within the jurisdiction of the general boundaries (Siriba et al., 2011). A distinct property of line boundaries is inaccurate and not legally binding but only indicative. The preliminary Index Diagrams (PIDs) are still in use to date. This leads to unsubstantial as well as old- fashioned information for the management of land survey and transaction processes (Ondulo et al., 2015). The preliminary Index Diagrams (PIDs) limitations are: within a particular index map sheet, the scale is non-uniform. They have unreliable distances and areas that are calculated by the use of these map sheets.

Further, the preliminary Index Diagrams (PIDs) have distortions sometimes of the land parcels' shapes. Hence, PIDs have not been controlled either way.

Table 1. 1 Types of cadastral maps with their positional accuracies and common scales (Siriba et al., 2011)

Type of Map	Common Scales	Positional accuracy
Survey Plans/Deed Plans	1/500 – 1/5000	±0.03 m
Registry Index Maps (RIM)	1/10000	±0.30 m
Demarcation maps	1/2500	variable
Preliminary Index Diagrams (PID)	1/2500 – 1/5000	variable
RIM Range (Provisional)	1/50000	± 10 m

1.2 New Technique in the mapping of Settlement Scheme

In terms of measurements of both length and area, RIMs lack an indication of measurements for the individual parcel of land. For instance, if an unworthiness cartographer illegally changes the boundary position it would be difficult to discover the fact (K. Wanyoike: 2001). Due to the scaling of the boundary that is used with the scale ruler in order to determine both the length and area, then the true acreage and position of the parcels are not guaranteed. Similarly, if the RIM is used on its own sorely as the only cadastral map in the processing of field sheets in case of the first edition and also in the case of the second edition for mutation forms, that is the time the measurement of the boundary would be approved (K. Wanyoike: 2001). This is due to the map scale being fixed, and all the amendments are made on the original sheet.

This leads to the creation of a lot of congestion due to changes that continue on resultant consecutive parcels that yield to illegibility. The maintenance of the physical boundary is the success of RIM map in which it relies upon. Thus, the map is changed in case of a conflict between the ground and the map. Some of the RIM maps are perceived as not boundary

authoritative and this has lead to map users' confusion more especially when it has been used to solve boundary disputes in courts of law (K. Wanyoike: 2001).

The use of new technologies in addressing these issues is prominent. This study is to investigate the use of a new system in land management. It facilitates faster creation of reliable, attested, and accurate maps of the cadastral survey. This is via high imagery of Unmanned Aerial Vehicle (UAV) that is Ortho-rectified with a high spatial resolution (Hellen, 2010). Similarly, it's possible to obtain the complete attribute data as well as coordinates with mobile technology. Thus, it justifies that it is possible to improve the settlement schemes in terms of the quality of spatial data. To resolve this challenge, according to (Ondulo et al., 2015), recommended that the use of high spatial resolution imagery is necessary. For example, satellite imagery, or UAV imagery.

These imageries are prominent as they have useful sources of land information, especially in the adjudication process. Maps especially cadastral maps like RIMs have been used for land registration in settlement schemes. This is because the boundaries of each parcel on the map are a clear reflection of the physical boundary on the ground of the same area on the map. A cadastral survey is the bases for accurate and reliable registration and geo-referencing, especially in title registration. Each parcel is illustrated on a map with accurate cadastral index maps and well-defined boundaries. The study equally seeks to investigate the possibility of using the combination of modern technologies like Unmanned Aerial Vehicle (UAV), Global Positioning System (GPS), and digital mapping. This technology is used in the development of a more accurate, reliable approach to establishing boundaries and geo-referencing of parcels.

There has been a problem in title registration for land parcels in settlement schemes under Registered Land Act cap 281 of 1919 that is now repealed (RLA). This is a result of a lack of reliable and accurate large scale maps. The study demonstrates the imagery obtained from UAV with high spatial resolution can be applied as feed-in for derived surveying methodology. This is illustrated by (Wayumba, 2019), the emergency of modern Geospatial technologies like UAV, Digital Photogrammetry, and GNSS. He recommends the use of modern technology to process Ortho-rectified fully aerial imagery at high momentum in the

field of survey. For instance, in the settlement schemes regions as well as other rural areas unlike the former methods of survey.

1.3 Problem Statement

There have been challenges in title registration for settlement schemes in Kenya under the Registered Land Act 300 of 1963 that is now repealed (RLA). This has been caused by the use of Preliminary Index Diagrams (PIDs) in the mapping of rural and settlement schemes in Kenya. The Preliminary Index Diagrams (PIDs) limitations include a non-uniform scale within a particular index map sheet. Unreliable distances and areas that are calculated by the use of these map sheets. Distortions sometimes of the land parcels' shape (Siriba et al., 2011). Thus, Preliminary Index Diagrams (PIDs) are not controlled either way. Similarly, Registry Index Maps (RIMs) are not coordinated. But show the outline of all individual parcels of land within the jurisdiction of the general boundaries. A distinct property of line boundaries is inaccurate and only indicative of not legally binding.

Hence, the use of Unmanned Aerial Vehicles (UAVs) in the mapping of settlement schemes as a source of data. Unmanned Aerial Vehicle (UAV) generated imagery as a source of data that has accurate maps for registration of settlement schemes should be considered.

1.4 Objectives

1.4.1 Main objective

To validate the application and use of UAV acquired imagery vis-à-vis existing PIDs/RIMs in Mapping of Settlement Scheme

1.4.2 Specific objectives

i) To document the mapping processes in settlement schemes
ii) To fly and generate high spatial resolution Ortho-photos in the area of study
iii) To determine the possible extent of shifts between the UAV generated boundaries and the PIDs/RIMs boundaries

1.5 Methodology

It entails the use of all the materials and types of equipment in data collection for the project of the study area. For instance, the collection of RIMs maps from the survey offices in Kisii County, scanning, and digitization of the scanned RIMs, and geo-referencing using ArcGIS. Reconnaissance Survey in the study area, search for existing control points with handheld GPS. Establishment of new control points with Real-Time Kinematic (RTK) GPS and UAV mapping of the area. Then, Process of data with UAS Master Software to obtain Ortho-rectified imagery. The RIM was chosen for the settlement scheme in this project due to its availability in the survey of Kenya unlike the PIDs of the same area. This is because the PIDs after aerial re-fly of the same area to create a more rectified image of the settlement scheme, the PIDs were done away with. There are two methods in which RIMs are generated. These are from an aerial photograph method or ground survey method. In aerial photography methods, boundaries are marked on the enlarged photographs. Through Photogrammetric processes, RIMs are generated. The nominal positional accuracy of RIMs is 30 cm for settlement schemes.

1.6 Justification for the study

The landowners of either freehold land or leaseholder land by rent are obligated to payment of land tax as well as rent respectively to the government. This is to enhance its livelihood of meeting its planning, for instance, the four big agenda of the current government of Kenya. Thus, affordable housing, improved agriculture, universal health care, and improved manufacturing industries (Ministry of Lands and Physical Planning, 2017). Similarly, it is unfortunate that land management and administration in Kenya are facing major challenges. For example, outdated as well as missing cadastral information, inefficient as well as uncoordinated land taxation processes and insecurity of tenure, are inadequate.

With the aid of UAV mapping especially in settlement schemes to generate Ortho-rectified images or photographs would be integrated. Also, to be used to generate accurate and reliable information on each parcel of land as they are coordinated. This will ease the problem of land management and administration as the government will have reliable information for land taxation to generate income to foster its four big agendas.

1.7 Scope and limitation of the study

This study involves the use of UAV imagery of parcels of land to compare their areas and boundaries with that of existing land registration, Registry Index Maps (RIMs) of the Nyansiongo settlement scheme in Nyamira County. The method that was used to create RIMs for Nyansiongo Settlement Scheme is aerial photography methods. The use of UAV imagery helps in analyzing the significant changes that exist between the Registry Index Maps (RIMs) and UAV Ortho-rectified imageries. The handheld GPS was used in searching for existing control points, the use of Real-Time Kinematic (RTK) GPS in the establishment of new control points. The control points were used in flight planning and orientation of the Unmanned Aerial Vehicle (UAV) mapping. The limitations encountered are financial constraints in the use of the UAV for mapping. The market rate for the UAV is Ksh 5,000 per acre. As the size of the area to be mapped by the UAV enlarges the cost increases in mapping.

1.8 Organization of the project

The project is organized into six chapters sequentially from chapter one to chapter six. Chapter one entails the introduction, background of the study, problem statement, objectives, methodology, justification, scope, and limitations of the study and organization of the project. Chapter two contains the literature review while Chapter three contains the methodology, data sources, instruments, and materials used in data collection and processing. Chapter four entails the results of the data processed and Chapter five comprises of the analysis and discussion. Finally, Chapter six entails conclusions and recommendations and chapter eight references that comprise of the work cited.

CHAPTER 2: LITERATURE REVIEW

2.1 Settlement Schemes in Kenya

The provisions of maps that have analogous of patchwork qualities in terms of position have to lead to incomplete land registration nation-wide. This is due to the unreliability of integration coverage. Thus, since independence, this country Kenya has no nationwide defined policy but incompatible operation land laws. The vehicle has resulted in the breakdown of land administration, fragmentation as well as poverty. This has yielded to management and land administration complexity. Therefore, this has resulted in insecurity of tenure, social and political conflicts, diminished land quality productivity, landlessness, and squattering (Siriba et al., 2011).

Kenya has incomplete cadastre up to now. This is because the cadastral maps that are available are from different scales; coordinate systems and the surveying methods used are different. This is a result of the existence of different regulations and laws of the land in this country. Land management refers to mechanisms and established goals that impact the use of land to achieve policy objectives desired.

In Kenya, not all land in this county is registered. This happens as a result of a dual application of deed and title systems of land registration. Together with the Torrens and English approaches that allowed the use of land registration in fixed boundary and general boundary for property identification in Kenya (Siriba et al., 2011).

2.1.1 Historical land ownership

2.1.1.1 The East Africa colonization

According to (Wilson, 2016), the Berlin conference was held from 1884 to 1885 in German under chancellor Otto Von Bismarck. The Berlin conference agreed that no European power had to claim the whole of Africa has its own. This is due to the effective principle of occupation that was established by the subsequent acts of the Berlin conference. The principle states that other states should be informed on occupying a given part of Africa. Further (Wilson, 2016), illustrates that the principles generally stipulated ways of colonizing

Africa by the then superpower states. For instance, Kenya and Uganda were occupied by Britain and declared protectorates in 18 95 and 1894 respectively. Uganda was renamed Uganda Territory and Kenya was referred to as the British East Africa Territory. Similarly, Tanzania was renamed as German East Africa Protectorate (Wayumba, 2019).

In the year 1888, Sir William Mackinnon became the first administrator of the East Africa Territory under the (IBEACo). This was abased Bombay referred to as the Imperial British East Africa Company (Wayumba, 2019). As illustrated by (Wayumba, 2019), IBEACo's objectives were to manage the ten-mile coastal strip administration. This was through the use of treaty or purchase. The company had to acquire land territories from the native local chiefs within the British sphere of influence. It affected the following; levy taxes, grant licenses, construct roads, and public works as well as the establishment of civil administration. Also, judicial administration in the company's rule of the acquired districts was established. In the year 1894, a set of land regulations were published by the company. This enabled the country to have leases that are within a span of 21 years that were renewable (Wilson, 2016).

Further, (Wayumba, 2019) suggested that the settlers were awarded a variety of leases. For example, the lease for agriculture (2000 acres), leases for homestead (100 acres), and that of grazing (20,000). This act caused controversy issues to customary rights. It restricted their movements as well as the use of land in the pre-independence.

2.1.1.2 Establishment of the White Highlands in Kenya

According to (Wilson, 2016), the Kenya highlands had favorable climatic conditions for agriculture. Approximately 220, 000 acres of land were alienated from the indigenous to the white settlers. The settlers were enrolled from Australia, South Africa, New Zealand, and Europe. This was implemented by the second governor of the protectorate known as Charles Elliot in the year 1901. Charles Elliot worked with Lord Delamere.

The beneficiaries of this include

  i. The syndicate of East Africa (320,000 acres) that was an offshoot of South Africa Rand Corporation.
  ii. the syndicate of Uplands of East Africa limited (350,000 acres),

iii. Lord Delamere (150,000 acres) and

iv. The concession of Grogan Forest (200,000 acres).

Between 1905 to1914, the European settlers had alienated five million acres of land from natives. Hence the term white highlands as they started to dominate in Kenya (Wayumba, 2019).

The introduction of the ex-soldiers settlement scheme in the white highlands was enacted. This was after the First World War that ended in 1919 as a means of provision of security to the settlers. This happened because the African soldiers that returned from the war. The African soldiers notified that the European upon disarmed of the firearms is as weak as any other person (Wayumba, 2019). African land of about 12,810 square kilometers was appropriated by the governor to the ex-soldiers settlement scheme. A total of 9000 settlers were in Kenya by 1919. The process of alienation of the African land of 7.5 million continued up to 1963. Kenya attained its independence in 1963. These plots that were taken from Africans were surveyed to the accuracy of the cadastre standards of 1903. This cadastre was tied to the national geodetic network. This was through observations of triangulations that were similarly tied to the African geodetic network through Uganda (Wilson, 2016).

It happened through the registration of Title Act Cap 281 of 1919 that is now repealed. These cadastral surveys were checked by the Director of Surveys and authenticated. This was in order to enhance the assurance of deed plans that took place in1920 for registering of white highlands. Earlier on, the parcels of white highlands were registered by the government under the system known as the deed registration. This was similar to the crown lands ordinance, and registration of documents act cap 285 of 1901 that awarded leases of 99 years. The government lands act cap 280 was enacted in 1915 when the government repealed the crown lands ordinance. This allowed the commissioner of lands issue 999, as well as 9999 years, leases to white settlers for agriculture (Wayumba, 2019).

The Africans lived in reserves. The reserves were unfavorable due to overpopulation, forced labor, payment of hut-tax, and shortage of food supply. As suggested by (Wayumba, 2019), this situation led to discontent amongst the communities of Africans. It also made the

European government to notify that the white settlers will soon lose the benefits of security. Thus, unless the Africans were given a form of stable arrangement of property were going to revolt. The rising status of the African reserves jurisdiction safeguarded the white settlers.
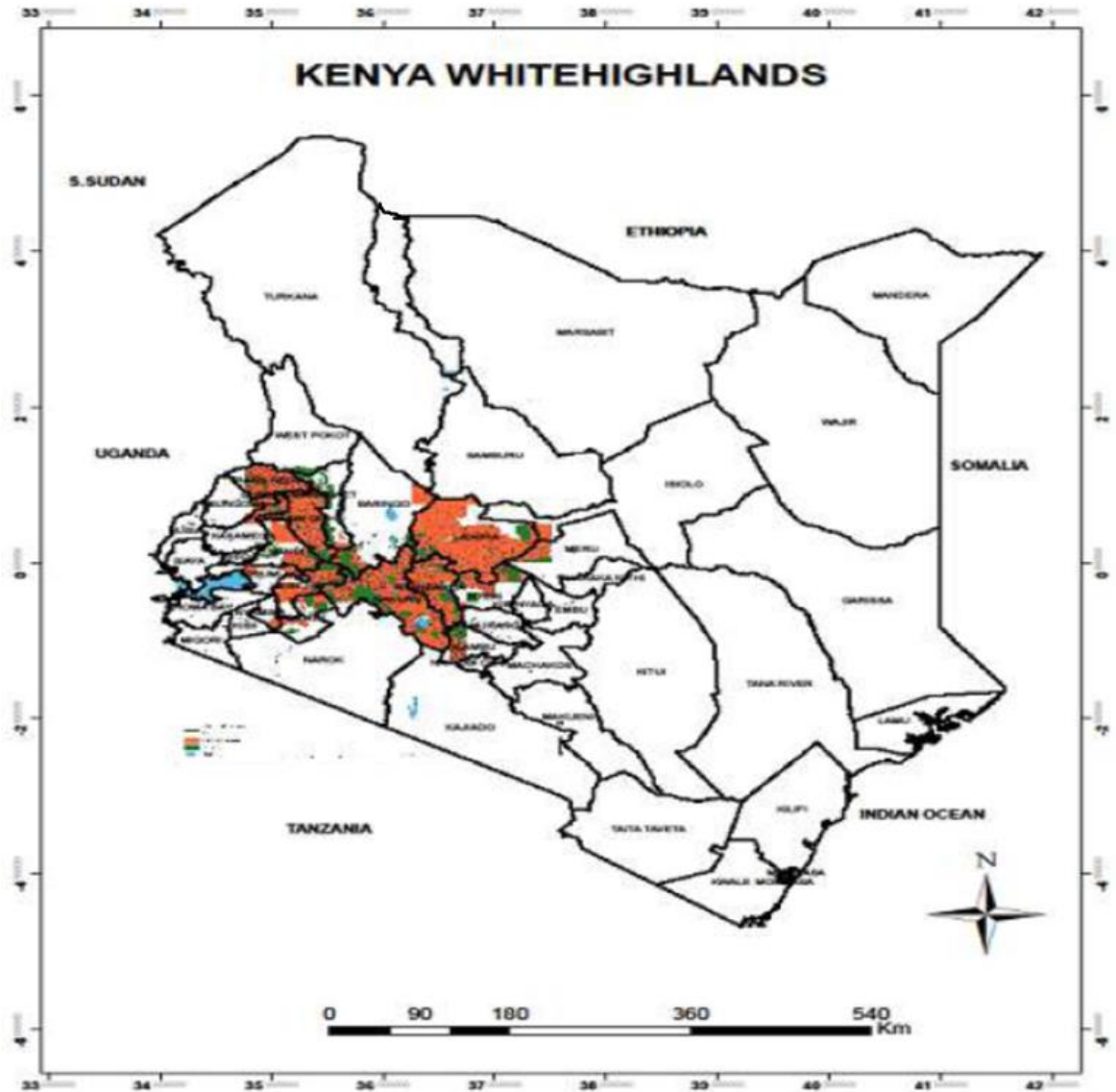
Figure 2. 1 A map of White Highland in Kenya (Wayumba, 2019)

2.1.1.3 Land Redistribution

Land Redistribution was done through a settlement program. The lands from the British settlers were bought by the government then redistributed to indigenous citizens. This was done through individualization of tenure at independence.

13

2.1.1.4 Individualization of African Tenure

According to (Harrison, 2012), there had been three significant regimes in Kenya at independence. Namely the customary land act, the Indian transfer of property act of the year 1882, and the registered land act, cap 300 of 1963. There is a complex infrastructure. In terms of administrative organizations that apportion land and other related matters. The main role of the infrastructure was to conserve a duplicate system of relationships in economics. That comprises of key export from white settlers that were the minority. Also, to the high population of Africans subsistence that was peasants (Harrison, 2012). The formation of the Swynnerton plan in 1954 had a five-year plan. It intended to develop intensified African agriculture by issuing title deeds to African individuals. Also, it encompassed land adjudication for the first time in land information history in Kenya.

2.1.2 Settlement Schemes

As illustrated by (Jones & Sorrenson, 2001), after the first Lancaster house conference, in 1960 the white highlands were opened to Africans. This was enacted by the Kenya Order in the council that allowed all races to occupy the white highlands. Hence the creation of African settlement schemes for the first time in Kenya. In 1906, Lord Elgin had declared that exclusively the white highlands belonged to only white people. Excluding other races like Asians, Indians, and Africans (Jones & Sorrenson, 2001). It was announced in 1960 unexpectedly and suddenly by the British government that Kenya would be under African rule in political independence. There was a shock from both leaders. That is from African politics as well as those from European leaders by the verdict.

Thus, in regard to white highlands decolonization, the political leaders from African communities gathered support from Africans (Harrison, 2012).

The program of land resettlement scheme strategy was created by the British government. This was so as to reserve the white highlands, as was promised by the British government. The white settlers to move Kenya into a political independence decision (Jones & Sorrenson, 2001). Thus, this plan was hoped by Ian Macleod. Who was the colonial secretary that the common white settlers would aid in the cooperation of the transfer of

power without any racial strife? The economy of the settlers was to remain intact without being dismantled (Jones & Sorrenson, 2001).

Hence, the end result was a settlement plan. The settlement plan was independent. It provided easy land redistribution in areas of settlers without racial segregation to ownership of land. Also, it gave a provision of property rights safeguard that was acquired during the colonial era (Harrison, 2012). This was the main principle of the establishment of diverse settlement schemes in Kenya, earlier 1960s. For example, the Yeoman settlement scheme, one million acre settlement scheme, and Z settlement schemes. Similarly, African elites that were in power were introduced to this plan. This was to ensure continuity of flow of machinery of state to the settler economy (Dakeyne, 2004).

2.1.2.1 Settlement Schemes in Kenya

2.1.2.1.1 The Low-Density Scheme or the Yeoman Scheme
In 1960, World Bank-financed families of over 20,000 of all races so as to be resettled in settlement schemes. This led to the establishment of a body known as the Land Development and settlement Board. Similarly, the bank also offered credit facilities between 1961- 1965 to large scale farmers and landowners. This was to purchase both large and medium farms of 229 from the white settlers (Jones & Sorrenson, 2001). Therefore, 5000 farmers who were experienced, in the first phase were enabled to purchase the farms. This was through the support from the British government, corporation of commonwealth development, and World Bank. The Yeoman scheme aimed at $280 per annum savings for the farmers. It was after all expenses of repayment of the loan as well as operating costs (Dakeyne, 2004).

It also targeted the purchase of 240,000 acres of land parcels from the white highlands. Then, be subdivided as well as distributed into 100- acre land to a specific group of Africans. They were to work hand in hand with the whites (Dakeyne, 2004). The project never took off as expected. Thus it changed its name to Assisted Farmers Scheme in 1961. This formed part of negotiations to independence as the Million-Acre Settlement Scheme. So that it can be received by the incoming government of Kenyatta. It was to be funded by the British government and the World Bank. The loans covered 90% of the sale price. They

were to be paid at a period of 10 years with an interest rate of 6.5% grants. These were given together with the issuing of titles for their farms (Harrison, 2012).

2.1.2.1.2 The Million Acre Settlement Scheme

The Million Acre Settlement Scheme is aimed at the endorsement of systematic and fast ownership transfer of farms. They were owned by the white settlers to the Africans for those whites that were leaving the country after independence (Jones & Sorrenson, 2001). The Million Acre scheme was based on a willing seller/ willing buyer. The British government facilitates the loans to both small and medium holdings summing to 1.15 million acres of parcels of land. The beneficiaries would be able to repay as well as pay cash. Similarly, the million-acre scheme was considered to be for unemployed Africans. Those that were landless as well as under-employed. But were practicing mixed farming in areas that were extensive. Generally, these areas were approximately 2.5 million white settlers' acres of land.

The high density of 200,000 was planned to be purchased through British government grants and loans per annum (Dakeyne, 2004). Approximately, families of about 10,000 had been settled. This was in areas of high-density white highlands regions in 1964. The low density of 30,000 acres of the settlement was to be financed by colonial development corporation and World Bank. In 1964 families of about 10,000 had been settled in the white highlands (Dakeyne, 2004).

2.1.2.1.3 The 'Z' plots –a 100 acres approximately having a Permanent House

The infiltration commencement of the 'Z' plots scheme is in 1964. The order was given by the president. That those 100 acres that were surrounded with colonial houses be reserved. They were reserved for distinguished individuals in the then government coexistence with the needy farmers (Jones & Sorrenson, 2001). This settlement scheme 'Z' plot was unfamiliar with the British government. That had given loans to purchase the white highlands that had a house together with 100 acres of land. Equally, the 'Z' plot aimed at using these farms as centers of demonstration. They were within all other settlement schemes since they had houses in them. Examples of 'Z' plots settlement scheme is the Liavo settlement scheme in TransNzoia and OlKalou Salient settlement scheme in Nyandarua (Dakeyne, 2004).

2.1.2.1.4 Haraka Settlement Schemes

As suggested by (Harrison, 2012), Haraka settlement schemes were initiated towards the end of the 1960s. This was to settle squatters of landless people by a cash program of the commissioner of squatters. There was the establishment of a land board. It was given the mandate to check mismanaged white highlands. The board then hands them to Settlement Fund Trustees that allocated these parcels of land to squatters. Examples of Haraka settlement schemes are Kandoo in Uasin Gishu and Itanga in Yatta (Dakeyne, 2004).

2.1.2.1.5 High-Density Schemes

According to (Jones & Sorrenson, 2001), the high-density settlement scheme targeted the people of high income. They ranged between 60 pounds to 70 pounds Per annum as the settlers were intended to be landless. In the years 1962 and 1963, the rule of law was stacked by the board. Thus, the farm laborers in good condition and region bought by the government were prioritized in selection (Jones & Sorrenson, 2001). The cost of land in the High-density scheme was £7.5. The provincial administration selected the settlers. The areas were semi-ranching land that was purchased in the Akamba settlement scheme in Machakos. The cost of land included the buildings in it as well as the improvements. This was in terms of permanent structures and had acreage of 6-10 acres area size. An example includes Ntirimiti in the Meru settlement scheme (Subbo, 2014).

2.1.2.1.6 Compassionate Settlement Schemes

The compassionate settlement schemes refer to the schemes that were purchased by the government from the white settlers. These settlers were unable to manage them because of various reasons. These include the old age, sickness, financial difficulties as well as risks of insecurity from Africans (Jones & Sorrenson, 2001). These farms were bought using funds from the United Kingdom board. This board represented white farmers through a committee of local agriculture. The committee was in charge of the selection of the order of priority and names. These farms were to be bought by the settlement board, the ministry, and the land development board. Approximately 500,000 acres had been bought in the year 1963 for compassionate schemes (Redkey & Sorrenson, 2015).

2.1.2.1.7 Sugar Settlement Schemes

As illustrated by (Wayumba, 2019), Settlement Fund Trustees (SFT) controlled the sugar settlement schemes. The workers had small farms, for instance, Nyando, God Abuoro settlement schemes in Kisumu. Plots of 10 acres, as well as sub-plots of 2 acres, were allocated to the settlers. These plots were plantation of sugarcane and residential areas respectively (Subbo, 2014).

2.1.2.1.8 Shirika Settlement Schemes

According to (Jones & Sorrenson, 2001), the Shirika settlement scheme started in 1971. The Settlement Fund Trustees (SFT) planned to settle individuals. This was through the basis of cooperatives or groups. These were farms the government acquired and converted them to programs of large farm management. In this case, the workers were selected by the government as employees on these farms. Each family from these workers was given 2.5 acres of land within the farms. They were to carry out their subsistence farming. The principal farm was commercialized and headed by a farm manager that was competent (Jones & Sorrenson, 2001).

2.1.2.1.9 Squatter Settlement Schemes

The individuals that occupy a given land that legally do not own or that belongs to other individuals or government are termed as squatters. Since the early 1960s, squatter problems have been contagious. This is particularly in the Coast, the central part of Eastern and Rift valley regions. This illegal squatting challenge leads to the creation of the special commissioner of squatters post by the central government in 1965. But this was later abolished in 1971 because its role was directed to the department of settlement (Bates & Sorrenson, 2004). The government established a different program. The program had the goal of regularizing and identifying squatters on government land. This took place in 1986, especially in the coastal region. This program is ongoing. The squatters are regularized reserved land meant for this purpose by the lands commissioner (Dakeyne, 2004).

2.1.2.2 Survey of Settlement Schemes

The following methods were used in the survey of settlement schemes; farm survey, land valuation, land development, and settlement acquisition. For example, measurements of plots as well as the provision of conservation services (Jones & Sorrenson, 2001). A scale of

1:50,000 topo-sheets were used to indicate the boundaries of the farm. The topo-sheets also were showing registration numbers for the areas that were to be purchased. The scale of the maps was incorporated into this data. This is by reducing and redrawing them. The measurements of the plots were done by surveyors from the ministry of agriculture. These surveyors were junior officers with minimum survey training. The training encompassed measurements. The surveyors were using the simple equipment of the survey.

For example, a chain and a compass to demarcate on the ground the settlement schemes for perimeter cut out for facing by the tractors (Bates & Sorrenson, 2004). There was waiting for the growth of the planted hedges of the fences and being air-visible. Survey aerial photographs of the settlement schemes were then taken when the fences were air-visible. This was to help in plot areas computations and other physical planning for different infrastructural developments. The geometric errors, of aerial photographs, were not corrected like tilt and relief. This is due to no Ortho-rectification was done. The technology level of that time was suitable for the work at hand thus, the Fit-For-Purpose technique (Redkey & Sorrenson, 2015).

2.1.2.3 Achievements of Settlement Schemes
The prime achievements of white highlands decolonization are: there was gigantic and universal African land registration. There was no universal land registration since 1895 when Kenya became a British protectorate for the first time. This program acted as the start of the creation of a single land market. The colonial government together with the termination of the customary tenure system of the African that had no title deeds (Jones & Sorrenson, 2001). Alternatively, there was a creation of African farmers' elite gentry. That practiced improved and modern farming by boosting the rural economy. They used these modernized practices in agriculture (Redkey & Sorrenson, 2015).

2.1.2.4 Challenges Settlement Schemes are facing in Kenya

2.1.2.4.1 Population Increase and Degradation of the Environment
There has been quite a series of changes. That has taken place since the creation of settlement schemes in Kenya since the 1960s. This is due to an increase in population. In addition, the degradation of environmental conditions without the increase of existing land.

This resulted in the following parameters: urbanization, climate change, and downturn of the general boundary. Therefore, more individuals striving for land resources that are the same. This has led to a series of subdivisions of land to accommodate them. Equally, the social amenities that were established during the creation of the settlement schemes cannot serve the increase in the population currently (Dakeyne, 2004).

2.1.2.4.2 Peri-Urbanisms and Urbanization

As clarified by (Redkey & Sorrenson, 2015), the areas that were established as centers for the market originally have changed to peri-urban. This is due to an increase in population. It has led to the development of new infrastructure. The quality of the land tenure system, together with the general boundaries, has been compromised. For instance, areas of peri-urban attract an environment of the urban-like complex. It is a mixture of heterogeneous structures and unplanned neighborhoods. Hence causing land disputes, growth of the land market, and conversion of agricultural land to residential land. This has led to the loss of land. Urban new elites have an influence on the land registry without the knowhow of the landowners originally. Similarly, there is the uncertainty that is high in relation to land titles.

This happened especially in the urbanization of settlement schemes. This has promoted multiple rights and overlapping rights that contains interlocking of tenure systems (Taylor, 2006).

2.1.2.4.3 The Problem of General Boundary

According to (Redkey & Sorrenson, 2015), in 1959, the Native Land Registration Ordinance introduced the general boundary concept in Kenya. This was to support the land rights of the newly adjudicated in the previous native reserves. Similarly, the general boundary efficiency was promised to landowners. To plant live edges as visible fences acceptable height to enable air- visible aerial photos survey. They were satisfied with the chief land registrar. The adoption of registry index maps as a registration map in settlement schemes. It was of high accuracy. It was developed from preliminary index maps (PIDs). The aerial photos were acquired at a scale of 1:12,500. Later, these aerial photos were enlarged to a scale of 1:2,500. It was four times larger to enhance Preliminary Index Maps (PIDs) preparation (Jones & Sorrenson, 2001).

The PIDs were obtained from tracing directly parcels of land that were adjudicated. They were from the photo-enlargements that were un-rectified. They were serving as interim scheme maps in acquiring titles quickly. The (PIDs) were undertaken for a while. A re-fly would be done in the settlement schemes to rectify these aerial photos. In order to facilitate more production of cadastral maps that are accurate to secure the land tenure systems (Jones & Sorrenson, 2001). Due to pressure from politics in Kenya, the re-flies were not implemented. Equally, there was a lack of the capacity of technical support in Nairobi for the operations. But, a few of the undertaken aerial photos in the central region of Kenya were sent to London for processing at the time of land consolidation (Taylor, 2006).

The use of PIDs has been continued in use by the government. Especially in settlement schemes for parcels of land registration. This is as a result of the rectification of these maps was not implemented as was required (Redkey & Sorrenson, 2015). Similarly, the registration of settlement schemes has remained provisional. In a situation that has compromised the quality of titles from them. This has caused the reluctance of financial institutions to accept them as a safeguard in the borrowing of money. All the general boundaries' main challenge has been this in Kenya. The expertise in local geospatial is in continuous advocating for re-mapping of them so as to get accurate photographs that are rectified from the aerial surveys. This shall improve the quality of the titles as well as the provision of secure tenure for the farmers (Bates & Sorrenson, 2004).

In Kenya, there is a lack of accurate technologies that are fast in use especially in geospatial. The registration of the general boundary has remained as the approach of Fit-For-Purpose. In developing countries, without proper documentation of land resources, achieving sustainable economic growth is not possible (Taylor, 2006).

2.2 Cadastre in Kenya

According to (Wayumba, 2013), Patterns of land tenure are categorized into three. These are; Government land that is generally 10%. It is mainly vested for the citizens of Kenya by the government as trust land. Examples include all rivers, the government game reserves, lakes, and water catchment land. Private land is also 20%. It is held by either a legal group of persons like cooperative societies and private companies. Also, by individual persons due

to adjudication or from trust lands that are freehold lands or leasehold tenure. According to (Siriba et al., 2011), Community or trust land is 70%. As outlined in the new constitution and land policy, this land is held and vested in by communities. This was on the basis of cultural or ethnic basis as well. For example, the land of these categories are classified as community land; ancestral lands, traditional land that was occupied by hunters, and gathers. Also, county government trust lands like rural public schools and markets.

2.2.1 Cadastral maps

In Kenya, land registration is supported by different kinds of maps which include the following:

The survey plans are normally in numerical form and mainly used for regions of urban areas.

Registry index maps (RIMs) which are general in graphical form and usually used in rural areas localities. The maps for example survey plans and registry index maps are created in the first registration of the land. They are subject to amendment during the processes of subdivision of the same land.

Survey plan and deed plan: Deed plan is produced for each parcel of land in urban areas by tracing it from the survey plan and is majorly based on a fixed boundary survey.

A fixed boundary survey refers to an invisible line that is defined geometrically through an accurate survey that is accurate and legal (Wayumba, 2013).

The deep plan is purely an abstract from the survey plan.

2.2.1.1 Survey Plan

The survey plan shows all surveyed parcels and adjoining parcels. The measurements like bearings, areas, distances, and coordinates are indicated. They are based on ground survey methods of fixed surveys. The use of GPS, Total station, tachometer, Electronic Distance Meter (EDM), and Theodolite instruments is required.

2.2.1.2 The Registry Index Maps (RIMs)

According to (Wayumba, 2013), the Registry Index Map (RIM) is prepared for the first registration as the main cadastral map for the land. During the adjudication processes, it is

subject to amendment for each subsequent land subdivision. The Registry Index Map (RIM) is used to serve the following purposes

i) For identification of the ground of a plot that is shown on the register.

ii) It helps to assist in relocating the boundary of a given parcel of land if it is lost.

iii) To facilitated subdivision of land to be affected.

iv) To enhanced area calculation of a given piece of land

The Registry Index Maps (RIMs) are not coordinated. But in actual sense, they show the outline of all individual parcels of land within the jurisdiction of the general boundaries. The general boundary refers to the demarcation done by natural as well as artificial features (Siriba et al., 2011). This is like fences, ditches, walls, and edges with a distinct property of line boundaries being inaccurate and not legally binding. But it was indicative only. The Registry Index Maps (RIMs) are usually prepared by either a registering district. The method referred to as a ground control survey or divided into registration sections by a part thereof (Siriba et al., 2011). To identify them by using names as they are distinctive. Furthermore, the registration section is divided into blocks. The blocks are usually identified by the use of letters, numbers, or combinations of letters and numbers.

The Registry Index Maps (RIMs) comprises of the following detail of information: Location, sheet and index number, edition of the sheet, sheet history, plot numbers, and scale.

The scale provided in Registry Index Maps (RIMs) is very crucial. They aid in dimensions of the boundaries and the user relies on the map by use of scale rule to measure distances that are off from the map.

Further, (Siriba et al., 2011) suggests that the Registry Index Maps (RIMs) have the following setbacks

i) The areas of individual parcels, as well as the lengths of the boundaries, lack indication of measurements.

ii) Illegibility of the map due to constant changes leading to congestion on consecutive resultant parcels as they are based on a fixed scale.
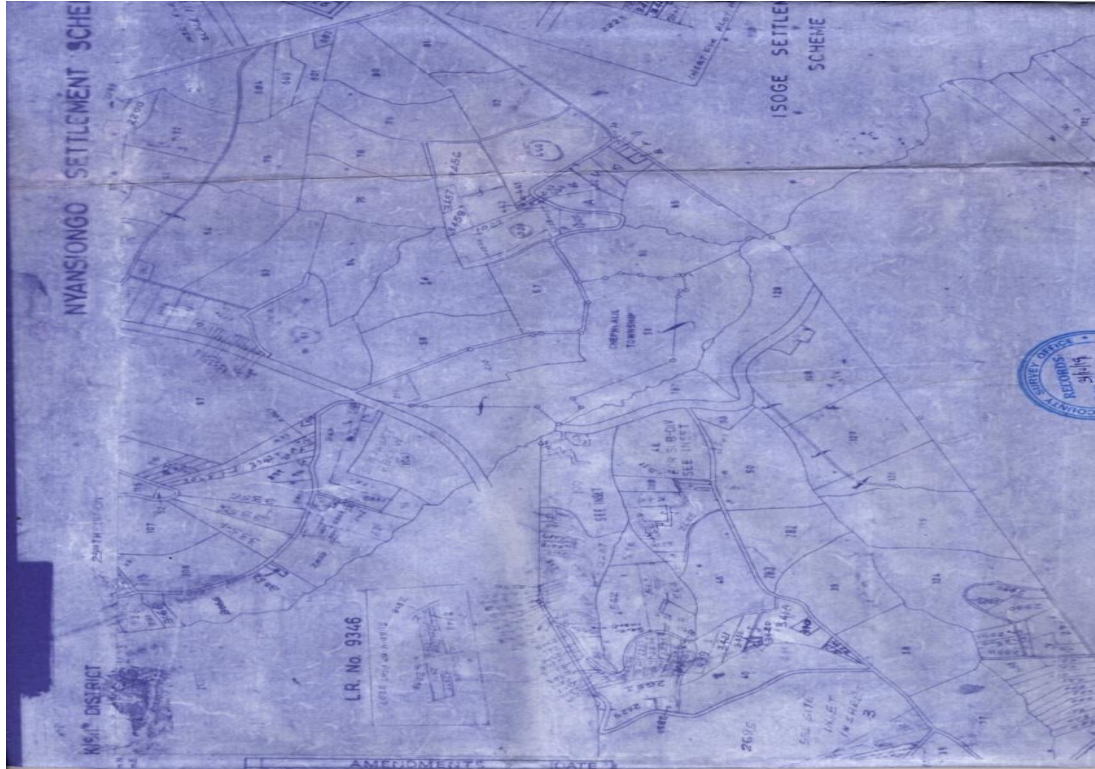
Figure 2. 2 Registry Index Map (source – Survey of Kenya)

2.2.1.3 Provisional cadastral maps

     i)   Preliminary index maps

     ii) Demarcation maps

2.2.1.3.1 Preliminary index maps (PIDs)

The Preliminary index maps (PIDs) are used as provisional maps. For the cadastral survey as well as mapping for enclosed areas for adjudication of land. They are created through either of the processes. The processes are enlarging aerial photographs or by the use of ground survey methods or the use of both methods. The scale usually used in this process is majorly 1:12500 or 1:25000. The aerial photograph is undertaken. These photographs are enlarged though they are usually not rectified and mosaicked to a scale of 1:2500 or 1:5000. After the boundaries of the parcel are identified, an interim map is produced. This map is used for registration. It is marked by those boundaries of photo interpretation and traced out from the marked photographs.

The Preliminary index maps (PIDs) have the following limitations:

i) Within a particular index map sheet, the scale is non-uniform.

ii) They have unreliable distances and areas that are calculated by the use of these map sheets.

iii) They have distortions sometimes of the land parcels' shapes hence, the Preliminary index maps (PIDs) are not controlled either way.

Figure 2. 3 Left marking of un-rectified aerial photographs; Right product – PID after tracing from marked photographs (Siriba et al., 2011)

2.2.1.3.2 Demarcation Map

Prior to the preparation of accurate RIMs, the Registered Land Act of 1963 allowed land registration to use provisional cadastral maps. For instance, cadastral surveying during land consolidation was based on aerial photographs of a 1:12500 scale. The base map was prepared from it to a scale of 1:5000. These base maps were further enlarged during subsequent map processes to a scale of 1: 2500. This is for the purposes of computation of areas and as the basis for "Allocation plan" preparation. The use of the allocation plan is for the demarcation of boundaries on the ground as are on allocation plan. In tracing the allocation plans, a map referred to as the demarcation map was prepared. This map was used to support the registration of a given area surveyed.
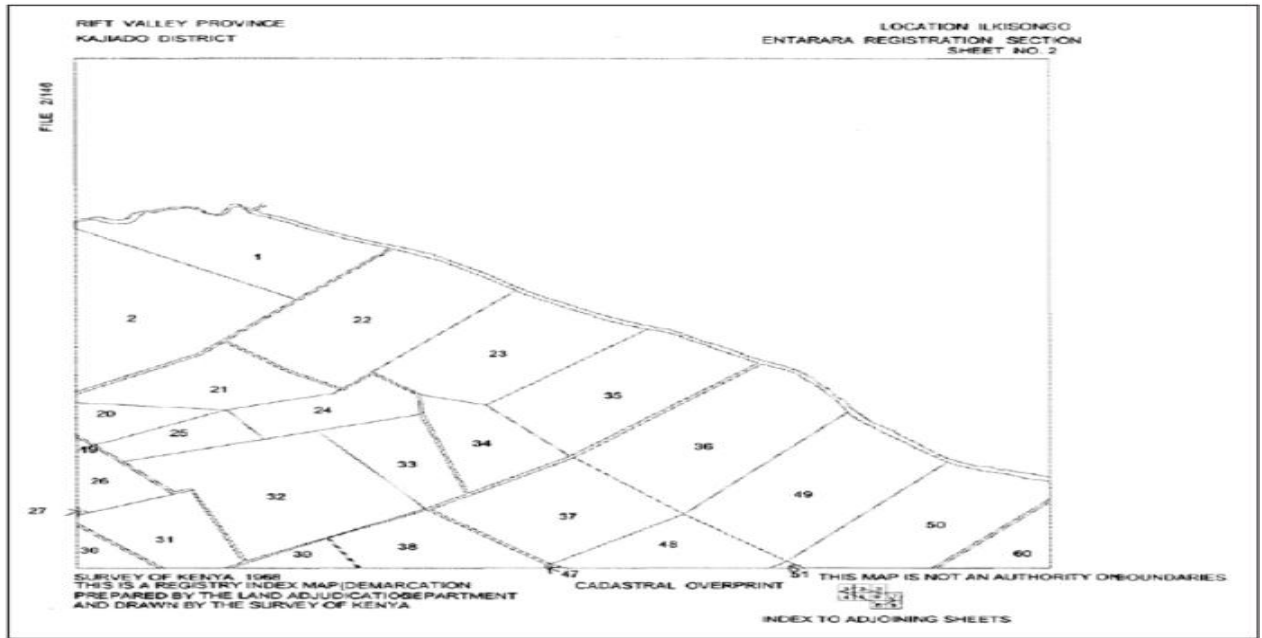
Figure 2. 4 Demarcation Map (Siriba et al., 2011)

Unfortunately, Provisional cadastral maps processes have not embraced the use of high-resolution imagery data to give land cover land use information conditions. In improving this data from the settlement scheme, one of the methods to adopt is the use of imagery from UAV as well as GNSS. It provides coordinates in a system of standardized reference systems (Wayumba, 2019). There is the usefulness of providing spatial data that is accurate with its attributes for land use land cover. This leads to the easy evaluation of the increase in population in the settlement schemes since it was established. Also, the parcels of land areas are measured accurately. Similarly, register data is accurately updated as well as the determination of the status of settlement schemes subdivision of land is up to date (Hellen, 2010).

Further, (Hellen, 2010) suggests the creation of the database of spatial data and records of land. This is for future reference and management of land accurately coordinated boundaries. These boundaries are more objective in re-establishment of general boundaries as opposed to the current methods that are compromised easily. Thus, this will be the main accomplishment of the National Land Commission (NLC). Therefore, this will lead to

26

reducing the multitude of disputes of boundaries in the Kenyan courts throughout the country (Hellen, 2010).

2.3 UAV Mapping

2.3.1 Technology

The term UAV refers to Unmanned Aerial Vehicles. They are aircraft systems remotely controlled by remote devices or a navigation system on-board and a control station aid it completely autonomous. The UAV has other names. These include Drones, Unmanned Vehicle System (UVS) as well as Unmanned Aircraft System (UAS). The two distinct categories of UAVs are the Rotary-wing system and fixed-wing UAV systems (Brach et al., 2019). The Rotary-wing UAV System is majorly based on blades and rotors. It is effectively used suitably in small areas surveying. This UAV system is designed as a real aircraft. It is best suited for mapping in large scale area surveying (Brach et al., 2019). The design of the multiple rotors of the rotary-wing UAV has the capability of flying steadily. It has an easy image capturing due to hovering over an area and being more stable (Mumbone, 2015).

DJI™ Phantom 3 in flight   Mavinci Sirius Pro Fixed-Wing

Figure 2. 5 Multi rotary and Fixed-Wing UAVs (Mumbone, 2015)

2.3.2 Products

The UAV has been used in China to map adjudication of land rights in some of the cities of China. Furthermore, the UAVs can be used in rural areas where the standards of accuracy are low. This has been tested in Northern Ghana where it has been noted the technology can deliver high-resolution Ortho-photos for cadastral surveying (Mumbone, 2015). The UAV system has the following advantages: UAV system flights provide eyes that are capable of reaching and hovering above the specific site of interest.

The UAV system is equipped with sensors that are used to measure, transmit as well as store data instantaneously as they are captured (Hong, 2016). The data that is obtained from UAV mapping when processed can be used for a variety of purposes. For example, to produce and update topographical maps, hydrographical maps, in calculations of volumetric for stockpiles, and more essentially in land registrations (Brach et al., 2019). The use of UAV as an overhead perspective and panoramas of 360^0, conveys information in a real-time scenario. Similarly, the data obtained from the UAV system can be rendered with surveying software like online Esri's ArcGIS web service and integrated for further processing in the same software (GONG et al., 2016).

Images that are acquired from UAV technology have high resolution and have the ability to serve a variety of uses. Thus, it renders no safety risks for the operators of this technology and they eliminate risks of personnel on the ground as well as on-air (Koeva et al., 2016).

2.3.2.1 Acquisition of spatial data
The spatial data is acquired in the following 3 steps.

2.3.2.2 Reconnaissance
Reconnaissance refers to the UAV operate familiarizing with the field of study. This helps in the determination of good scenery of establishing ground control points for the UAV images to be geo-referenced in the flight mission (GONG et al., 2016).

2.3.2.3 UAV mission planning
The flight path of the study area is generated with the appropriate software on the laptop like PIX4D automatically (Brach et al., 2019). The user considers the ground resolution, the flight height, and the percentage of overlap in forwarding and side overlap as well as the

duration of time or time endurance (Hong, 2016). This is done prior to fieldwork in the office.
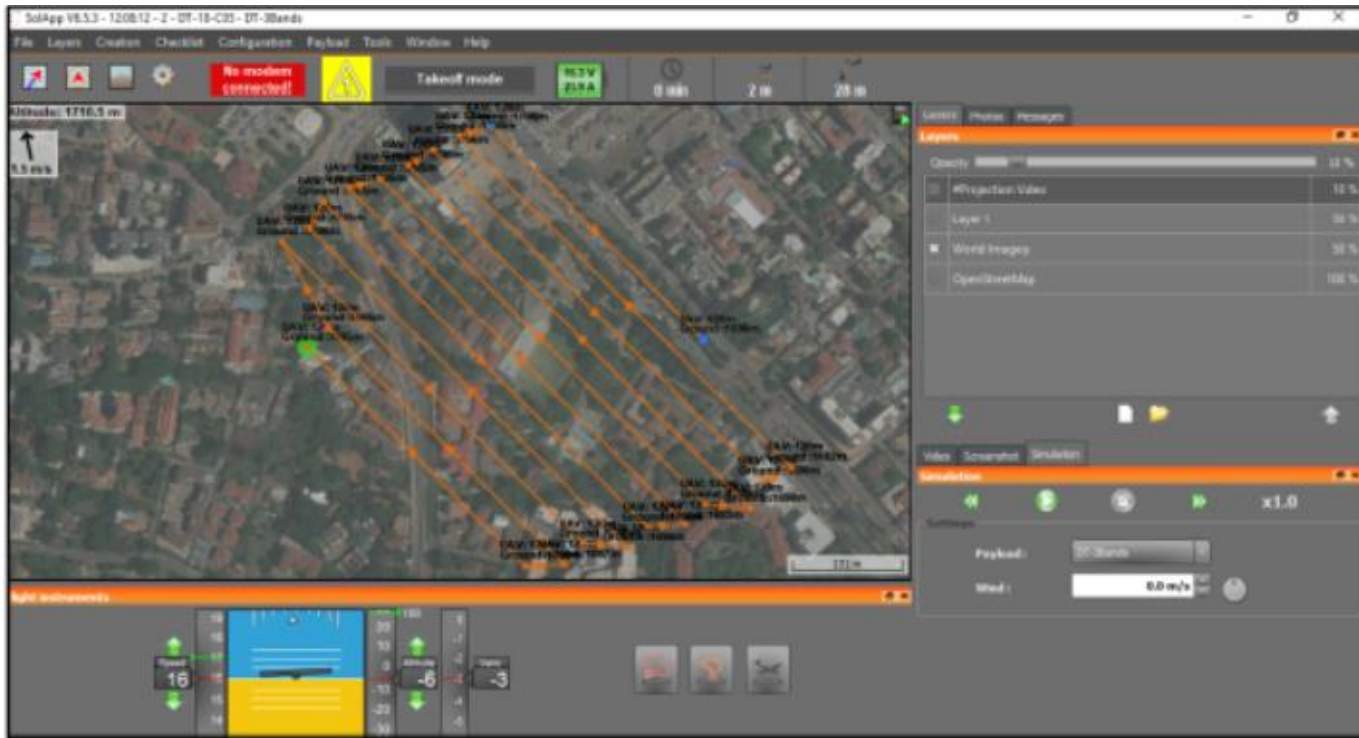
Figure 2. 6 Flight Path in SOLAP Software (Odwe et al., 2017)

2.3.2.4 Capturing of the image

With the aid of the manufacturers' manual, the UAV operator establishes the connection between the hyped, the drone, and the antenna (Choi et al., 2015). The functionality of the UAV is then tested. Thus, with the use of an optimum number of Global Navigation Satellite System (GNSS), the position of the UAV is determined. Therefore, the UAV operator can at this moment load the design of mission planning in the UAV. This is effective as the operator launches the UAV, then allowing it to fly as it captures the images in line with the predefined flight plan automatically (Brach et al., 2019).

2.3.2.5 Image processing

The images obtained from the UAV undergo processing so as to produce mosaicked and Ortho-rectified photos. Hence, enhance the tracing of the boundaries of the parcels of the mapped area. Generally, the forward overlap is at 65% while that of side overlap as 30% for the acquired images by the UAV (Choi et al., 2015). Equally, the cameras that are used to

acquire images are non-metric and generally unstable. The photographs generated enquire of classical photogrammetry and techniques of computer visioning (Tampubolon & Reinhardt, 2014). Similarly, in image processing, it requires image orientation and calibrations of the camera to be determined. Also, the performance of the extraction of tie points as well as bundle adjustment is done.

Either of the following commercial software is used in UAV image processing; PIX4D, UASMaster, Photoscan, Drone2Map as well as PHOTOMOD ("UASMASTER - APPLICATIONS", 2013).

2.3.2.6 UAV Maps for land registration

The maps that are in use for land registration in Kenya comprise of deed plans from accurately derived ground survey, Registry Index Maps (RIMs), and Preliminary Index Diagrams (PIDs.) This is obtained from aerial photographs. A new map for registration of land that is regally accepted should be adopted, from the UAV imagery. Since in Kenya, the country has several types of RIMs, the UAV generated maps can equally be referred to as UAV-RIMs or UAV based RIMs (Odwe et al., 2017). The PIDs are less accurate and lacks spatial reference. In the documentation of boundaries of parcels, the UAV platform is suitable. The high spatial resolution imagery from UAV has geometrical accuracy vis-à-vis conventional land surveying methods (Choi et al., 2015).

Thus, in the registration of land in Kenya, and alternative acquisition of geospatial data like the UAV platform can be used it is economically viable. According to (Odwe et al., 2017) the technology of UAV can provide better opportunities in the registration of land in Kenya as well as other developing countries. Thus, it has proven capable in cadastral surveying, especially in adjudication surveys. This is to boost increase land registration as well as updating its extent (Zhou & Reichle, 2015). Using drones for surveying, the approximate saving of time is higher as compared to other conventional surveying technologies (Koeva et al., 2016). Alternatively, in the case of construction operation, the drones do not cause any disruption.

But it improves accountability as well as saving of taxpayers' money. When flying a UAV for a given project, the agencies and managers of a particular city can use Ortho-

photography (Hong, 2016). This is due to the affordability to update the project of a given locality without necessarily covering the whole city. But only the area of interest and update the changes that are taking place in the same locality ("UASMaster", 2017).

2.4 Quality assessment

Quality assessment refers to the degree of conformity of the collection of data and analysis to standards predetermined and exemplified criteria (Anderson, 2017). There are attempts that are made to find out the reasons for the data not being conformity to the set standards. The quality assessment methods in ArcMap

  i.   Buffering

  ii.   Overlaying

2.4.1 Buffering

In buffering a set of features, it yields the output of a set of polygons. Thus, when buffering points or lines, a new layer of the polygon is created. In ArcGIS, it identifies inside the region by being distinguished in attribute table by different codes (Ekaso, Nex & Kerle, 2020). A fixed distance buffer is applied for each of the set features the same distance. As shown in the figure buffer areas are in blue for the network of road that is thick black lines. The corresponding table to show some coding within the buffer distances is generated.
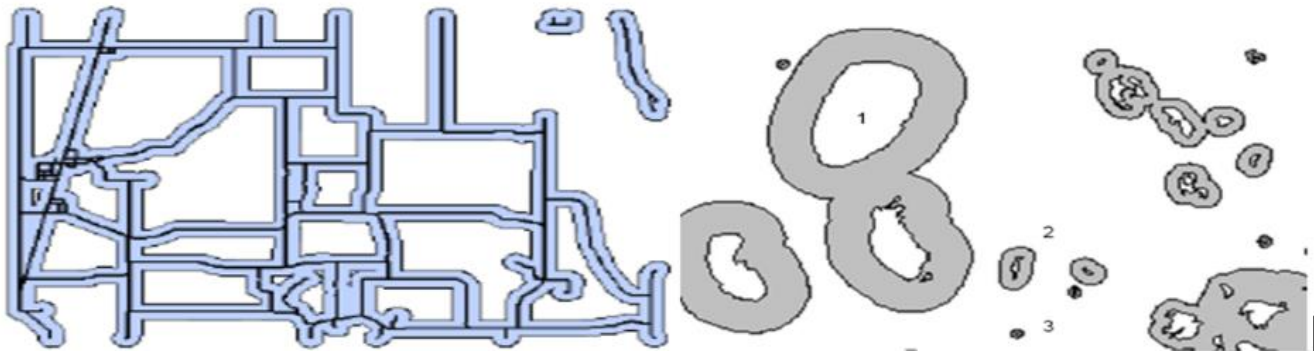
Figure 2. 7 Fixed buffering and variable buffering respectively

The variable buffers change the buffer distance depending on the attribute of features. This one changes the buffer distance depending on the feature attributes. It uses an attribute that specifies the distance of the buffer for each feature (Anderson, 2017).

2.4.2 Buffering in ArcMap

Create a new project and for example, the roads Shapefile data layer. Then click on the red Arc Toolbox so as to activate the tools menu, then Analysis Tools – proximity – buffer (Nadarajah, Paffenholz & Teunissen, 2014). This is displayed in the ArcGIS window. The input layer is set to roads.shp and the output features' location and name are specified for example road_buffer_300m.shp. The linear unit is entered and set as 300metres and dissolved Type is set to all then lastly ok button is clicked to display the results (Anderson, 2017).

2.4.3 Overlaying in ArcMap

Overlaying refers to the primary method of combining information from two themes that are separate. It is mostly done for polygonal data and performs a geometric intersection. It resulted in a new layer with the combined attributes of both initial layers (Paffenholz & Bae, 2012). Steps Open the Arc Toolbox, then Analysis, Tools Overlay, Erase. Input features are to be specified as the variables like parcels buffer layer. Then the erase features like parcels layer are specified. The output destination is set in the output feature class after which the ok button is clicked to apply the buffer (Ekaso, Nex & Kerle, 2020). As shown in this figure.
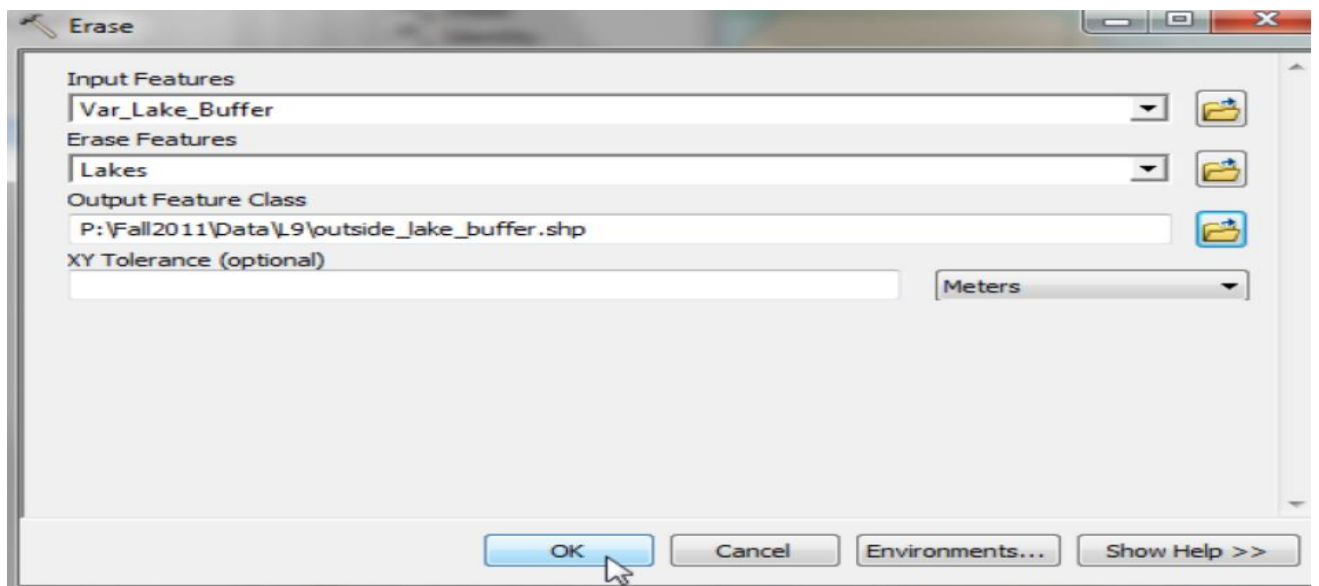
Figure 2. 8 Shows the process of overlaying in ArcGIS

Finally, the erasement of the parcel from the buffer layer overlays the two buffer layers. This is by; Selecting the Arc Toolbox, Analysis Tools, Overlay then Union. Then specify the

input layers-outside-parcel-buffer and road_buffer_300m. The output layer is specified union_Parcel_Road the ok button pressed to display the results. The attribute table is open to creating a new field in both to identify those areas that meet both inside parcel buffer and inside road buffer (Nadarajah, Paffenholz & Teunissen, 2014). Then, the attribute is selected to find those areas with insd_ibuf=1 and insd_rbuf=1, be assigned number 1 with the use of a calculator.

The attribute table is closed; the Union_parcel_road layer is selected and right clicked to select data-export data specifically to the accepted area on this selected attribute (Paffenholz & Bae, 2012). The toolbox is selected database management, feature, multipart to single-part that helps to ungroup the combined polygons to create a row in the attribute table for each polygon as shown in the figure.
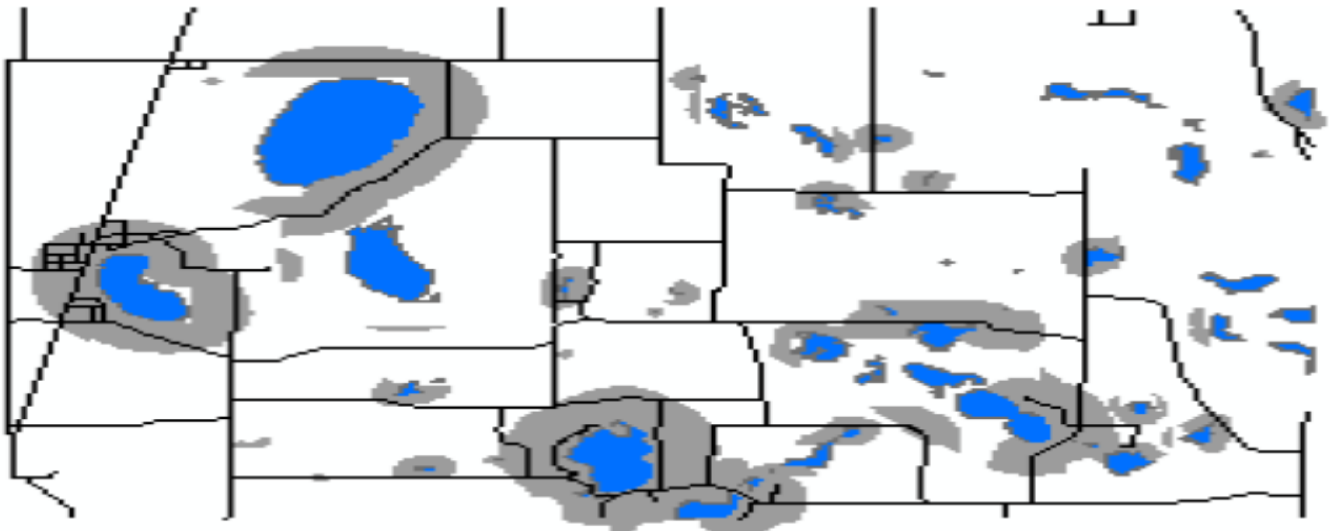
Figure 2. 9 Results of overlaying in ArcGIS

By opening the attribute table and add a float or double field named "Hectares" with a precision of scale of 1 or 2. In right-clicking the column heading Hectares column then clicking on calculates geometry in the menu dropdown. Then specify the area in the property drop-down box to obtain the default coordinate system and Hectares then an ok button. The new hectares column is to be populated with numbers of a given range in values. On clicking on the right on the hectares column on statistics so as the statistical summary may be displayed (Paffenholz & Bae, 2012).

CHAPTER 3: MATERIALS AND METHODS

3.1 Area of study

Nyansiongo settlement scheme is located in Nyamira County with the following coordinates

Latitude in degrees, minutes and seconds ranges between 00° 47' 00" S and 0.78° 00' 00" S

Longitude in degrees, minutes and seconds ranges between 35° 01' 00" E and 35° 00' 00" E

The adjoining neighboring Settlement schemes are Manga Settlement Scheme, Gesima Settlement Scheme, Isoge Settlement Scheme, and Matutu Settlement Scheme that are all situated in the Nyamira County.

According to the population census of 24th August 2019, Nyansiongo has a population of 5, 993 people which are categorized into 2,915 male and 3,078 female.

The size of Nyansiongo settlement scheme is approximately 43,422 Meters Sum Perimeters and 3,032 Hectares Sum Areas
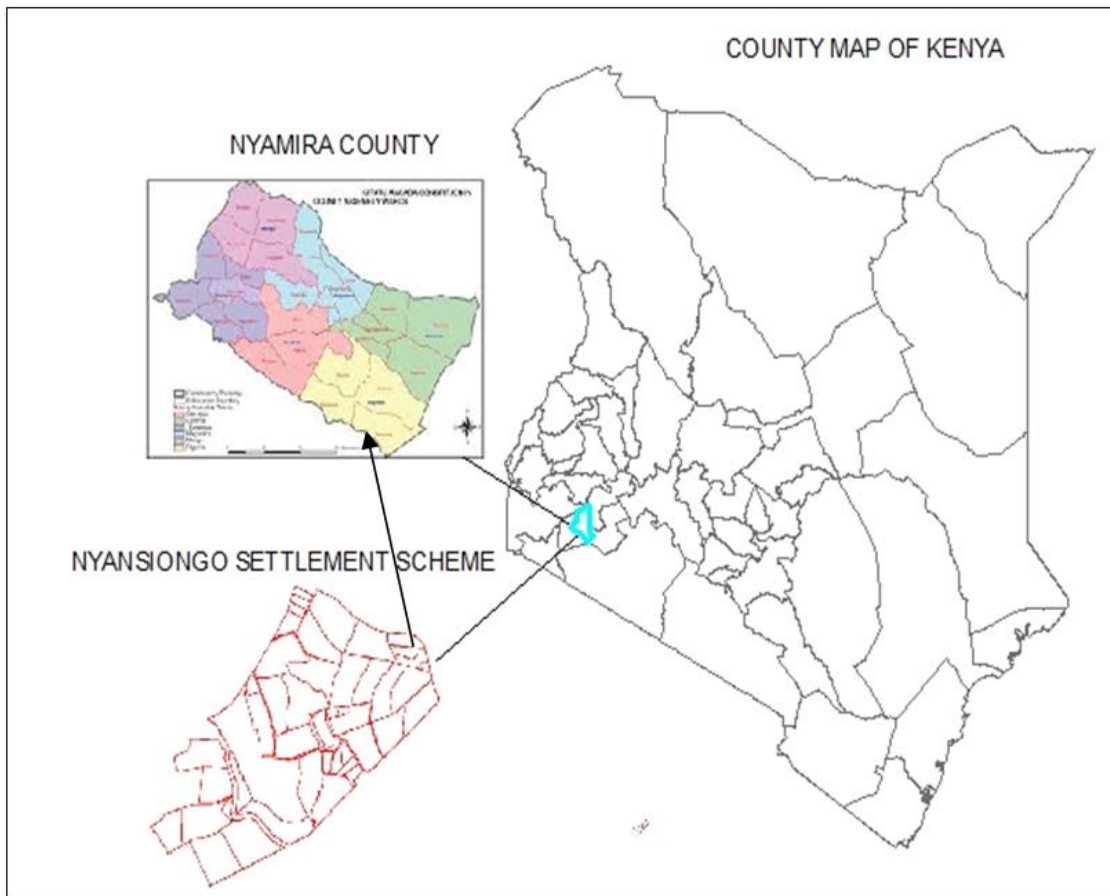
Figure3. 1Map of the study area

Table 3. 1 Data and data sources

No	data	source	format
1	RIMs	Kisii-Survey office	Hardcopies
2	Survey plan	Survey of Kenya	hardcopy
3	RTK data	Field picking	vector-format with a positional accuracy of 3cm
4	UAV data	Field picking	Raster-format with the Resolution 5cm

3.1.1 **Types of equipment**

The following types of equipment were deployed in data collection; Handheld GPS for searching for existing coordinates obtained from the survey plan. Trimble RTK (Real-Time Kinematic) (survey GNSS) for the establishment of control points and picking of boundary lines of the selected plots Navigation Systems company limited. Similarly, DJI Phantom UAV for the aerial survey was hired from Sky- Maps Surveys limited.

3.1.2 Software Capabilities

The following software was used in the data processing

ArcGIS for georeferencing and digitizing the scanned RIM map of the Nyansiongo Settlement Scheme. Similarly, ArcGIS was used in overlaying the plots from the UAV Ortho-rectified, RTK plots together with that of RIM for comparison of area boundaries, sizes, and swifts. ArcGIS software platform enhances creation, management, sharing as well as analyzing spatial data. It also has applications like mobile and desktop as well as server components together with developer tools.

Python software was used in the coding of coordinate conversion from the Cassini coordinate system to the UTM coordinate system that was obtained from the survey plan of the study area. Thus, Python is open source software and has extensive libraries support to use. Similarly, python data structures are user friendly.

Pix4D software was used in flight planning of the JI Phantom UAV to enable access to the reconnaissance field for the survey. Pix4D software is highly automated for computing and has a user-friendly interface especially when getting started has a low threshold to support a wide range of cameras.

UASMaster software was used in the processing of the Ortho-rectified image from the UAV imageries acquired from the field survey. It has a detailed manual guide on every stage for data processing. The character lines are fully supported and it is convenient as it paints the point clouds as well as 3D models colours similar to what an elevation map has.

Excel sheet was used in the coordinate transformation from the UTM coordinate system to WGS84 for the study area. Equally the excel data was uploaded in ArcGIS software to enhance ease conversion to KMZ shapefiles that were uploaded to Google-earth. Thus, testing the conversion if it was within the vicinity of the study area, the points testified.

Google earth is used in the location of the study area as well as in-flight planning since it is editable in PIX4d software.
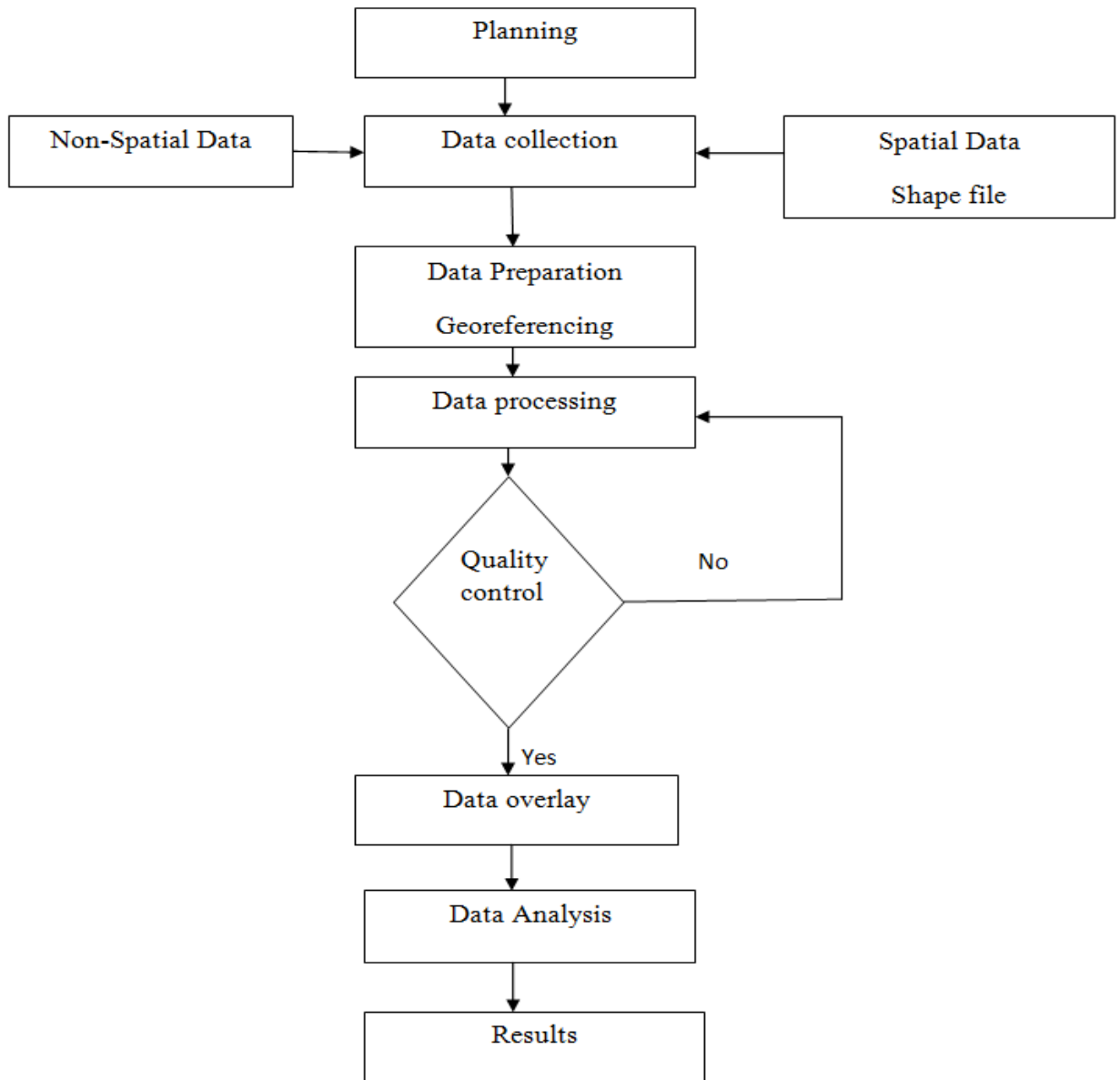
```
                          ┌─────────────────┐
                          │    Planning     │
                          └─────────────────┘
                                   │
                                   ▼
┌─────────────────┐       ┌─────────────────┐       ┌─────────────────┐
│ Non-Spatial Data│──────▶│ Data collection │◀──────│  Spatial Data   │
└─────────────────┘       └─────────────────┘       │   Shape file    │
                                   │                 └─────────────────┘
                                   ▼
                          ┌─────────────────┐
                          │ Data Preparation│
                          │ Georeferencing  │
                          └─────────────────┘
                                   │
                                   ▼
                          ┌─────────────────┐
                          │ Data processing │◀──────────┐
                          └─────────────────┘           │
                                   │                     │
                                   ▼                     │
                               ╱───────╲                 │
                              ╱ Quality ╲    No          │
                              ╲ control  ╱───────────────┘
                               ╲───────╱
                                   │ Yes
                                   ▼
                          ┌─────────────────┐
                          │   Data overlay  │
                          └─────────────────┘
                                   │
                                   ▼
                          ┌─────────────────┐
                          │  Data Analysis  │
                          └─────────────────┘
                                   │
                                   ▼
                          ┌─────────────────┐
                          │     Results     │
                          └─────────────────┘
```

Figure3. 2 Methodology Overview

3.1.2.1 Project planning

It was essential to help in meeting the objectives of the project within the set time frame. It ensures delivery of the ultimate result of the project which is the comparing of areas from digitized RIM parcels with parcels derived from the UAV.

3.1.2.2 Data collection

The data that was collected for this project comprises of non-spatial data and spatial data.

3.1.2.3 Non-spatial data

The non-spatial data that was essential to facilitate the research work of this project on the site was needed. This includes the letter from the University of Nairobi, Department of Geospatial and Space Technology that identified me as a student of the University of Nairobi. This letter was essential in the local area chief and Nyumba Kumi who could allow the research to be conducted. Also, the letter from the Ministry of Interior and Coordination of National Government that was a requirement by the local authority to facilitate the research at the Nyansiongo Settlement Scheme.

3.1.2.4 Spatial data

The spatial data that was required for this project comprises of RIM that was obtained from Kisii Surveys Office, and Survey plan from Survey of Kenya. Similarly, the RKT data as control points for the UAV imagery orientation.

3.1.2.5 Data preparation and Geo-referencing

The RIM was scanned, geo-referenced, and then digitized to obtain parcels. The parcels obtained from RIM, their areas were determined.

3.1.2.6 Data processing

The UAV acquired imagery, was then processed with UASMaster software to generate Ortho-rectified imagery of the study area.

3.1.2.7 Quality control

The UAV setting parameters were entered during the data processing together with ground control points to facilitate the Ortho-rectification of the imagery from the UAV.

3.1.2.8 Data overlay

The Ortho-rectified imagery from the UAV was overlaid with RIM to enable digitize the boundary line of the parcels from the UAV imagery. The parcels that were derived from the UAV were then compared with those from RIMs in terms of area and perimeter.

3.1.2.9 Data analysis

The parcels from the UAV when overlaid on the parcels digitized from the RIM, it was noted that there was a shift in the boundary from the two data sets.

The shift must have happened due to the level of technology that has been used in the survey of the settlement scheme.

3.1.2.10 Results

In terms of data on how settlement Schemes were surveyed. An area was first identified by the government, then planning took place, the area was then surveyed, title prepared then allocation was done by the government to a specific individual or group of people.

The Ortho-rectified imagery from the UAV that was obtained was digitized, to obtain parcels that were compared in terms of area and boundary shift with the parcels obtained from the RIM of the same area. The shift in the perimeter is 558.31 Meters while as the shift in the area of the same section was 6,080.82Square Meters.

3.1.3 Coordinate Transformation

Conversion of the control points from Cassini to UTM. The converted coordinates were essential to enable ground survey, searching for the control, and re-establishment of new controls for the study area.

Thus helps in the creation of homogenous, coherent datasets to be used on one platform. It helps to avoid challenges especially of working from different coordinate systems that can lead to misleading information of the area of study.

3.1.4 Geo-referencing

It was crucial to Geo-referencing the scanned RIM map so that its internal coordinate system can be related to the geographic coordinate of the ground system. The scanned map was assigned to the spatial coordinates by launching the ArcGIS software. Using the display panel, the add icon was used to connect the folder that had the scanned image. Once the

image was displayed in the panel, the geo-referencing icon was activated by right-clicking on the display panel.
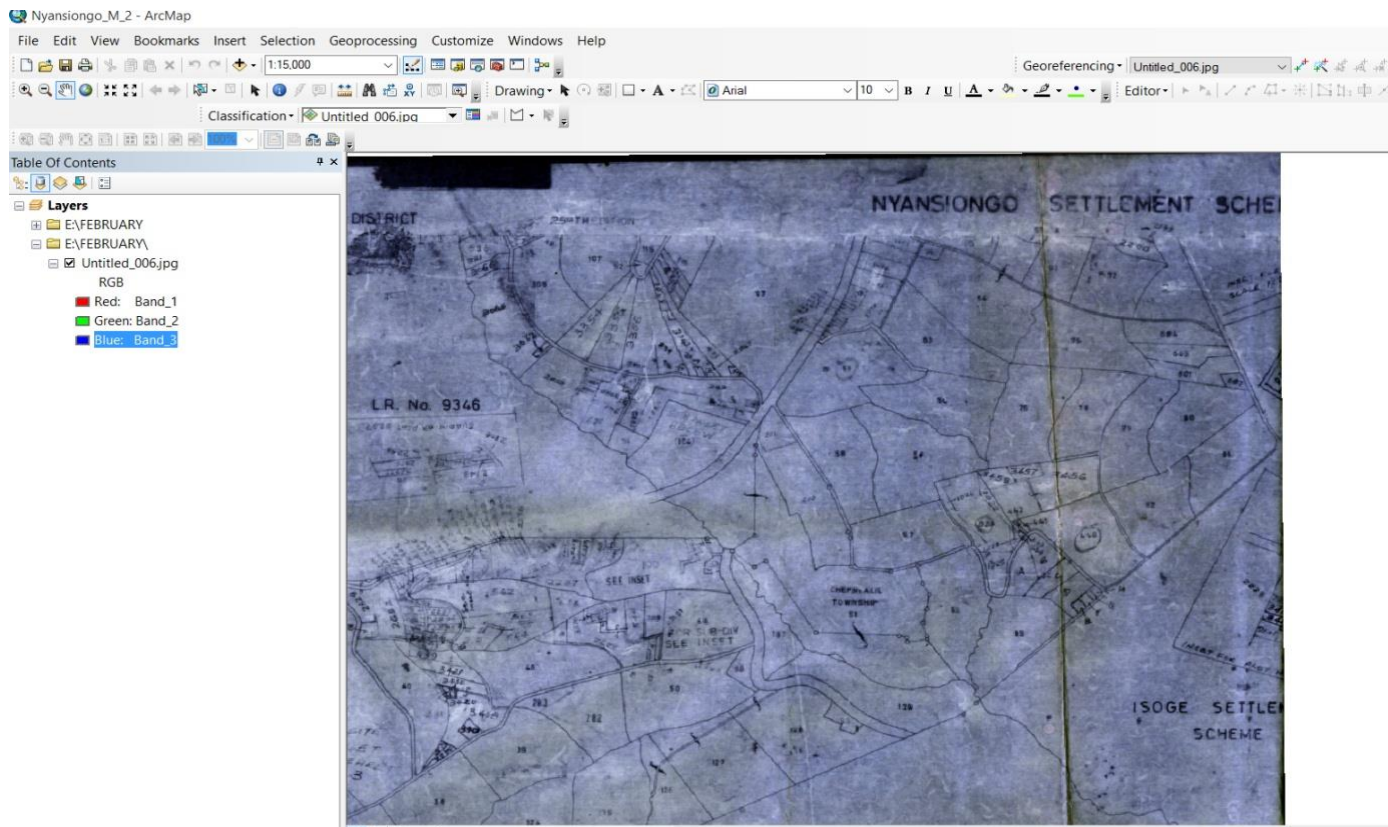

Figure3. 3 Geo-referencing processing of scanned RIM with Arc GIS

3.1.5 Adding control points for RIM Geo-referencing

On zooming on the identified point, the control points were added that is the X-coordinate and Y-coordinate of each control point.

The transformation that was used is projected, world, UTM, WGS84 northern hemisphere 36N, for the local coordinate system Nyanza region Kenya.
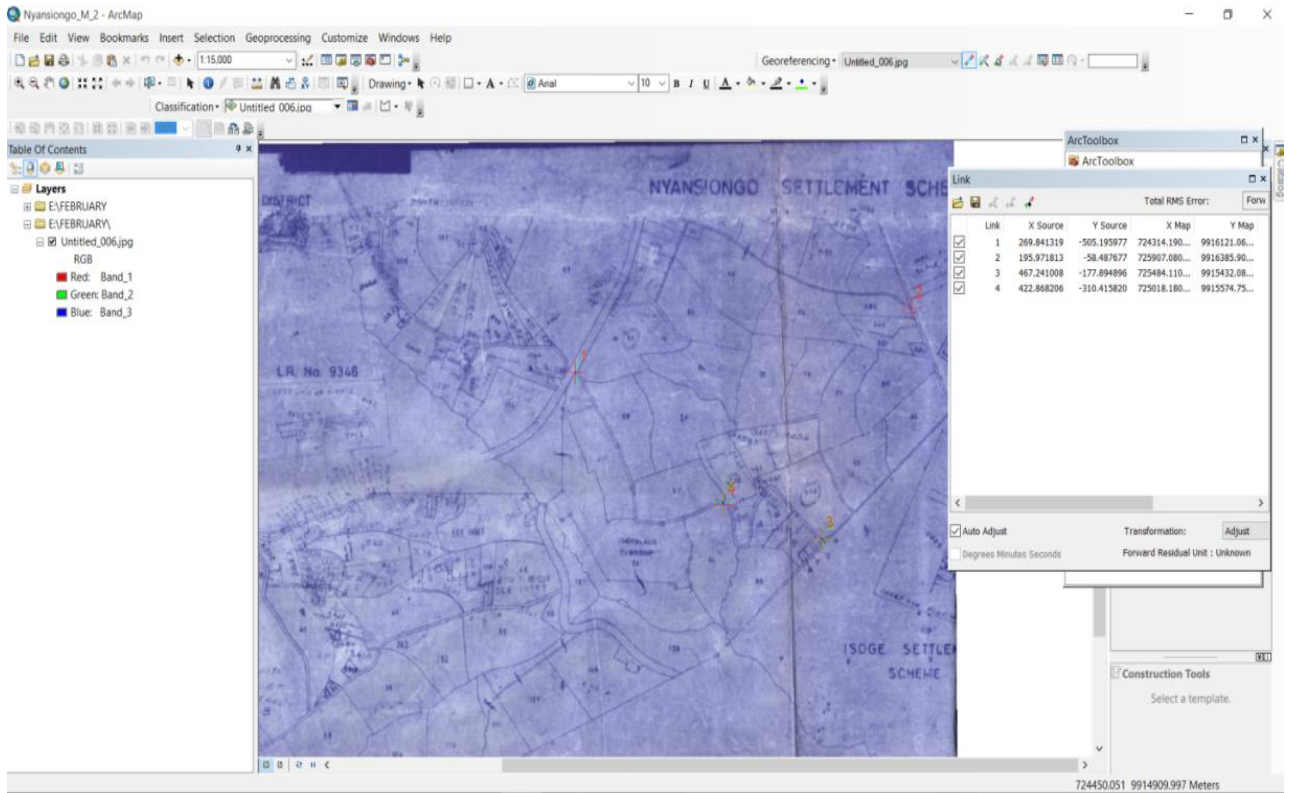
Figure3. 4 Adding control points for Geo-referencing of RIMs

3.1.6 The creation of parcel shapefile

The shapefile refers to the geospatial vector data format used for geographic information system software. The shapefiles describe spatially geometries like points, polylines, and polygons. For instance, points represent control points; polygons represent parcels of land and polylines to represent the digitized road networks. The shapefiles are created with the help of arc-catalog.

Using the data management tool, the projections and transformation tools, the tool referred to as a projection to define the preferred projection.

3.1.7 Editing process

With the use of the editing tools, after activating it, starting editing to enable the created shapefiles to be active. Then by choosing the correct symbol to enable to conduct editing, for instance, the parcel of land by zooming it to full extent until completion and stop editing to enable saving the work.

Digitizing of the parcels of land and adding of labels of each parcel as it is in the scanned RIMs.
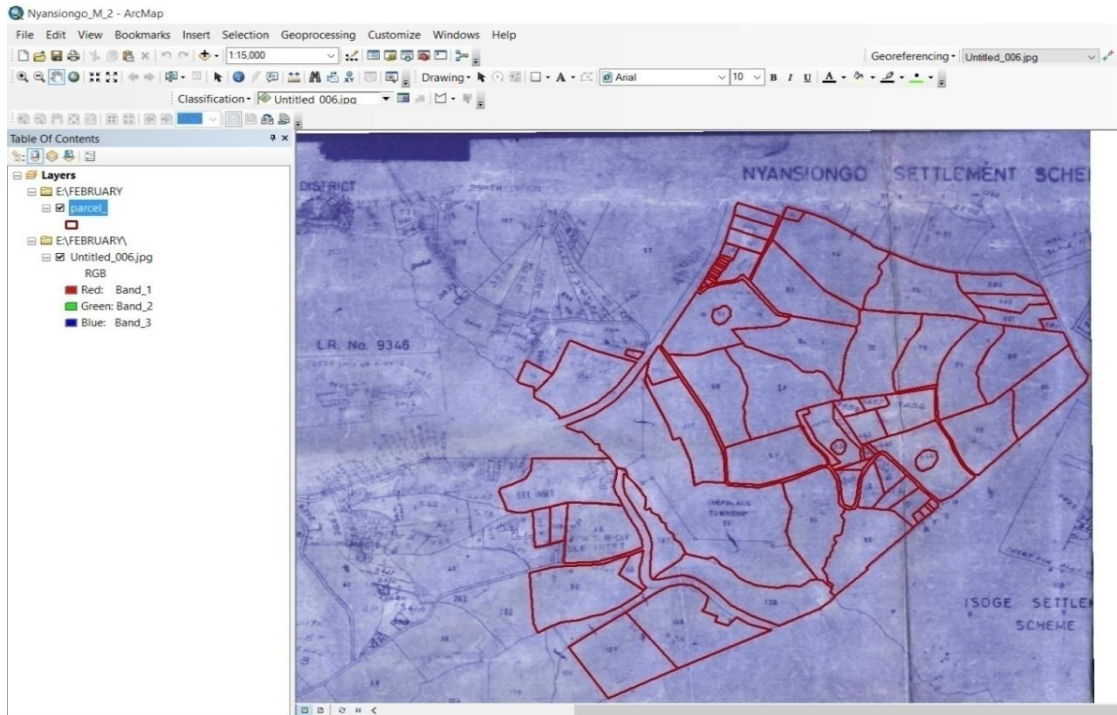

Figure3. 5 Digitizing process of RIMs

Figure 3.6 shows the survey plan for part of the Nyansiongo settlement Scheme that was obtained from the survey of Kenya. The survey plan had the coordinate list that was in Cassini coordinate systems. These coordinates were later converted to UTM coordinate system that is used mostly in the Kenyan surveys.
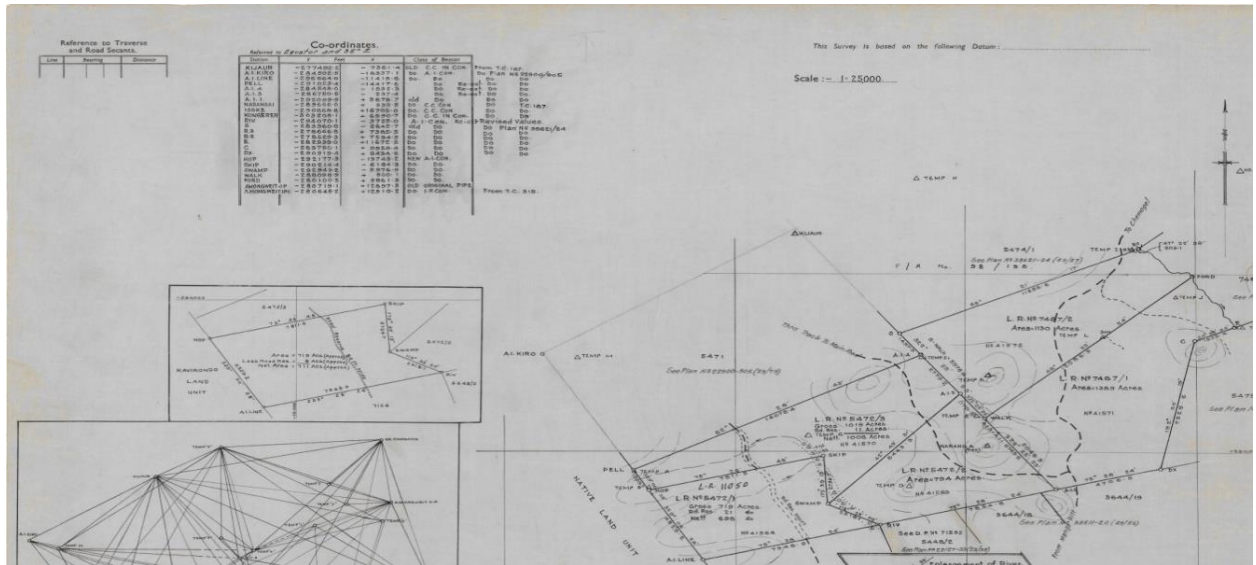
Figure3. 6 Survey plan with a coordinate list of the study area

The KMZ shapefile that was generated from the digitized RIM of the Nyansiongo Settlement scheme was uploaded to Google Earth. The digitized parcels from the RIM were uploaded into Google earth to check the ground area if it was tarrying with the control points and the digitized map. As shown in figure 3.7, the ground area concurred with the control points as the map zoomed to the Nyansiongo region in Nyamira County.

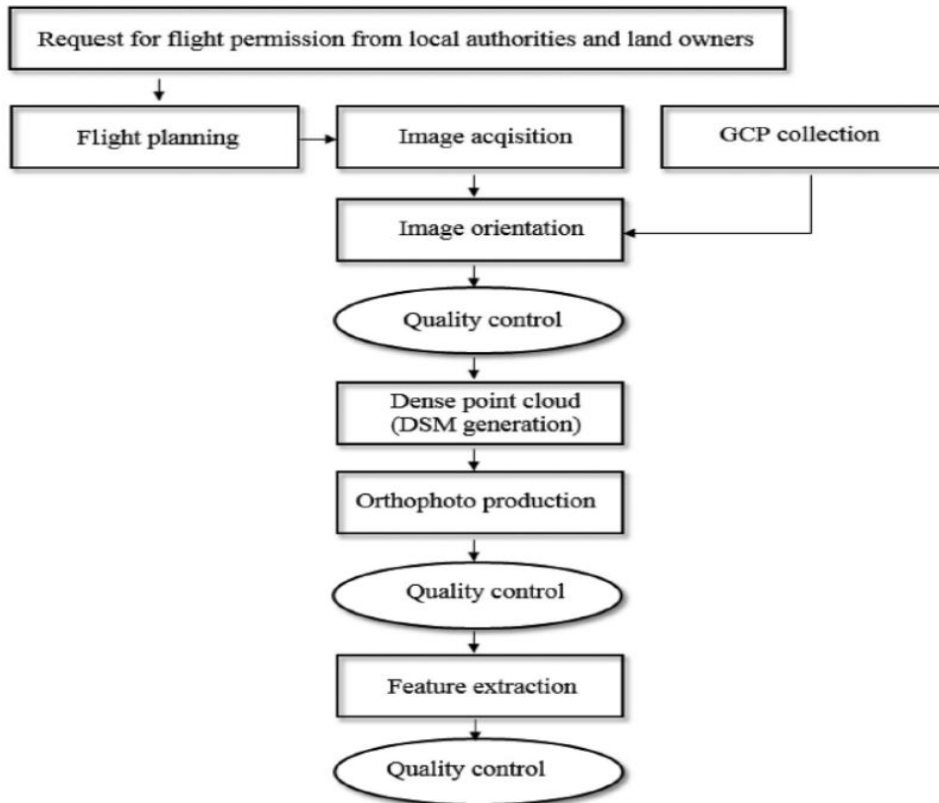**Figure3. 7 The study area uploaded in Google Earth**

Figure3. 8 UAV Mapping and Data Processing

The permission for flight planning was given from the local authority in line with the ministry of interior and coordination of national government. The assistant chief from the Nyansiongo settlement scheme sent the 'Nyumba Kumi' initiative to inform the landowners for the research survey of the territories.

3.1 Flight planning

Flight planning is essential for any field operation for aerial surveys especially UAV in order to obtain the ground size pixel of the area and with the following information: the onboard Inertial Navigation System (INS) use as well as the use of GNSS. Similarly, it's important to consider the Ground Control Points on the ground together with technical instruments used. The acquired image quality dictates the final product of Ortho-photos to be produced.

Figure3.9 Flight planning

3.2 Image orientation

Photogrammetric aims at 3 D extraction of information from images in 2D by interior orientation and exterior orientation. In interior orientation, it aids in position definition of the projection of the camera's center as well as the focal length and distortions of the lens. The exterior orientation helps in the definition of the projection center of the camera's position together with optical axis assembling rotation in line with the frame of mapping that must be computed.

3.3 True- Ortho-photo

The Ortho-rectification process aid in the creation of the final product of the image acquired for mapping purposes as it removes all distortions of projection from the original image. Through the use of a qualitative approach and quantitative approach of assessments, the results to be obtained are fine details of the required information.

3.4 Ground control points

The development of the technology of GNSS reference stations application as boosted the surveying operations with RTK. The efficiency of the GNSS network with RTK positioning has increased tremendously in Kenya. Therefore, having a known continuous network in a given region, a surveyor can use the RTK rover to carry out surveying in a given field. Thus the establishment of control points, as well as land subdivisions in real-time situations using the mobile networks for communication. The RTK rover communicates with the station reference point irrespective of the coordinate system the rover is in due to the inbuilt software to carry out the computations and give coordinates of the rover.

The CORS- NETWORK that was used as a reference point is at Kisii town station RTCM (Radio Technical Commission of Maritime). It was used in establishing the control points for the UAV mapping as well as RTK mapping of the field survey in part of the Nyansiongo Settlement scheme.

Connect	Rover	Base	Status	Properties
Position				
Latitude				-000°45'39.337194"
Longitude				035°00'53.691204"
Height				1876.7430m
Horizontal precision				0.0085m
Vertical precision				0.0160m
PDOP				1.0
Solution type				RTKFixed
Correction age				1s
Base information				
Latitude				-000°46'45.969720"
Longitude				034°56'48.902280"
Height				2091.7370m
Antenna height				0.0000m
Baseline				7845.9194m
Base index				5
Satellites tracked:27				
GPS				11
GLONASS				6
Beidou				6
Galileo				4
QZSS				0
Satellites used:15				
GPS				10

Figure3. 10 Kisii CORS-Network RTCM Station

Table 3. 2 RTK Control points and corner points

ID	Northing	Easting	Height	Status
corner1	9915731.757	725392.533	1896.699	RTKFixed
GCP_1	9915734.585	725394.942	1896.976	RTKFixed
corner2	9915745.129	725421.958	1898.204	RTKFixed
corner3	9915758.6	725445.497	1900.495	RTKFixed
corner4	9915844.131	725536.105	1909.507	RTKFixed
corner5	9915849.124	725540.832	1910.115	RTKFloat
corner6	9916273.637	726001.856	1959.209	RTKFixed
corner7	9916281.242	726003.165	1959.557	RTKFixed
corner8	9916293.103	725997.968	1959.568	RTKFixed
GCP_2	9916278.002	726004.926	1959.794	RTKFixed
Corner9	9916312.984	725983.246	1958.005	RTKFixed
GCP_3	9916431.044	725926.562	1949.198	RTKFixed
corner10	9916430.481	725925.773	1949.374	RTKFixed
GCP_4	9915954.712	725173.264	1887.237	RTKFixed
corner12	9915954.751	725176.978	1887.753	RTKFixed
cornerpoint13	9916016.31	725172.089	1887.005	RTKFixed
corner14	9916006.461	725714.833	1931.987	RTKFixed
cornerfloat15	9916041.411	725698.603	1932.385	RTKFloat
cornerfloat16	9916069.696	725694.075	1931.468	RTKFloat
corner17	9916173.321	725699.689	1931.361	RTKFixed
corner18	9916205.875	725700.593	1931.021	RTKFixed
floatcorner19	9916236.518	725690.329	1934.485	RTKFloat
floatcorner20	9916175.972	725613.403	1946.927	RTKFloat
floatcorner21	9916140.812	725524.869	1919.767	RTKFixed
corner22	9916088.04	725391.527	1907.444	RTKFixed
corner23	9916086.061	725386.253	1907.286	RTKFixed
corner25	9916020.451	725431.592	1912.769	RTKFloat
corner26	9916006.354	725437.447	1909.135	RTKFloat
corner27	9916007.898	725438.689	1913.655	RTKFloat

corner28	9915996.007	725441.306	1909.461	RTKFloat
corner29	9915997.872	725441.572	1914.098	RTKFloat
corner30	9915970.547	725445.022	1915.16	RTKFloat
corner31	9915971.494	725447.886	1915.096	RTKFloat
corner32	9915956.969	725450.967	1915.531	RTKFloat
corner33	9915957.752	725454.176	1915.552	RTKFloat
corner34	9915923.246	725474.149	1909.877	RTKFloat
corner35	9915923.672	725477.411	1910.651	RTKFloat
corner36	9915889.719	725488.718	1913.472	RTKFloat
corner37	9915889.882	725493.483	1910.728	RTKFloat
corner38	9915868.101	725507.085	1910.193	RTKFloat
corner39	9915870.789	725509.754	1910.69	RTKFloat
corner40	9915900.178	725094.397	1878.458	RTKFixed
corner41	9915904.825	725062.028	1873.641	RTKFixed

3.5 UASMaster INPHO SOFTWARE

3.5.1 Geo-referencing

This entails the removal of blunders automatically to enhance high-quality products. It has powerful datum transformations to enable the use of predefined projections together with analysis graphical tools that are thorough as well as reports that are detailed.

The geo-referencing processes are as shown in Figure 3.11.
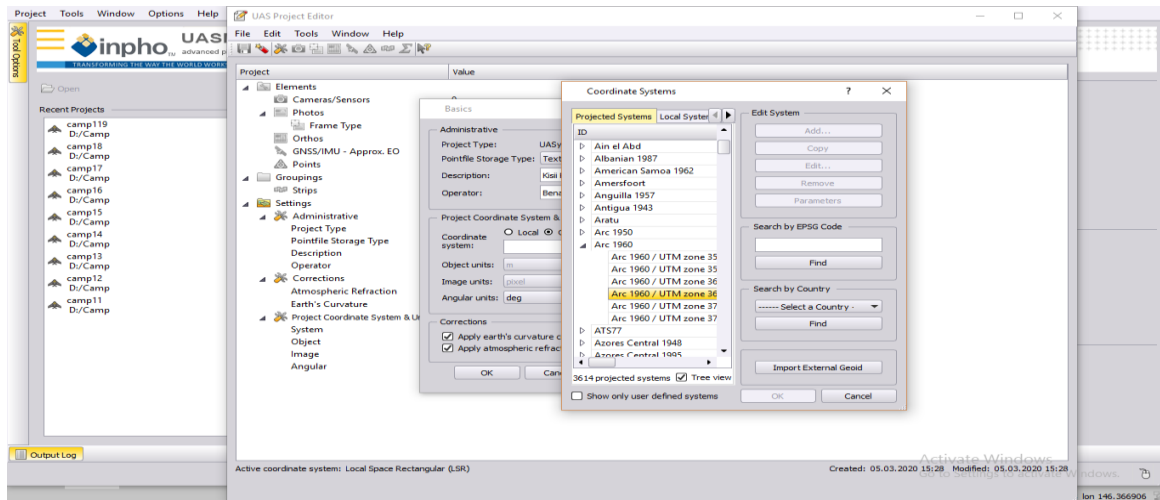
Figure3. 11 Defining the coordinate system

The intuitive analyzer of graphic block performs the following roles; Visualization and faster checkout of data sets that are large. It enhances the location of image footprints as well as overlaps the images. It enables residual scrutiny and error ellipses to allow the proper and accuracy of the fieldwork of captured data. It is by analysis of the geometrical sector for images together with points.

In terms of analysis of connectivity and point cells, it has a tool for binning cells to visualize and examining the data sets as shown in Figure 3.12.
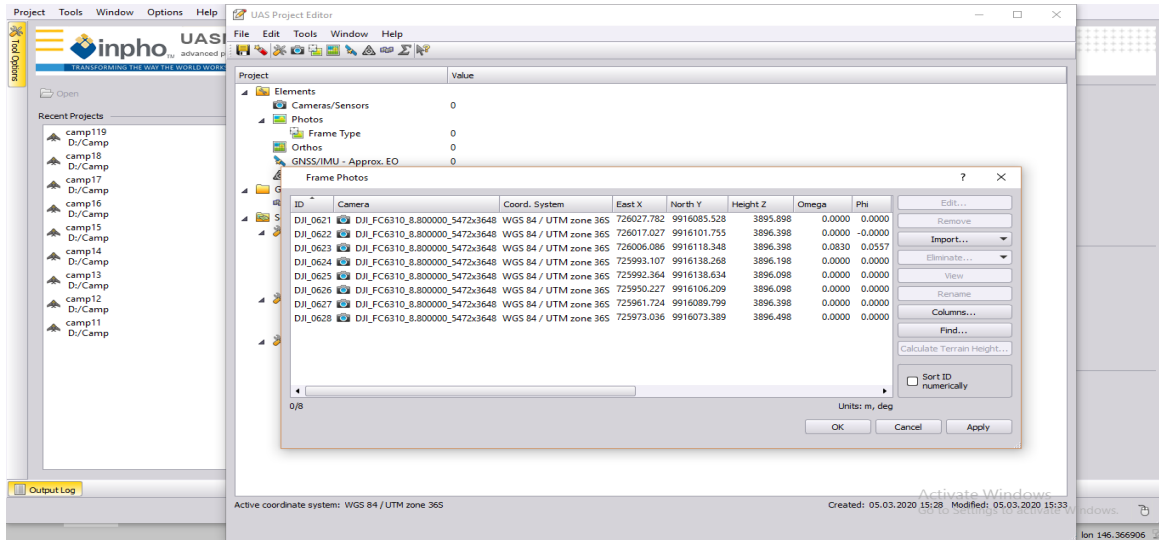
Figure3. 12 Importing photos to UAS-Master program

The course camera calibrations are defined as the camera ID which was DJI_FC6310_8.800000_5472*3648, sensor type: digital CCD Frame, the marker as DJI, mode of FC6310, S/N of 8.8000000. The sensor type in terms of width is 5472 pix and height as 3648 pix as shown in Figure 3.0 which were to be keyed in properly before clicking apply bottom.
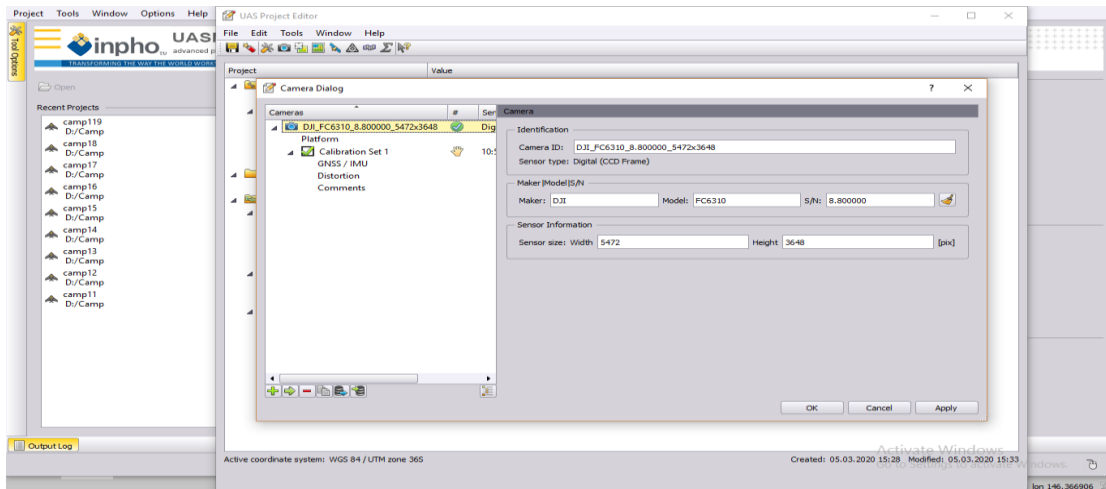

Figure3. 3 Definition of camera parameters

Still, cameras with no video frames are uploaded. Flight planning derived from course GPS is similarly uploaded.

The calibrations of the camera are the data sets that should be marked active. The sensor system that comprises of focal length 8.845 mm, the sensor size: width 5474, and height that was 3648 pix. The pixel size similarly has a width of 2.4123 and a height of 2.4123 um. Also, the principal point in terms of X coordinate as -0.0012 and that of Y coordinate as -0.0012 mm. after defining all of this specification, click apply bottom then ok as shown in Figure 3.14
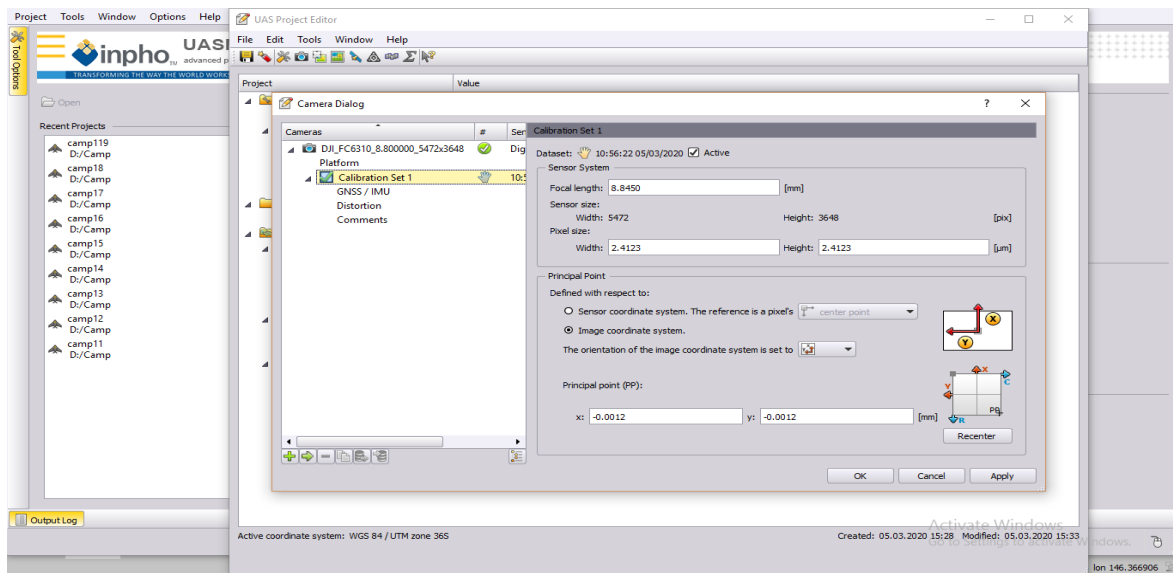
Figure3. 4 Defining the camera parameters

3.5.2 Project definition

The exterior parameters comprise of the coordinate systems together with the X-coordinates, Y-coordinates, height, and standard deviations. The editing tools for points enable stereoscopic, monoscopic, and visualization of the points. Editing tools are content-driven with heads-up-display. In viewing of millions of points, it has point cloud viewer that is 3D to facilitate high performance together with height coding and on- fly-contours.

The automated model for visualization in stereoscopic viewing during editing of points is enhanced.

The batch point cloud processing enables the performance of tiling, gridding, and contouring as shown in Figure 3.15.
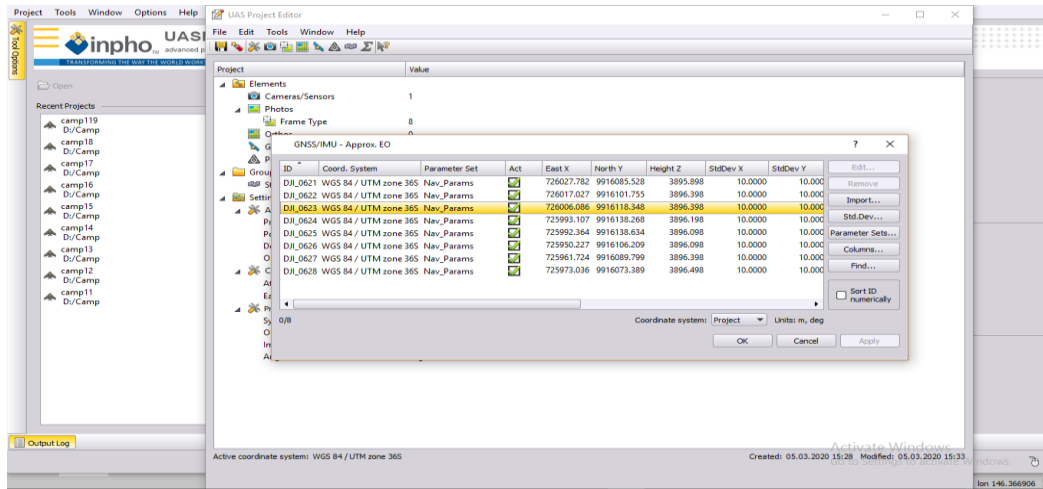

Figure3. 5 Importing exterior orientation files

The intuitive analyzer identifies tie points and ground control points. The points and photo connections that facilitate the rectification of the images are also determined by the intuitive analyzer. It enables residual scrutiny and error ellipses to allow the proper and accuracy of the fieldwork of captured data.

In terms of analysis of connectivity and point cells, UASMaster has a tool for binning cells to visualize and examining the data sets. The control points that were used for the UAV survey were for namely, GCP1, GCP2, GCP3, and GPC33 as shown in Figure 3.16.
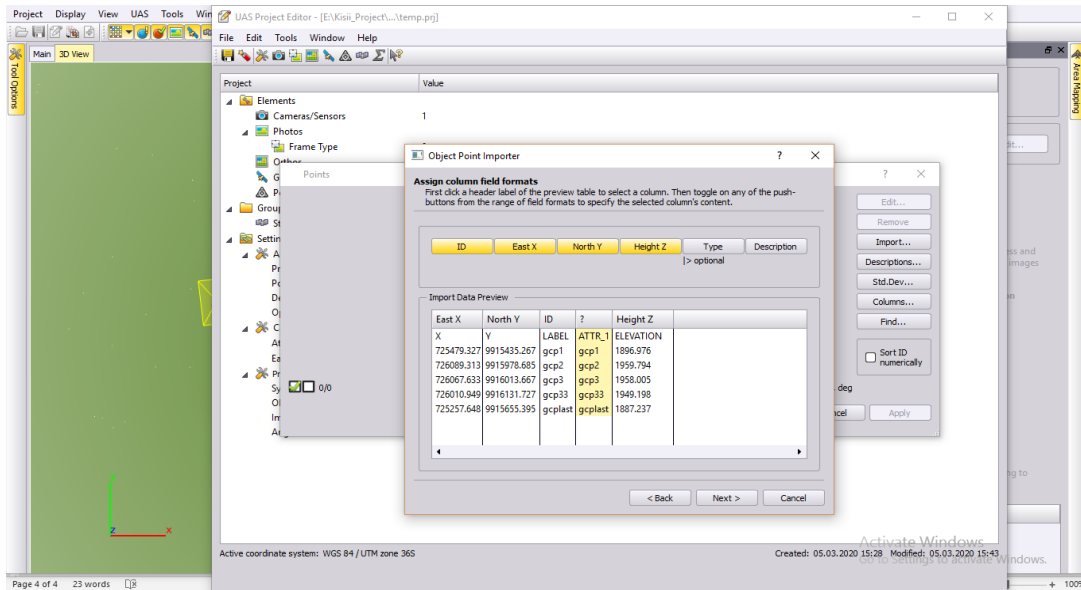
Figure3. 6 Import control points

In the bundle adjustment, of aerial images, the tie points are determined automatically with UASMaster software and standard deviations computed. The tie points in the triangulation network's accuracy were estimated by the standard variation. The tie point is generated by a tool referred to as a Cost-Based Matching option that is in UASMaster. This is shown in Figure 3.17 and Figure 3.18 respectively.
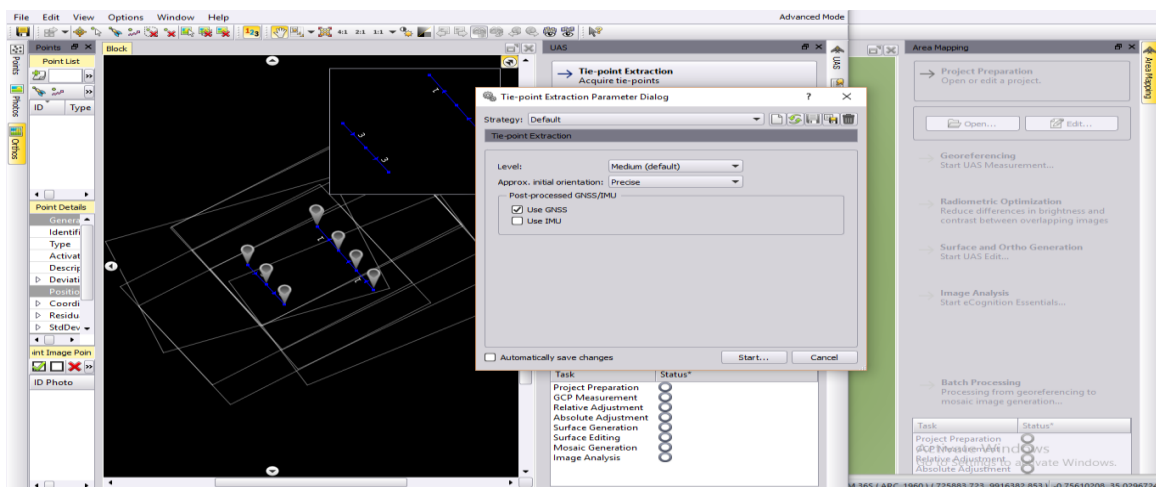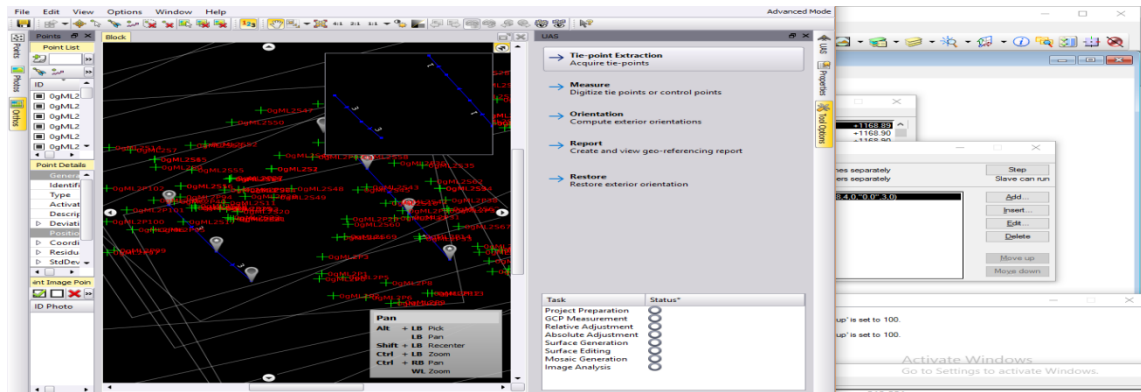

Figure3. 7 Tie point extraction

Figure3. 18 Tie point extraction

3.5.3 Automation/ check/ interactive

The process of full automation is carried out stepwise from initial to another up to final. The implementation of a one-stop solution in the UASMaster is unique. From the previous steps, there is one step that integrates the previous results. The Automatic checks are done for all the processes enabling an interruption for further analysis of the batch process. For example;

i. Geo-referencing is full automation. These are a generation of tie points, bundle adjustment as well as camera calibration.

ii. DSM (digital surface model) full automation as well as DTM (Digital Terrain model) for bare earth, generation.

iii. The automation of Ortho-mosaics is full. The true Ortho-photos that have no facades.

The interactive parts comprise of project definition, DSM editing, check of procedures, and optional measurements of ground controls.

The tie points are crucial as the relative locations of most images can be referenced to the reference image. Thus sufficient overlaps help to have more tie points in more than two images. The use of accurately GCPs as tie points that are adequate in number increases the accuracy of aero-triangulation as shown in Figure 3.19.
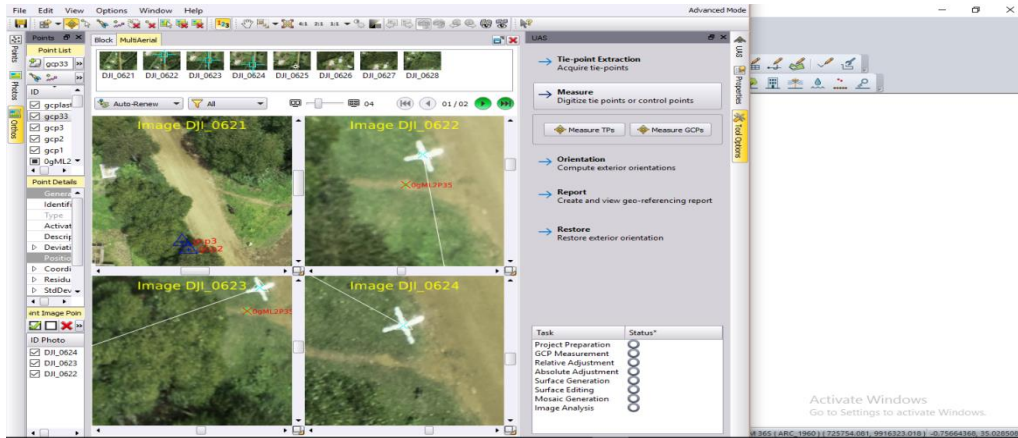
Figure3. 19 Measuring control points

3.5.4 DSM and DTM generation

The DSM generation is a workspace that shows the required tools and visualization in the UASMaster. Within the interface of UASmaster, all the dialogs are launched directly and graphics updated automatically. Alternatively, the area of DSM can be digitized optionally. For the generation of the point cloud, there is a consideration of morphological data. This is according to imported data as well as displayed data layers. The strategy for the support of one DSM area to be processed at a time it is digitized. Point-clouds and height data enables the generation of colored point clouds. It includes surface grids and DTM (Digital Terrain Model) of bare earth as an output. It also checks for effective point clouds filtering of noise. Thus, for classification and point cloud filtering features that is sophisticated to enhance separation of ground from the off ground.

The editing capability of basic DSM with DTMaster that one can visualize, select, delete, classify as well as move or pan are incorporated in this panel as shown in Figure 3.20.
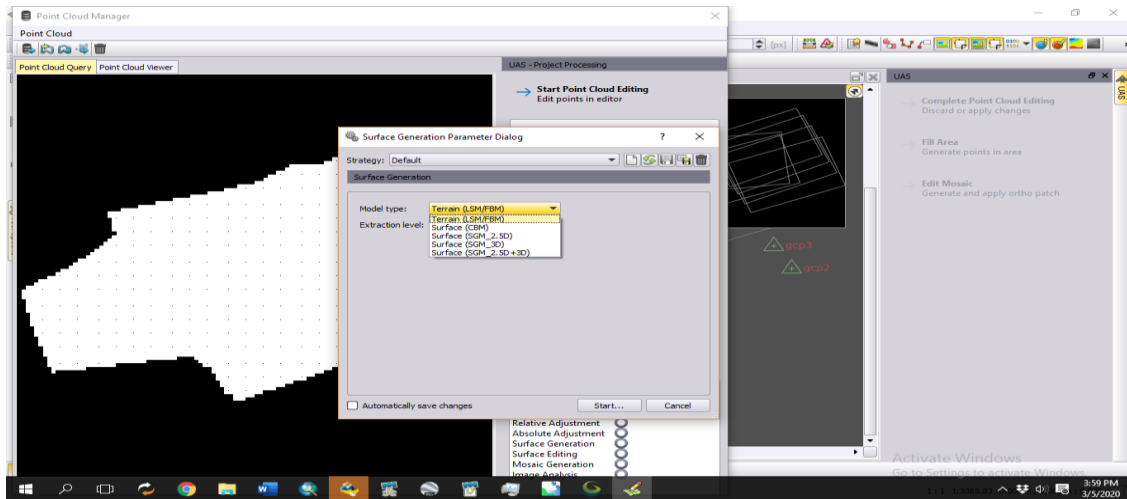
Figure3. 8 DTM generation

3.5.5 Ortho Mosaic Generation

This is an implementation of an aggregated Ortho-workflow in the UASMaster. The UASMaster viewer allows full integration of Ortho-processing. There is a possibility of loading an existing point cloud into the project as well as vector information to be used for Ortho-rectification. This ensures the refinement of results from the point cloud. The parameter sets are reduced on the GUI, while the output is in 'Bigtiff' with no seam editing capability as shown in Figure 3.21.
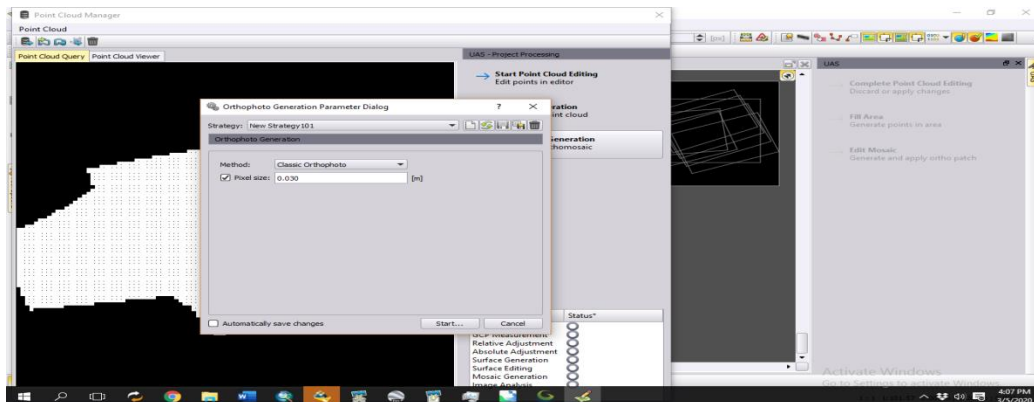

Figure3. 9 Ortho-Mosaic generation

CHAPTER FOUR: RESULTS

4.1 The mapping processes in settlement schemes

After an area had been declared an adjudication section by the adjudication officer, the process of land consolidation commenced. The adjudication officer was appointed by the minister for lands and settlement schemes to conduct land rights in the adjudicated area. Junior survey assistants as a team of measurers with basic training in the survey moved in to measure each area of a parcel of land.

The assistant land surveyors demarcated the boundaries by digging shallow trenches along the whole holding length. The trenches were then planted with visible green hedges to ensure the house holdings are drawn permanently on the map. The demarcation maps are then prepared that shows all the surveyed field and areas determined by the planimeter. Then the adjudication register is also prepared that contains all the pieces of land in the adjudication section by name as well as the area (Redkey & Sorrenson, 2015).

Then, a re-fly is done once the hedges have grown and are air-visible to create new air photographs. The mapping is mainly intended for the production of Registry Index Maps at a scale of 1:2500. The maps show cadastral boundaries without having contours. Thus, the boundaries are adjusted so as to accommodate the objection as captured (Redkey & Sorrenson, 2015).

A register of titles is prepared. The freehold titles that are negotiable are then issued by the Chief Registrar to each landholder under the repealed Registered Lands Act Cap 300 of 1963. The Registry Index Maps at the land Registry substitute the demarcation maps as they become the cadastral map for the Settlement Schemes.
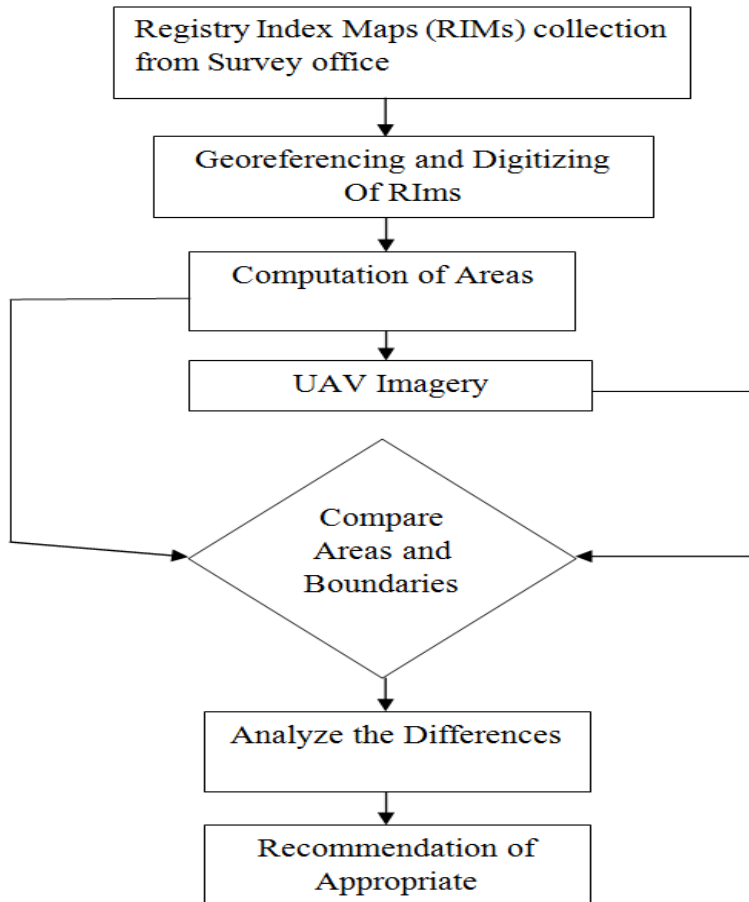
Figure 4. 1 Compulsion of UAV and RIM areas

4.2 Assessment of new methods

The image shown below represents the processed image that was acquired from the UAV with a resolution of 5cm.

4.2.1 Digitization of RIMs

4.2.1.1 Scanning of RIMs

Scanning refers to the means of capturing and archiving images and obtaining a high-quality image version. The hardcopy RIM was scanned to obtain a colored raster image. The images were converted into JPEG (Joint Photographic Expert) format. This is due to the image being compressible into the small files without loss in quality. It is also important as it can be opened by any software that supports images.

4.2.1.2 Import into Arc Map environment

By clicking in the insert menu that allowed to the browser in the folder where the image is stored. Then using the arrow in the drop-down the image was navigated and clicked on it. In the layout view, by clicking open the image was inserted and displayed in the display panel of Arc Map.
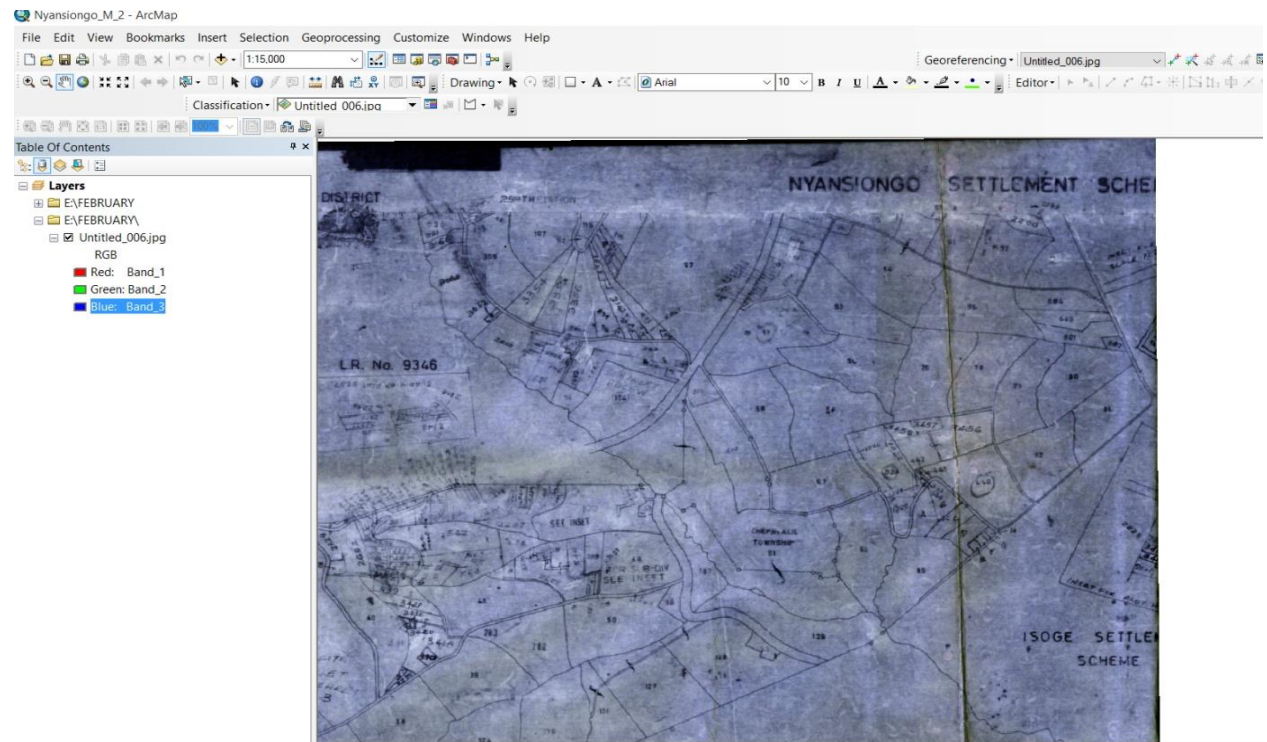

Figure 4. 2 Imported Scanned RIMs in ArcGIS

4.2.1.3 Geo-referencing

By using the four control points that were picked in the field by hand-held GPS, the image was geo-referenced. This is to ensure that the image was to be in the correct coordinate system for easy working in the same datum. The result is as shown in table 4.1 and figure 4.3.

Table 4. 1 Control points for Geo-referencing

| Link	X Source	Y source	X map	Y map	Residual_x	Residual_Y	Residual
			Total RMS Error: forward:8.89589				
1	467.472395	-178.029836	725392.533400	9915731.757000	-5.37706	-0.916137	5.45455
2	312.389244	-3.551832	726004.925700	9916278.002000	11.7191	1.99668	11.8879
3	269.689095	-26.510163	725926.561600	9916431.044000	-10.9575	-1.86692	11.1154
4	391.689295	-261.325463	725172.089000	9916016.310000	4.61546	0.786376	4.68197
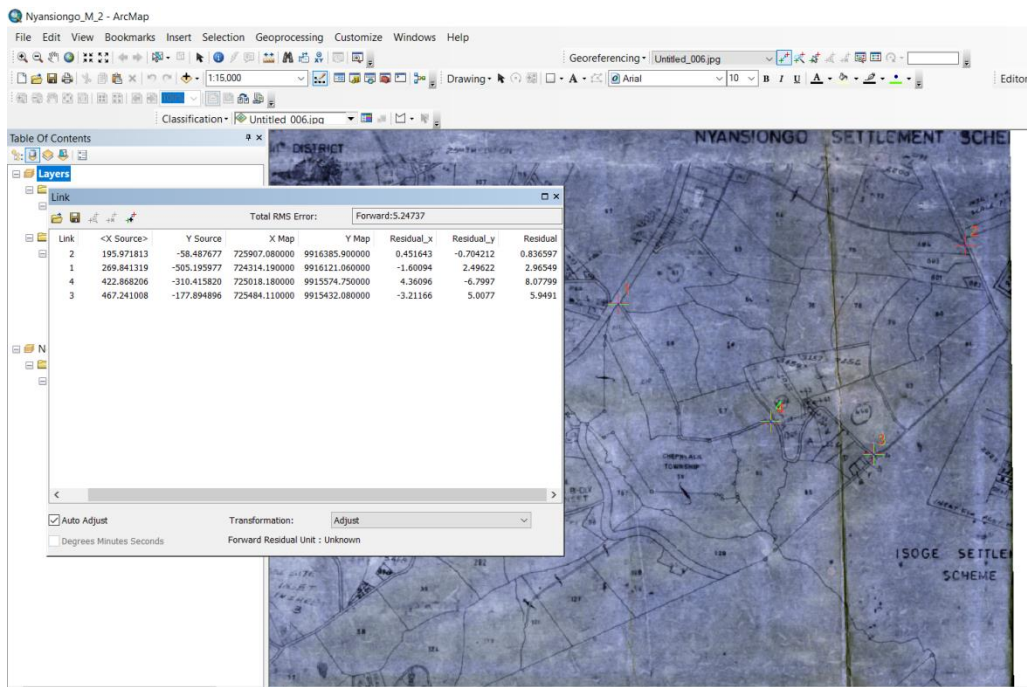
Figure 4. 3 Geo-referencing

4.2.1.4 Digitization

The polygons that were digitized from the RIM are as shown in figure 4.4. As they can be seen most of them are changed in shape and size on the ground. The changes have come due to more land subdivisions that have taken place and also constructions of new road networks.
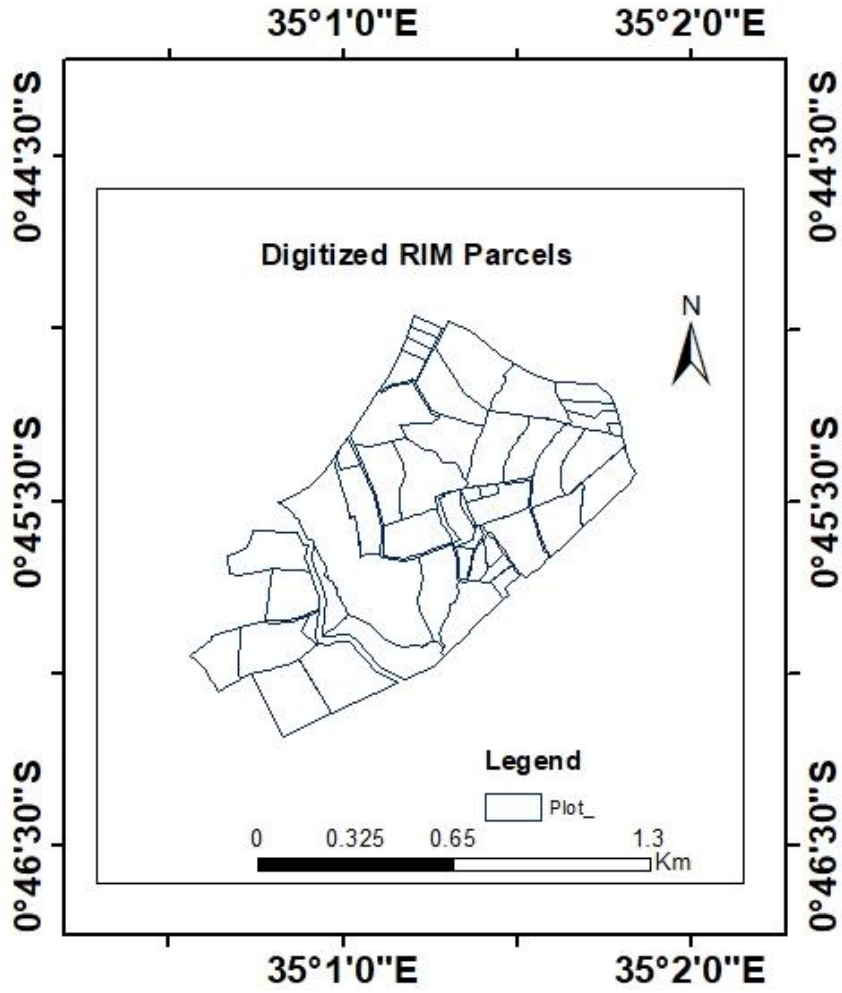
Figure 4. 4 Digitized RIM Parcels

The digitized RIM polygons are tabulated in table 4.2. Their areas were determined in square meters as well as in acres. Not all of the digitized parcels from the RIM were surveyed by the UAV. The digitized parcels from RIM that were surveyed by the UAV are with Id No. 81, 82, and 440 with the area as 60084.1992188 square meters, 60078.6992188 square meters and 67196.1015625 respectively. The same parcels their areas in Acres are 14.8471003, 14.8458004, and 16.6044998.

Table 4. 2 Areas obtained from Digitized RIM Parcels

FID	Id	Area_acres	Area_sqrm
0	81	14.8471003	60084.1992188
1	440	16.6044998	67196.1015625
2	82	14.8458004	60078.6992188
3	80	15.7439003	63713.5000000
4	3456	12.0431004	48736.5000000
5	79	14.8364000	60040.6992188
6	57	16.2728004	65853.7968750
7	78	14.0544996	56876.5000000
8	3	2.6604900	10766.5996094
9	2	2.7221899	11016.2998047
10	1	3.2996199	13353.0996094
11	4	2.9438300	11913.2998047
12	1725	2.7020700	10934.9003906
13	84	25.3918991	102757.0000000
14	76	19.4969006	78901.2031250
15	61	21.5382004	87161.8984375
16	80	23.2096004	93925.8984375
17	211	2.9331601	11870.0996094
18	210	15.9350004	64486.5000000
19	604	6.1773300	24998.8007813
20	603	4.4751801	18110.4003906
21	601	4.9082098	19862.8007813
22	83	17.9708004	72725.2968750
23	75	19.3213005	78190.3984375
24	3458	1.6106499	6518.0800781
25	3457	1.3462900	5448.2402344
26	24	7.2820702	29469.5000000

27	441	1.5341200	6208.3500977
28	53	18.8764992	76390.6015625
29	85	16.5620995	67024.3984375
30	51	75.4656982	305399.0000000
31	58	17.3078003	70042.2031250
32	129	19.5370007	79063.2968750
33	0	2.1917500	8869.6904297
34	50	21.6308002	87536.7031250
35	282	13.4575005	54460.5000000
36	128	26.4274006	106948.0000000
37	127	24.2577991	98167.7031250
38	48	15.5970001	63118.8007813
39	187	7.9669399	32241.0996094
40	199	18.6427002	75444.2968750
41	6	2.1754200	8803.5996094
42	7	2.3632400	9563.6796875
43	8	2.4734299	10009.5996094
44	9	5.9509401	24082.5996094
45	602	0.9440270	3820.3400879

RIM digitized parcels with ID number 81, 82, and 440 were compared with UAV derived parcels in size and areas. The RIM digitized parcels that were compared with the UAV derived parcels are as shown in table 4.3.

Table 4. 3 Digitized RIM Parcels that were compared with UAV-derived Parcels

FID	Shape *	Id	Area_acres	Area_sqrm
0	Polygon	81	14.8471	60084.2
2	Polygon	82	14.8458	60078.7
1	Polygon	440	16.6045	67196.1

4.2.2 Generation of UAV derived polygons

4.2.2.1 Flight results

The total images of the UAV flight were three hundred and seven. The following four photographs are the sample images of UAV flight.

Figure 4. 5 Sample images from UAV Flight

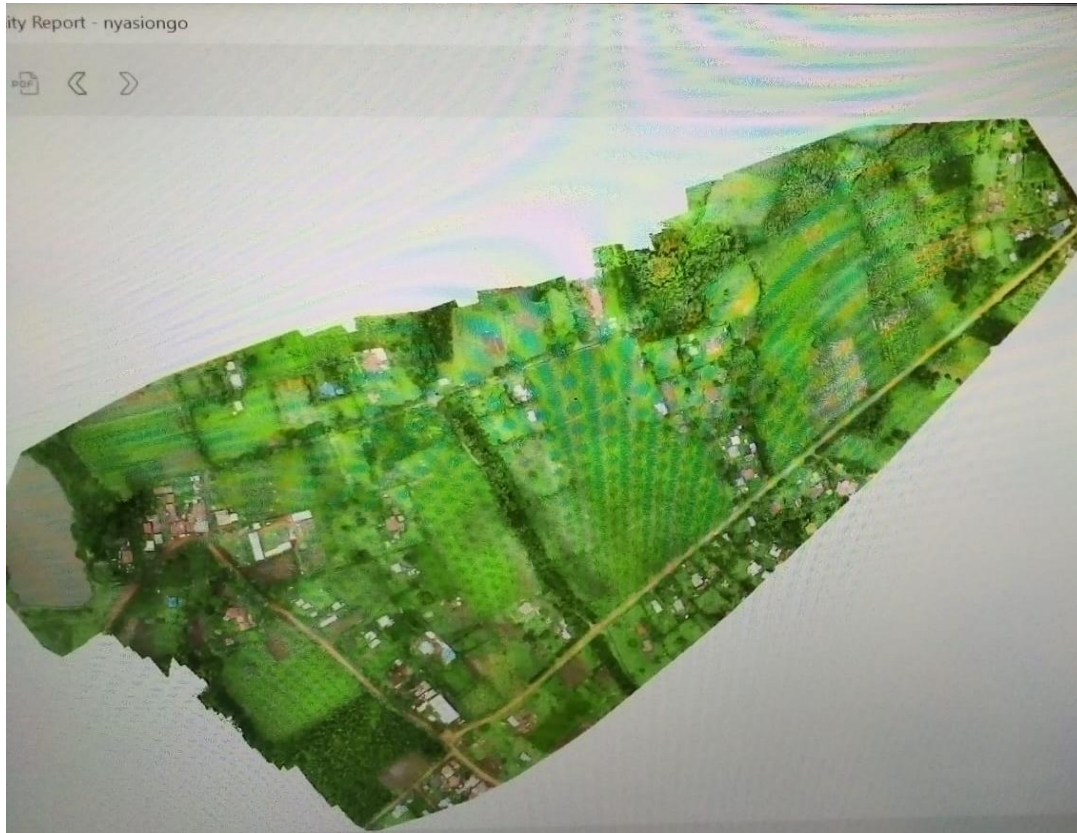All the images from the flight combined with the Pix4D program generated a bloc as shown in figure 4.6.

Figure 4. 6 Merged imagery from the UAV Platform

4.2.2.2 Post-processing

With the use of UASMaster, DSM (Digital Surface Model) was generated that was to be used in the production of the Digital Terrain Model (DTM). The Digital Surface Model in Arc Map working environment as shown in figure 4.7.
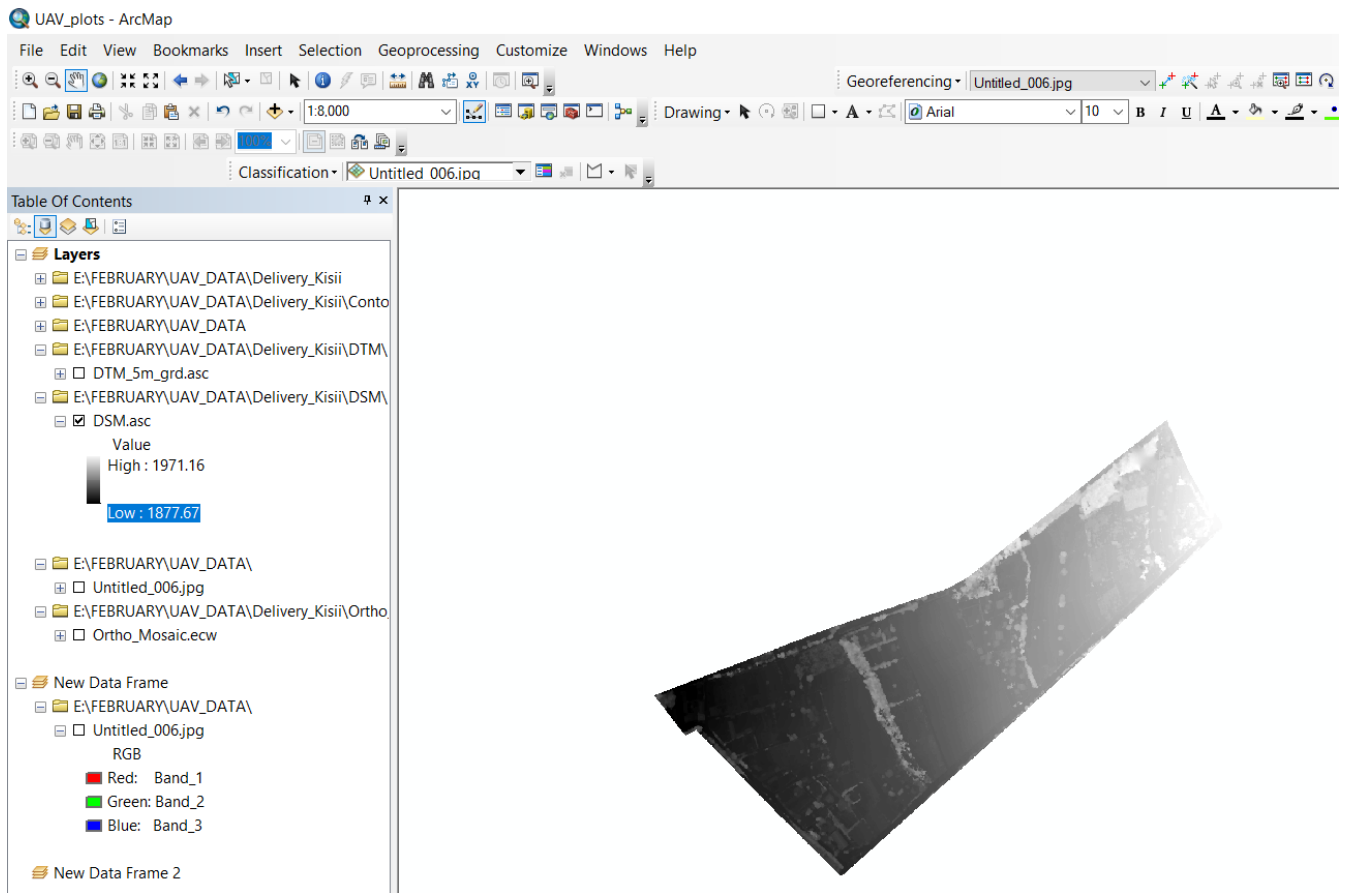
Figure 4. 7 Digital Surface Model displayed in ArcGIS
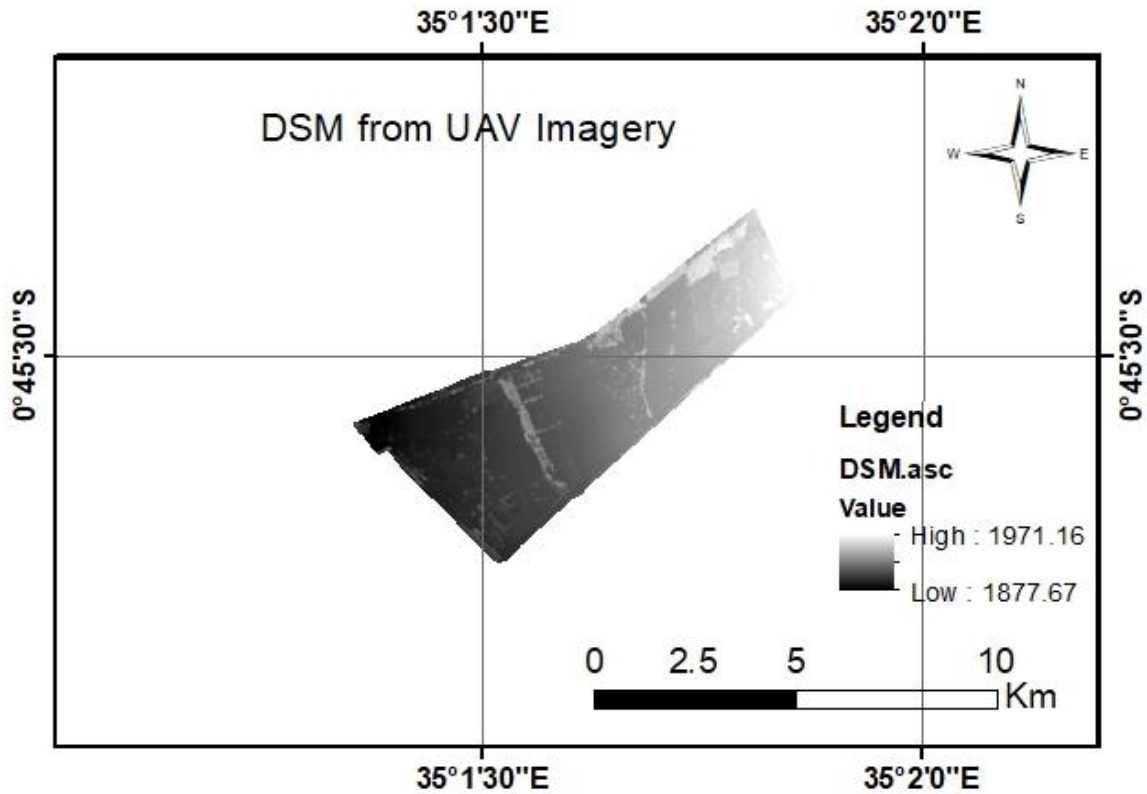
Figure 4. 8 the Digital Surface Model (DSM)

Similarly, with the help of the DSM, the contours were generated at an interval of 1 meter in the Arc Map working environment as shown in figure 4.9.
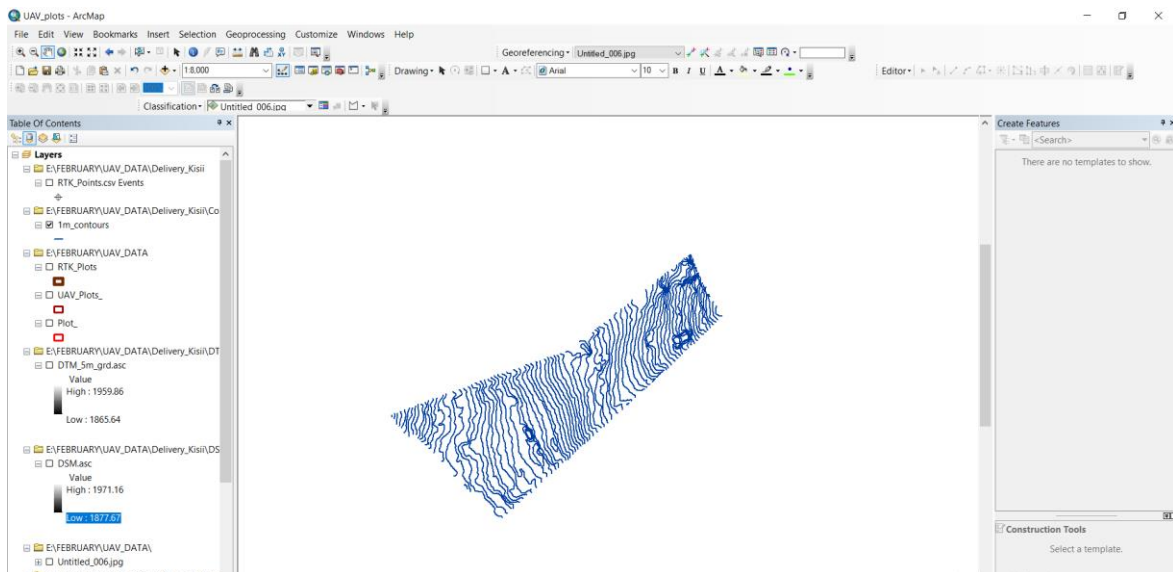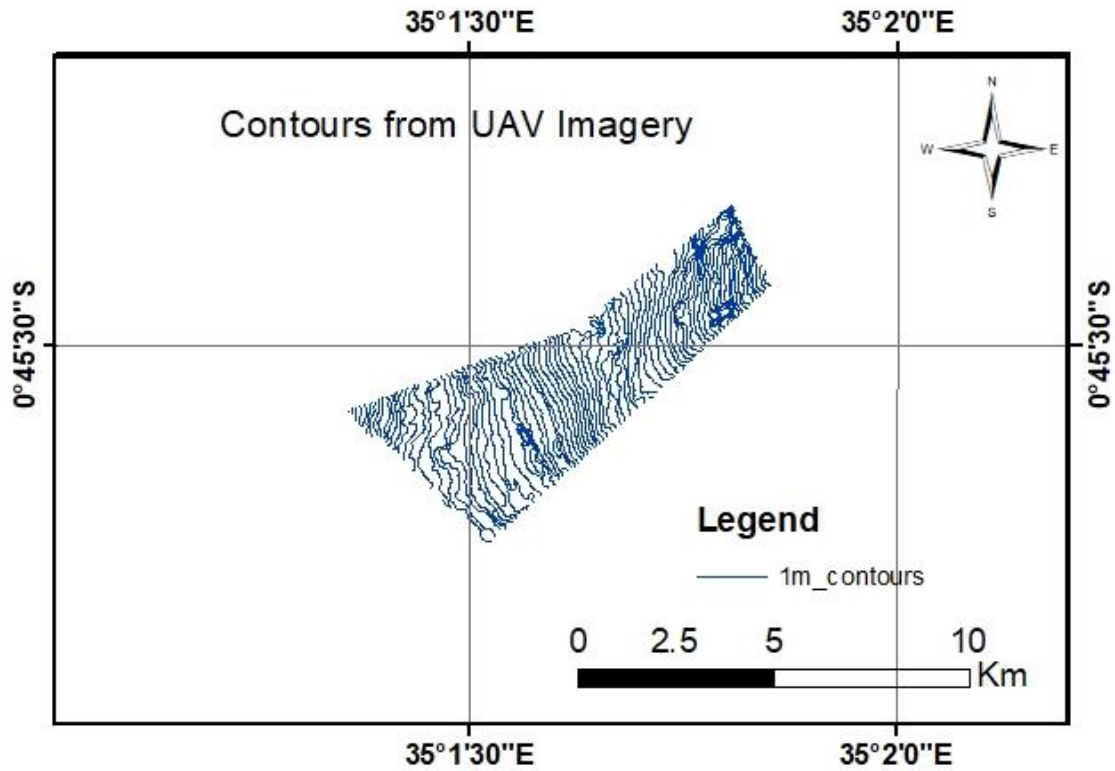

Figure 4. 9 Contour displayed in ArcGIS

Figure 4. 2 Contours at inter of 1 meter

DTM (Digital Terrain Model) was created which was to enhance the generation of the Ortho-mosaic image. Hence, the Ortho-photo image as shown in the figure.
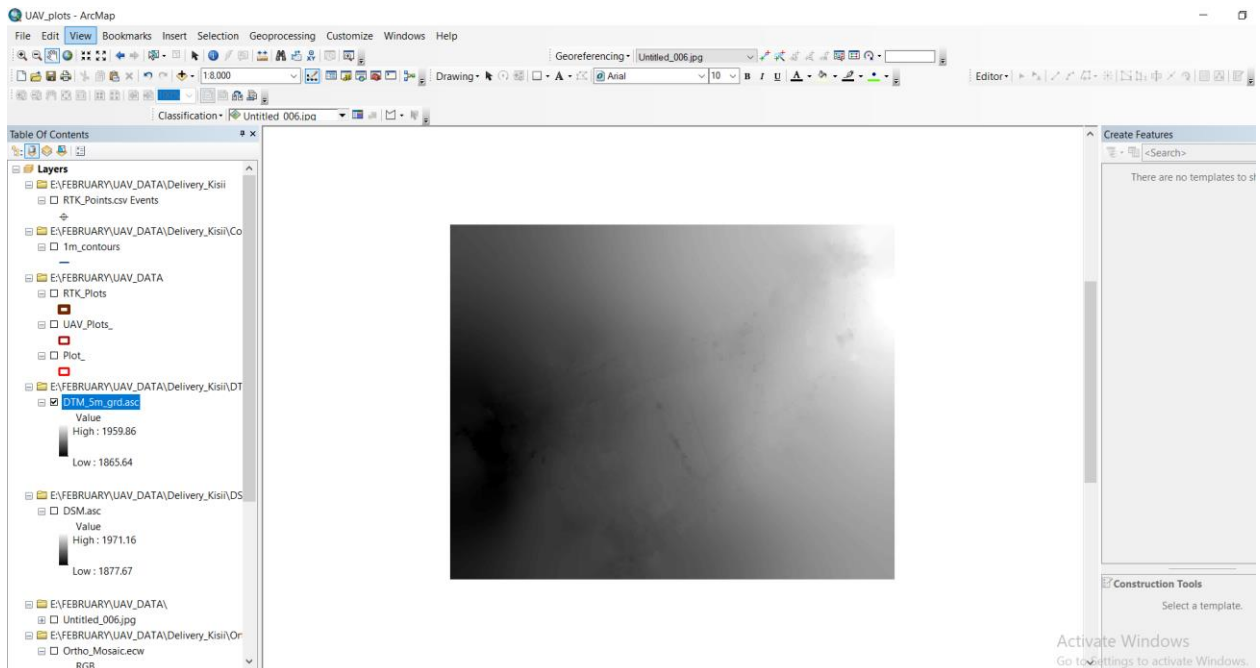

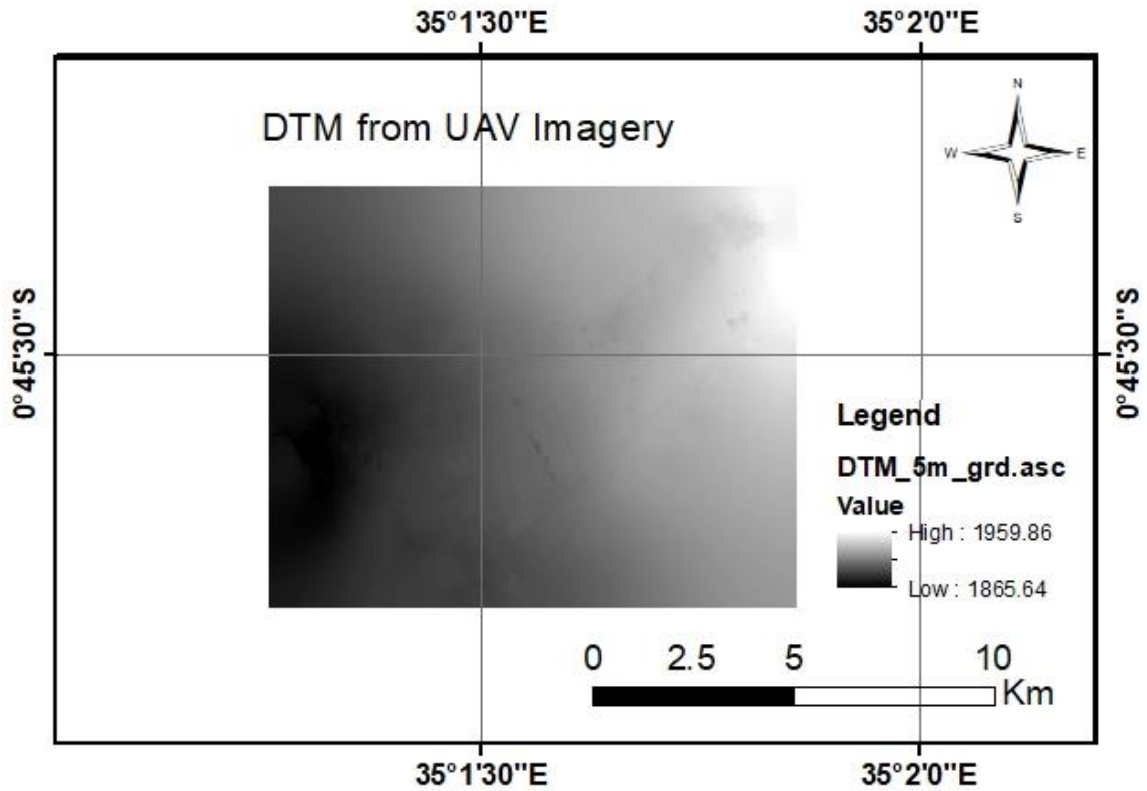**Figure 4. 3 Digital Terrain Model shown in ArcGIS Environment**

Figure 4. 4 Digital Terrain Model (DTM)

The Ortho-Mosaic image generated from the three hundred and seven images captured by UAV is as shown in the Arc Map working environment in figure 4.13.
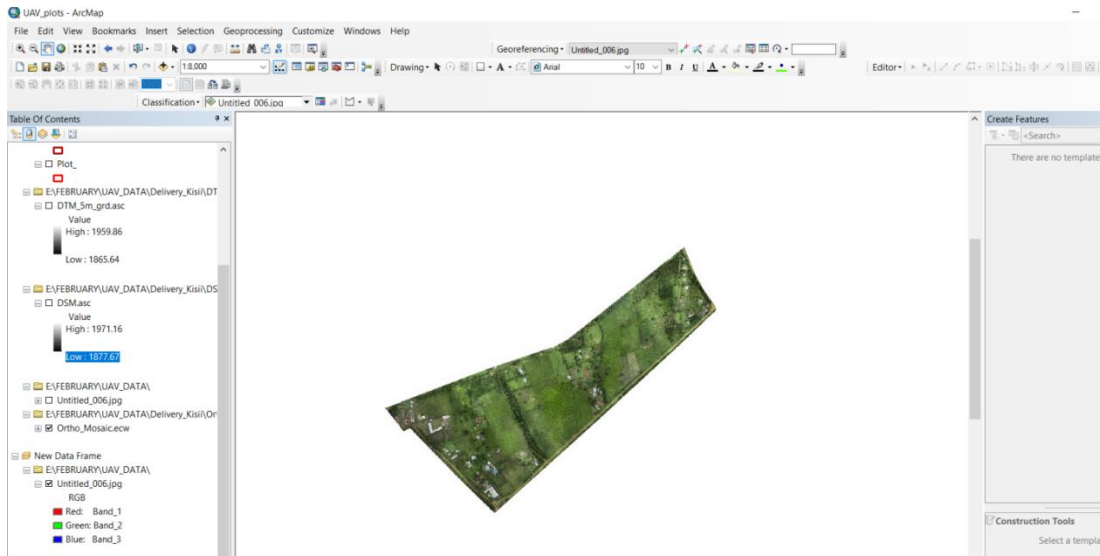

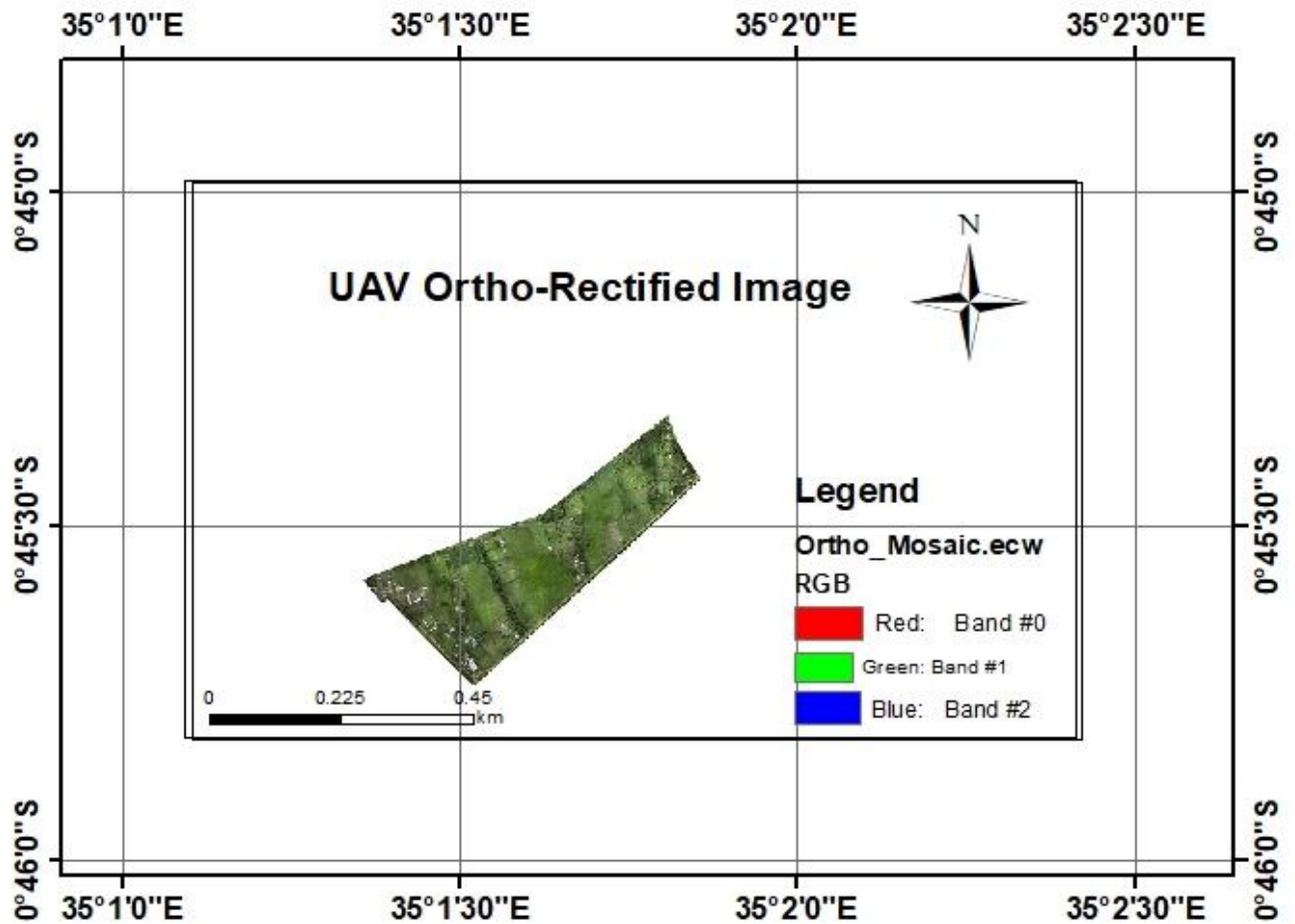**Figure 4. 5 Ortho-Mosaic photographs in Arc Map environment**

Figure 4. 6 UAV Ortho-rectified Image

4.2.3 Comparison of UAV derived polygons and digitized RIMs

4.2.3.1 Digitization of UAV derived polygons

The UAV derived parcels were digitized in the Arc Map software to obtain the three parcels of land as shown in figure 4.15 and figure 4.16 respectively.
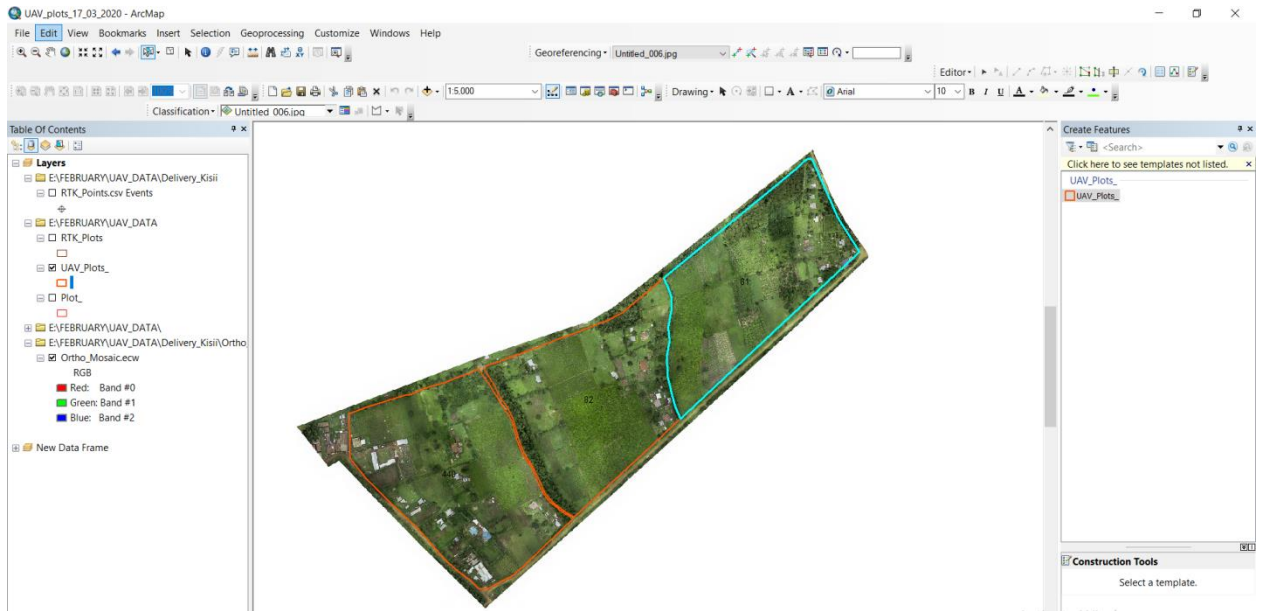
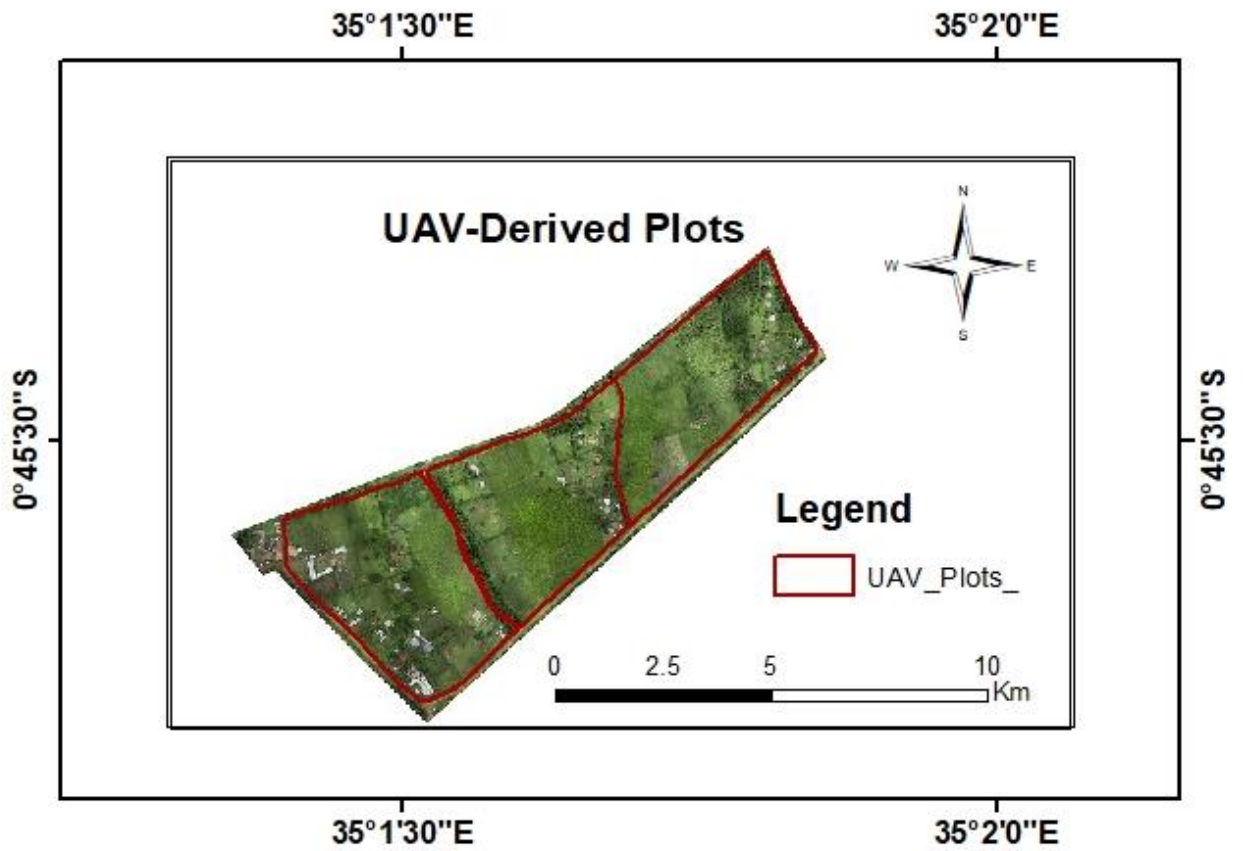**Figure 4. 7 Digitizing UAV derived Parcels in ArcGIS**
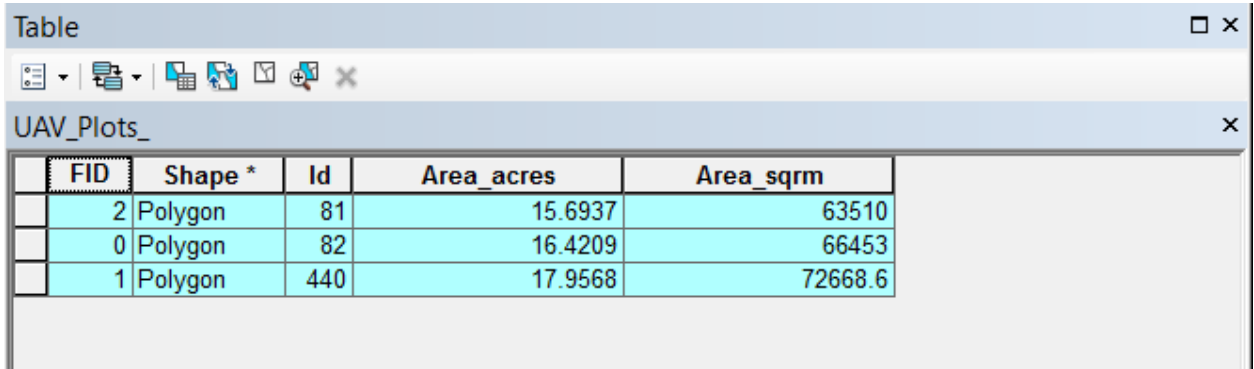

Figure 4. 8 Digitized UAV derived Parcels

The areas of the UAV derived polygons in acres and square meters are as shown in table 4.4.

Table 4. 4 areas of the UAV derived polygons

FID	Shape *	Id	Area_acres	Area_sqrm
2	Polygon	81	15.6937	63510
0	Polygon	82	16.4209	66453
1	Polygon	440	17.9568	72668.6

4.2.3.2 Digitization of RTK derived polygons

The parcels that were generated from the RTK are as shown in figure 4.17 and figure 4.18 respectively.
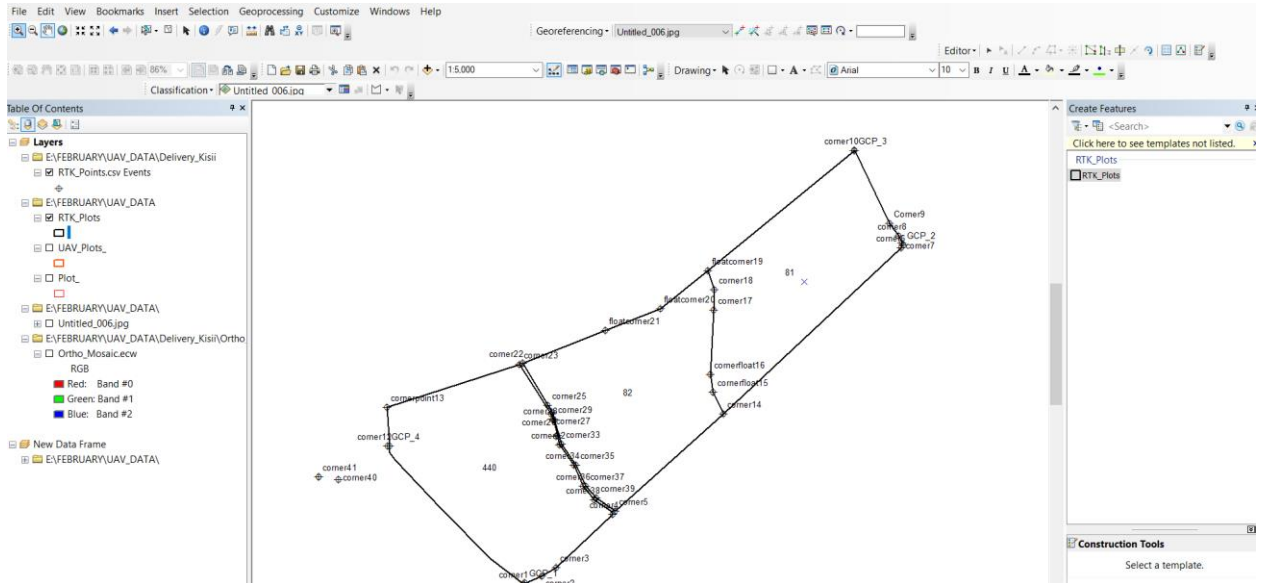
Figure 4. 9 Digitizing RTK derived polygons in ArcGIS

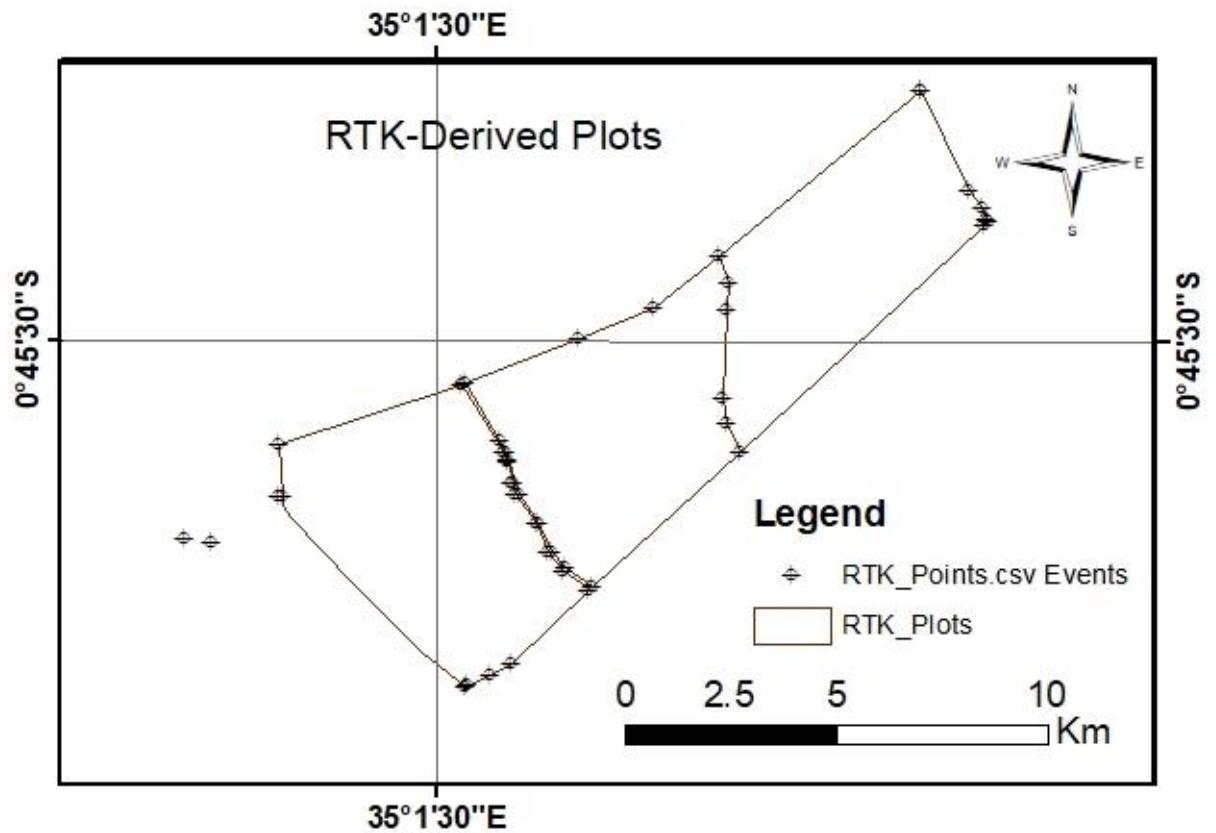**Figure 4. 10 Digitized RTK derived polygons**

The areas of RTK derived polygons in acres and square meters with ID 81, 82 and 440 are as shown in table 4.5

Table 4. 5 Areas of RTK derived polygons

FID	Shape *	Area	Area_metre	ID
0	Polygon	15.6353	63273.8	81
1	Polygon	16.5428	66946.4	82
2	Polygon	17.819	72110.9	440

4.2.3.2 Overlaying process

Overlaying of UAV Derived polygons with the RIMs digitized polygon using symmetrical difference tool. The result is as shown in the Arc Map working environment in figure 4.19.
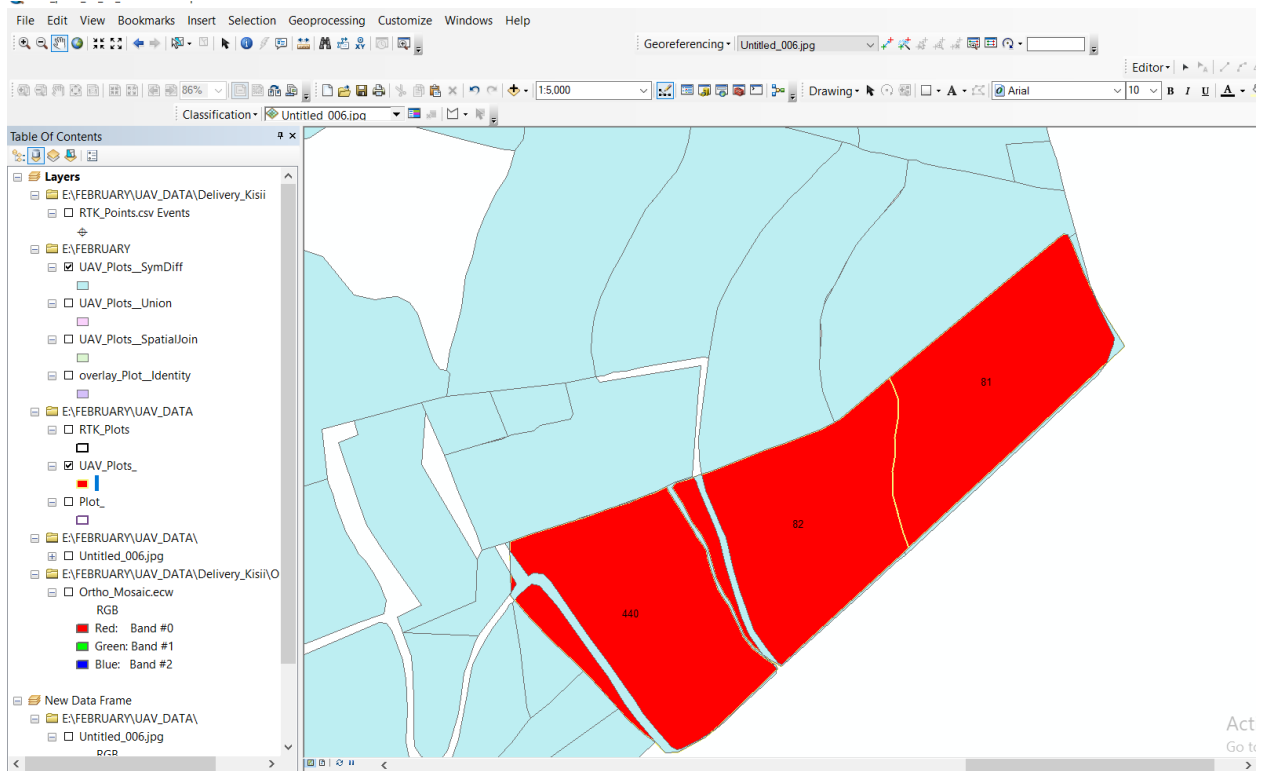

Figure 4. 19 UAV Derived polygons with the RIMs digitized polygon in Arc-Map

Where the red color represents the UAV plots and the sky blue color represents the RIMs plots. The difference between digitized parcels from RIM and UAV derived parcels is as seen in the figure. There is also a swift in comparison of the two sets of parcels of land from digitized RIMs in relation to that of UAV derived parcels of the same area. This is as a result of the two types of technology that are used in the survey. The positional accuracy of RIMs at a scale of 1:10000 is ± 0.30 m while the provisional range RIMs at a scale of 1:50000 is ± 10 m. The UAV derived images have a resolution of 5cm. thus the positional accuracy of UAV derived parcels is higher as compared with that of digitized RIMs parcels. Hence the difference noted as illustrated in figure 4.20.
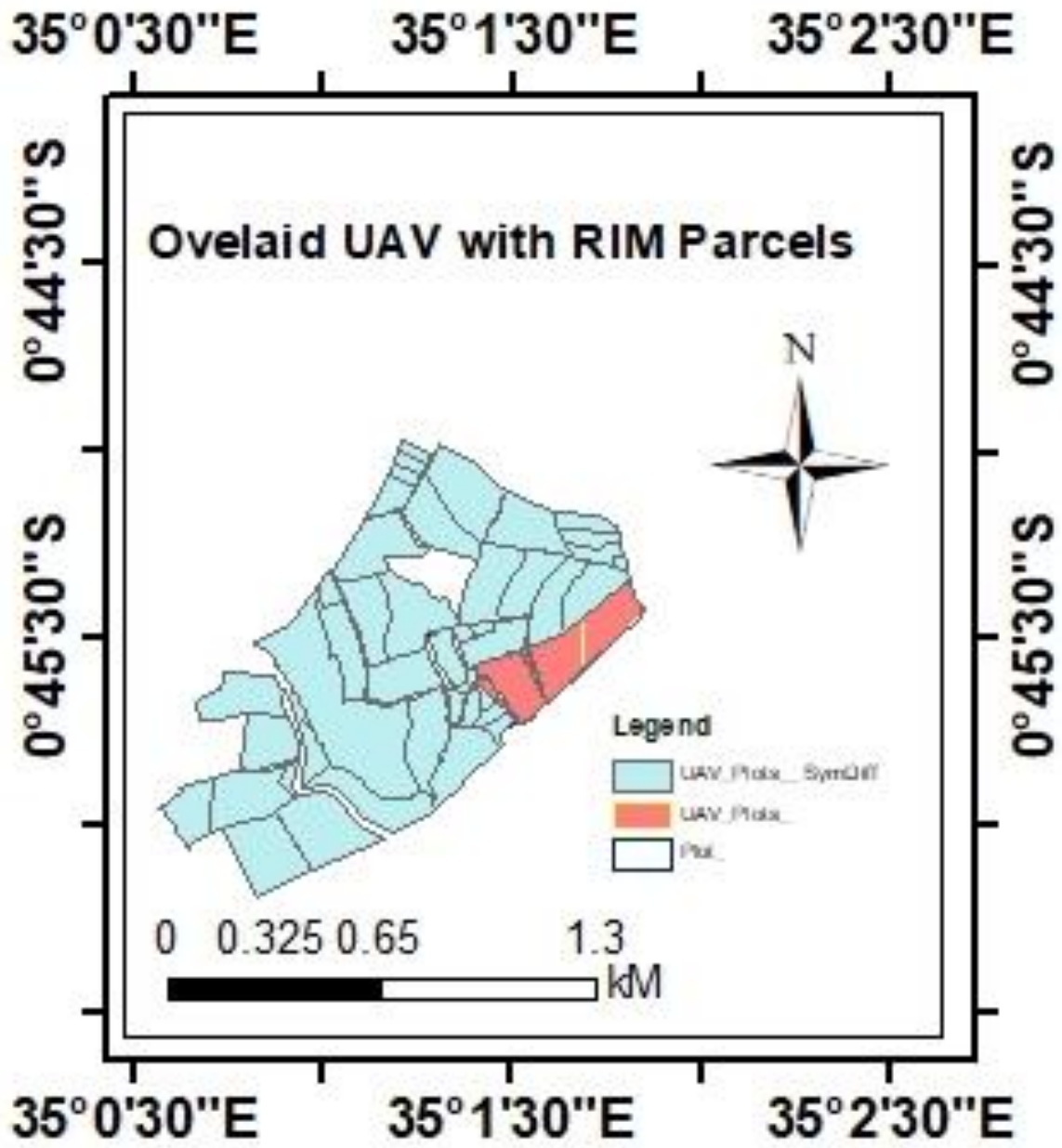
Figure 4. 11 Overlaid UAV Derived polygons in Red with the RIMs digitized polygon

Figure 4.21 shows the RIM digitized parcels overlaid with UAV derived parcels by erasing tool in Arc Map as shown. The red color shows UAV derived parcels with a yellow boundary. The grey color shows the shift of the boundary of digitized RIMs and UAV derived parcels.
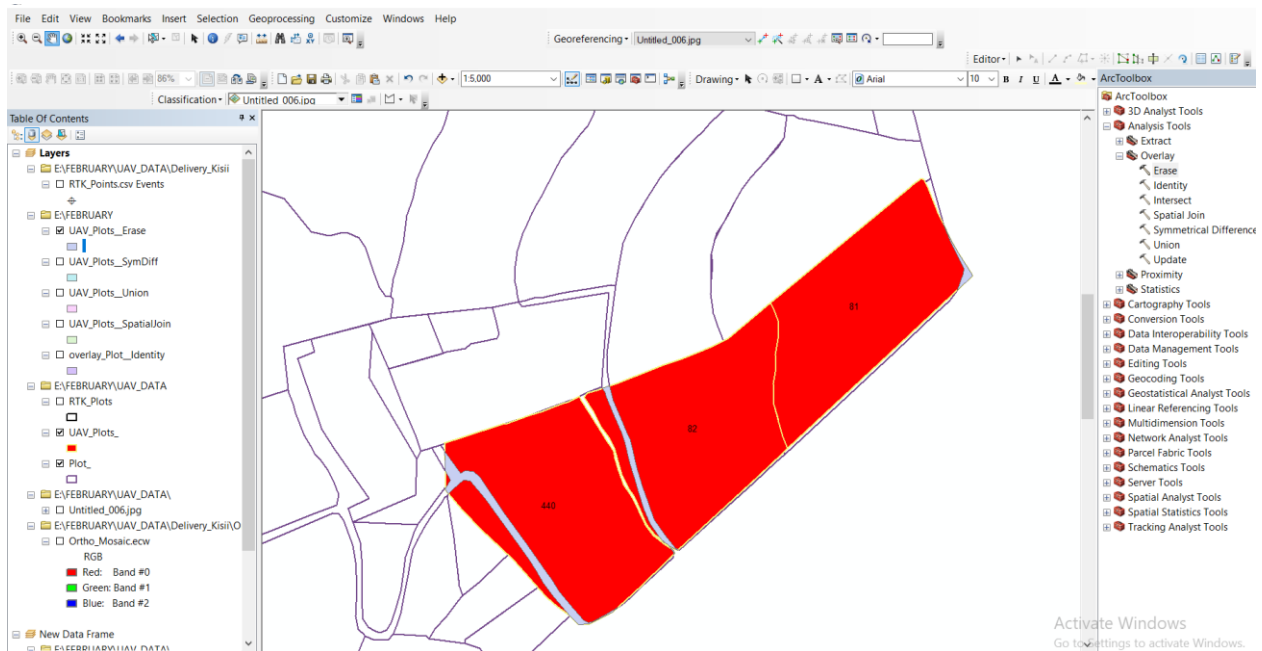
Figure 4. 12 Further Overlaying UAV Derived polygons with the RIMs digitized polygon in ArcGIS
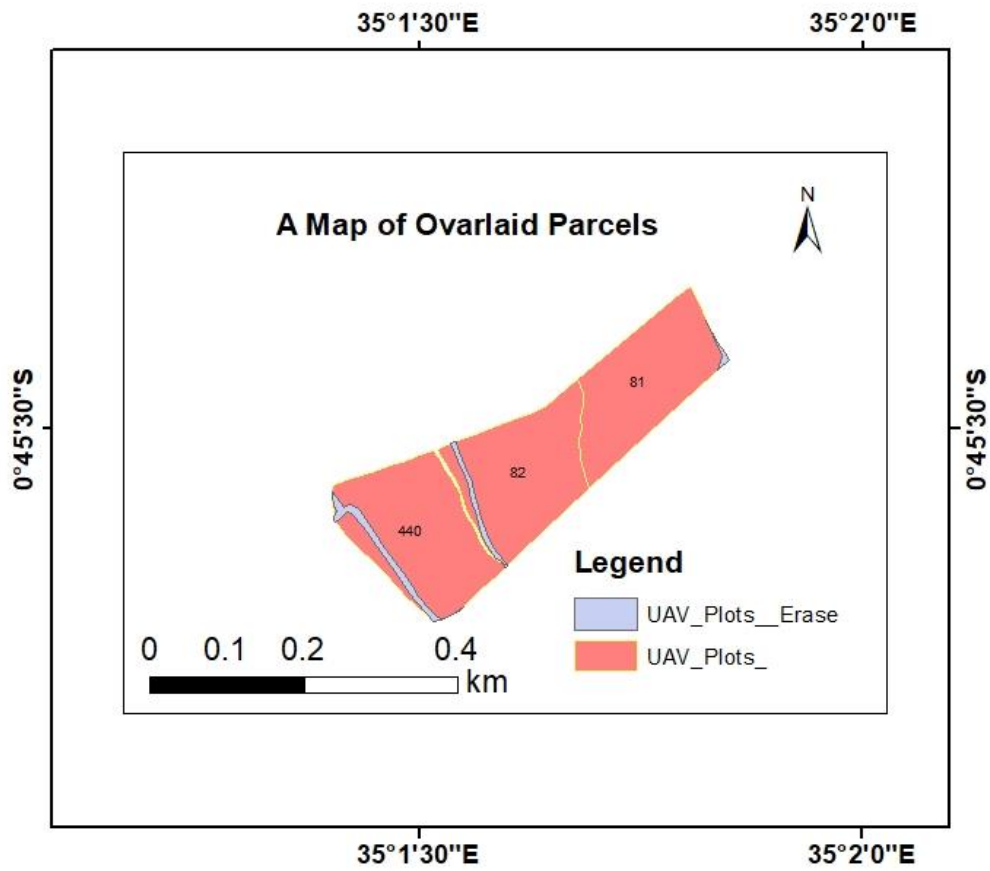
Figure 4. 13 Results from UAV Derived polygons with the RIMs digitized polygon

77

Figure 4.23 shows the buffering of the symmetrical difference of the UAV plots with that of RIMs. Similarly, as shown in figure 4.23, the red color represents UAV derived parcels while the yellowish color represents the parcels digitized from RIM. The shift is as shown in figure 4.23.
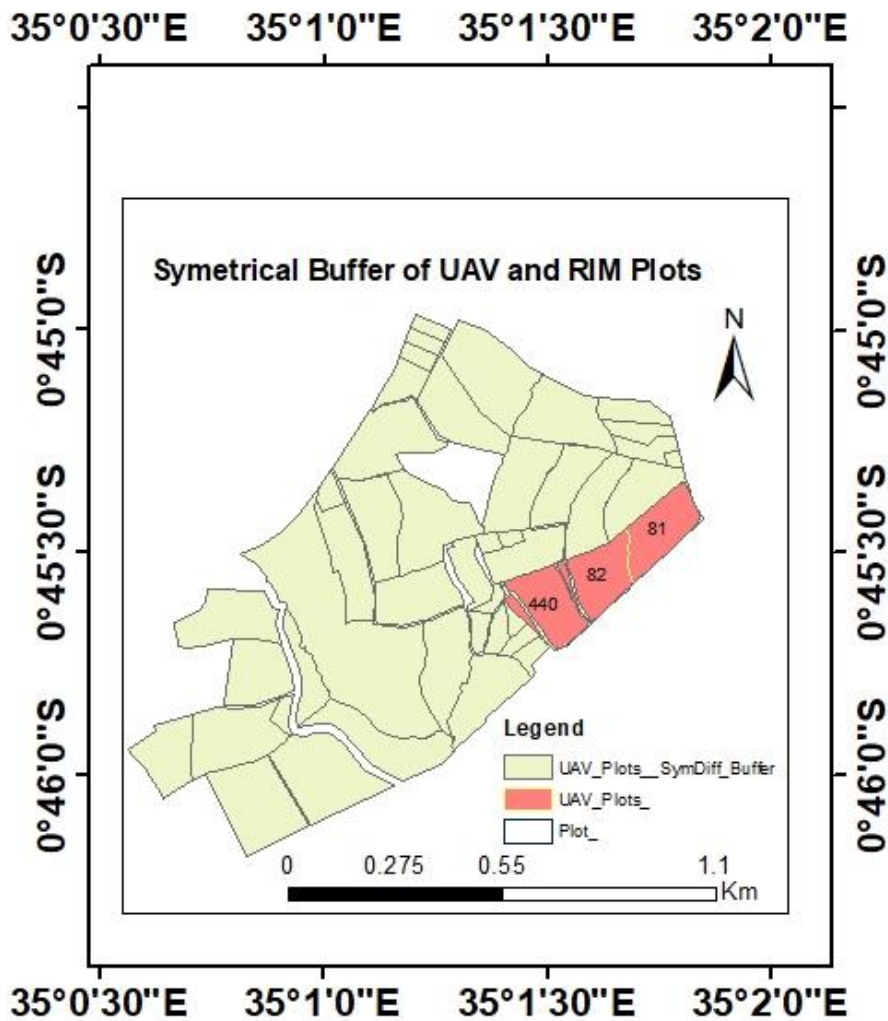
Figure 4. 14 The buffering of the symmetrical difference of the UAV plots with RIM plots

Overlaying of RTK Derived polygons with the RIMs digitized polygon using symmetrical difference tool. The result is as shown in figure 4.24.
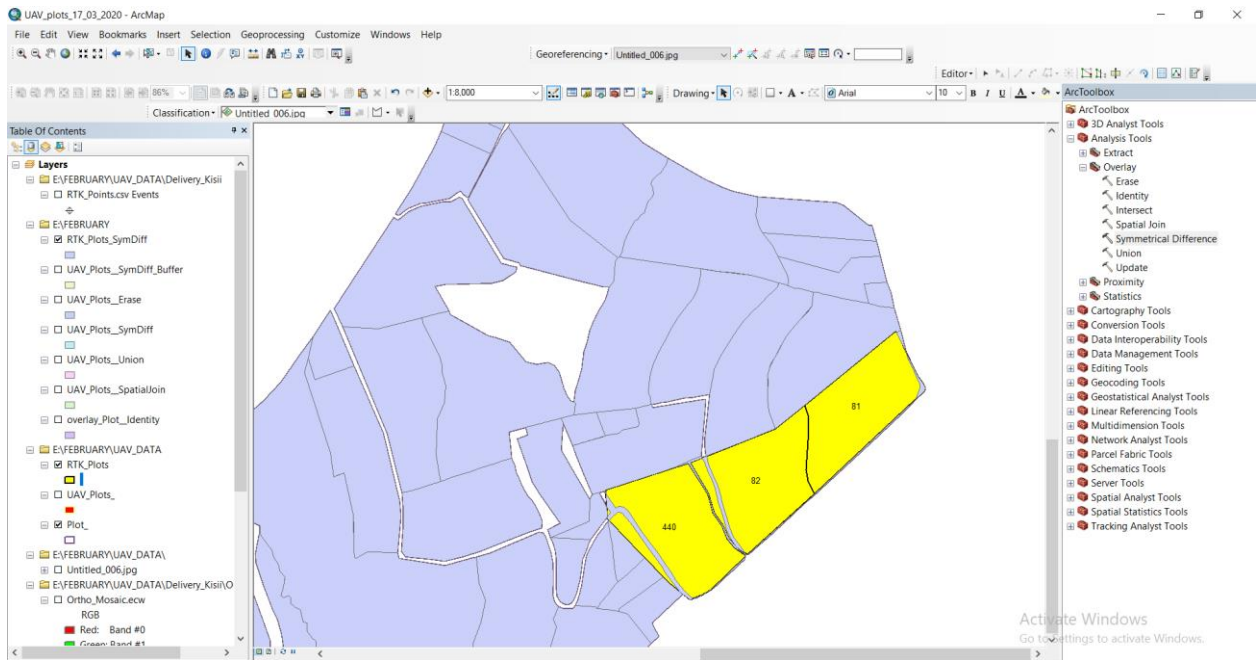
Figure 4. 15 Overlaying of RTK Derived polygons with RIM digitized Polygons in ArcGIS

The RTK parcels similarly are noted in yellow color while the parcels digitized from the RIMs are in grey color. The swift is of the same size and direction as it was with that of UAV derived parcels in relation to the digitized parcels from RIMs.
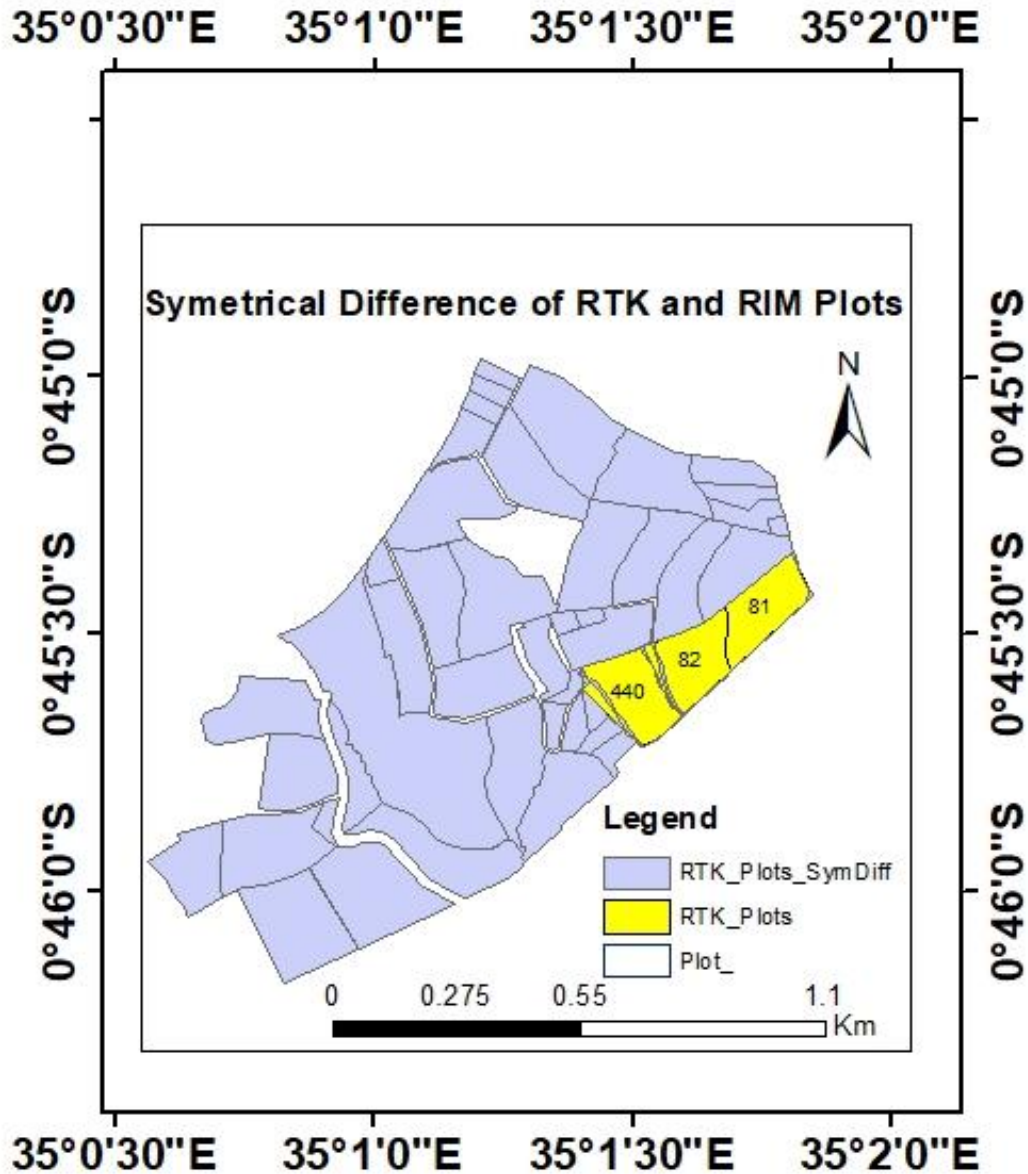
Figure 4. 16 Result of RTK Derived polygons with RIM digitized Polygons

Overlaying of RTK Derived polygons with UAV derived polygon using the symmetrical difference tool in Arc Map. The result is as shown in the figure. As can be seen, the difference is minimal between the UAV derived parcels in relation to the RTK derived parcels. The two technologies are of high accuracy in terms of positional accuracy. Therefore, they have equivalent results in terms of swift, size of plots in area and shape.
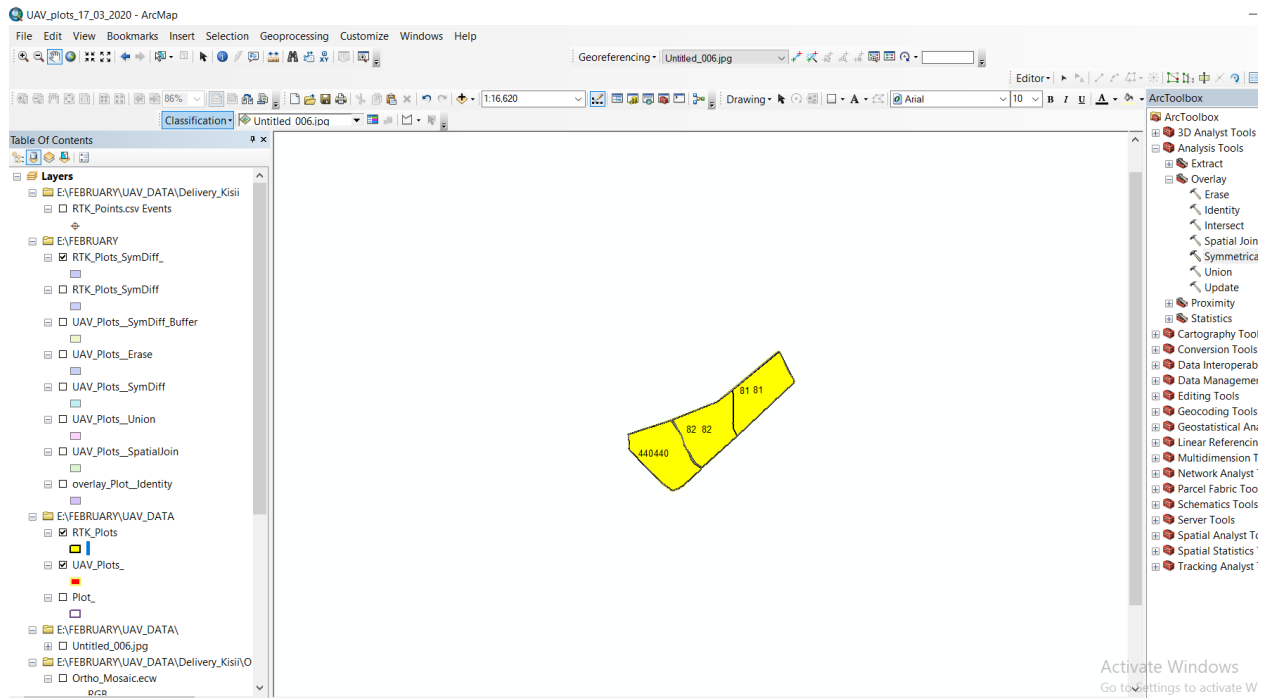
Figure 4. 17 Overlaying of RTK Derived polygons with UAV derived polygon in ArcGIS
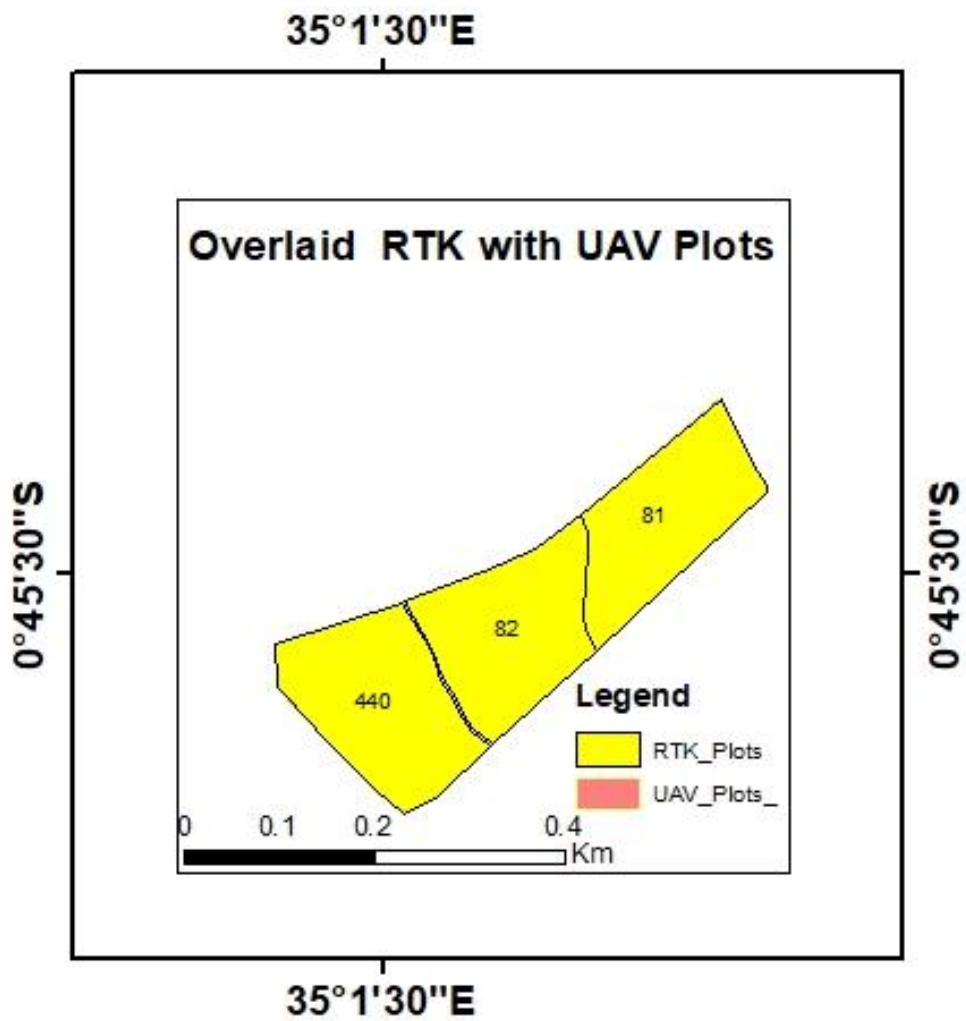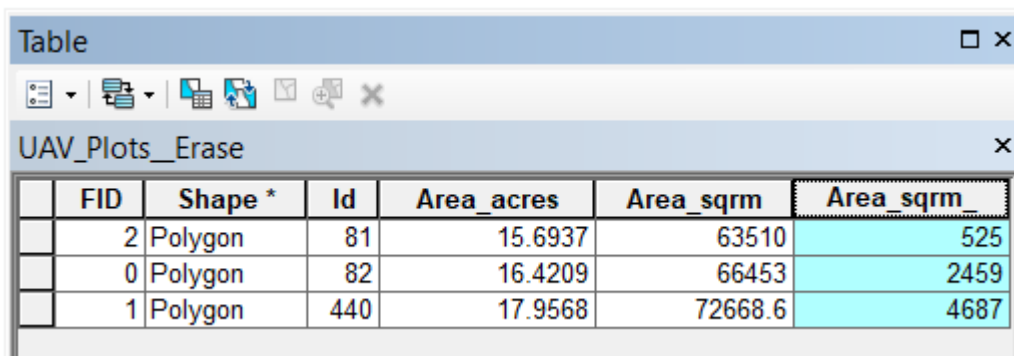
Figure 4. 18 Results of Overlaid RTK Derived polygons with UAV derived polygon

CHAPTER FIVE: ANALYSIS AND DISCUSSIONS

5.1 Analysis

The results were analyzed in terms of areas, perimeters, and boundary shifts using ArcGIS software. The same results can equally be compared with different software like Auto-CARD, Carlson Survey, as well as QGIS. This ensures the provision of room to weigh results from other software to know which one is better in yielding the most accurate or appropriate results.

Table 5. 1 Highlighted Differences in Areas Overlaid UAV Derived Parcels with RIM Digitized Parcels

	FID	Shape *	Id	Area_acres	Area_sqrm	Area_sqrm_
	2	Polygon	81	15.6937	63510	525
	0	Polygon	82	16.4209	66453	2459
	1	Polygon	440	17.9568	72668.6	4687

The area that is highlighted represents the overlay by Erase a tool whereby 525 Square meters represent the area that is outside the UAV plot of a polygon with Id 81. The area of 2459 Square meters represents the road that exists in the RIMs which has shifted in the UAV polygon that lies between polygon with Id number 82 and Id number 440.

The area of 4687 Square meters represents the existing road that shifted in the polygon 440. This is as shown in figure 5.1 that is represented by grey color.
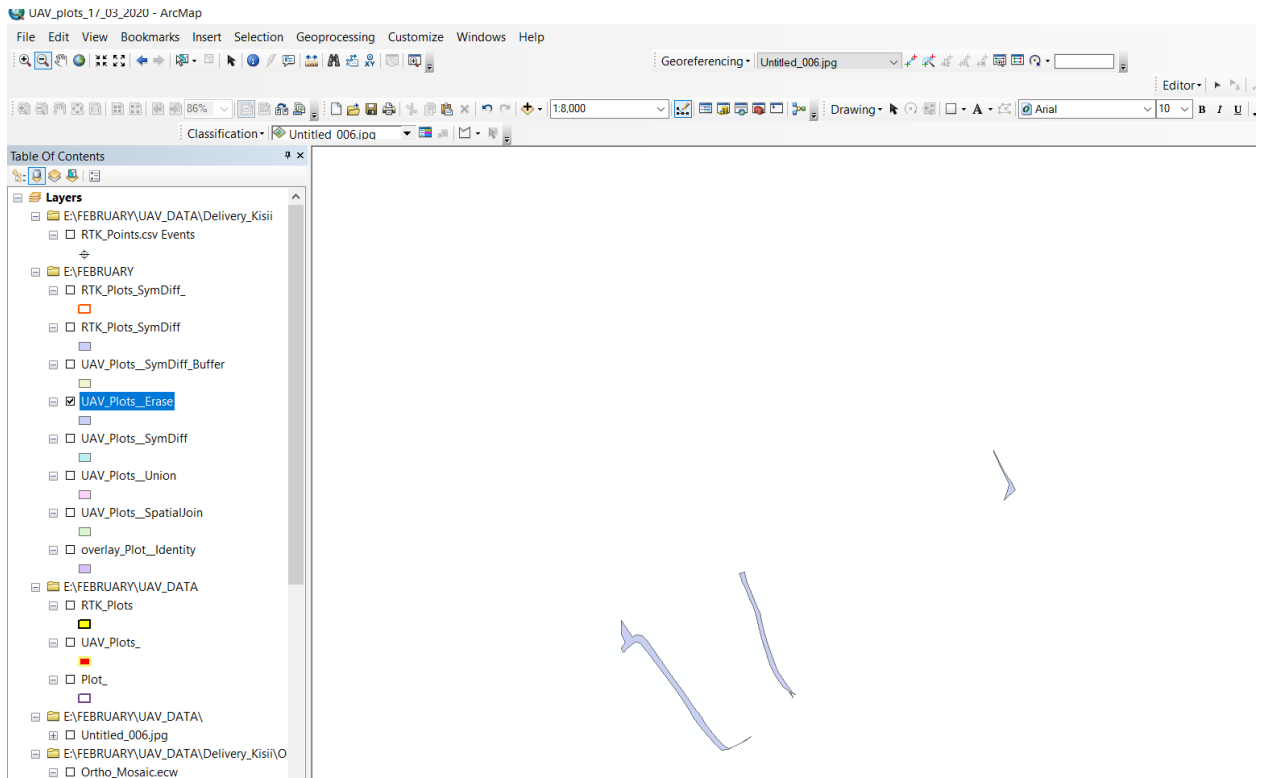
Figure 5. 1 Use of Erase tool in ArcGIS for the Overlaid UAV Derived Parcels with RIM Digitized Parcels

Measure
Area measurement
Segment: 342.134397 Meters
Perimeter: 1,227.348558 Meters
Area: 4,158.4893 Square Meters

Sum Perimeters: 1,896.393242 Meters
Sum Areas: 10,803.683862 Square Meters
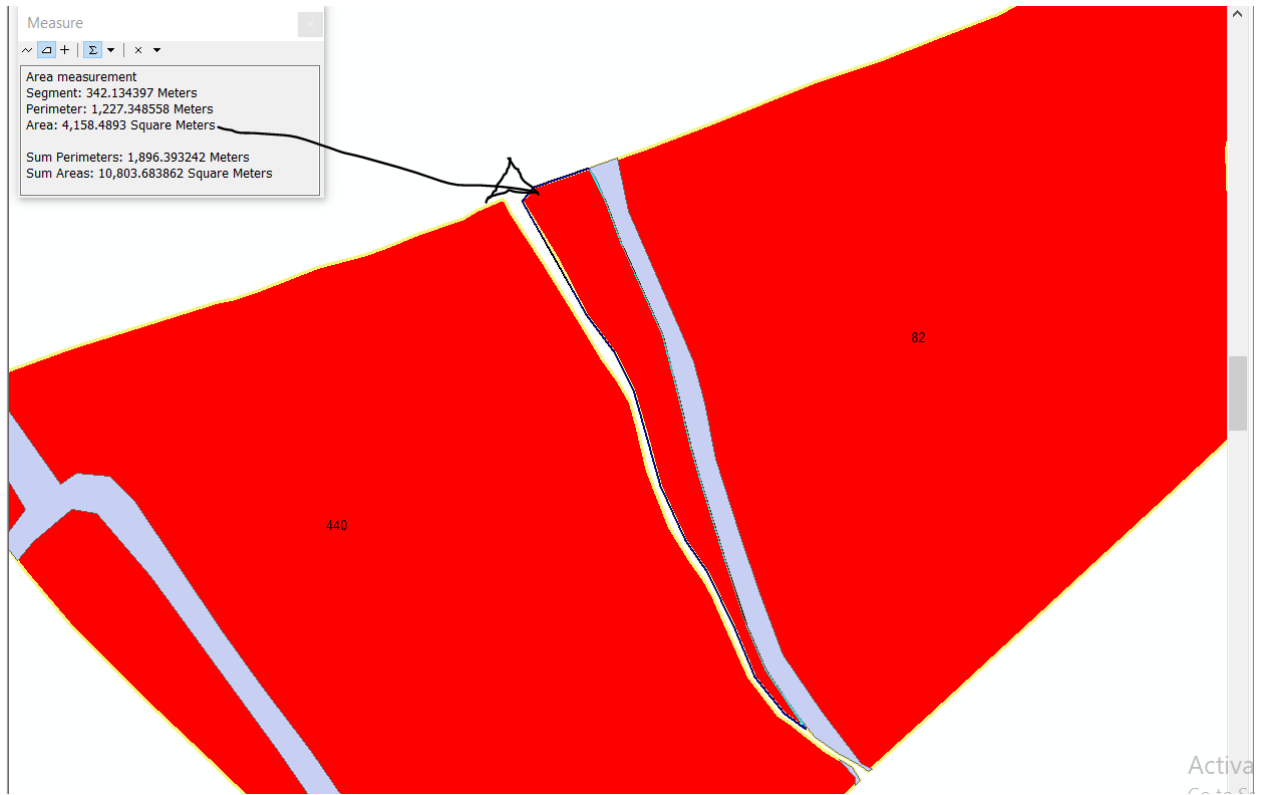
Figure 5. 2 Part 1 of the overlaid UAV derived parcel with Digitized RIM that has shifted

Figure 5.2 shown with an arrow has a Perimeter of 543.079763 Meters. Its Area is 4,158.4893 Square. This is the difference in area between the existing roads in the digitized RIM with the road from UAV derived Polygon with ID number 82.
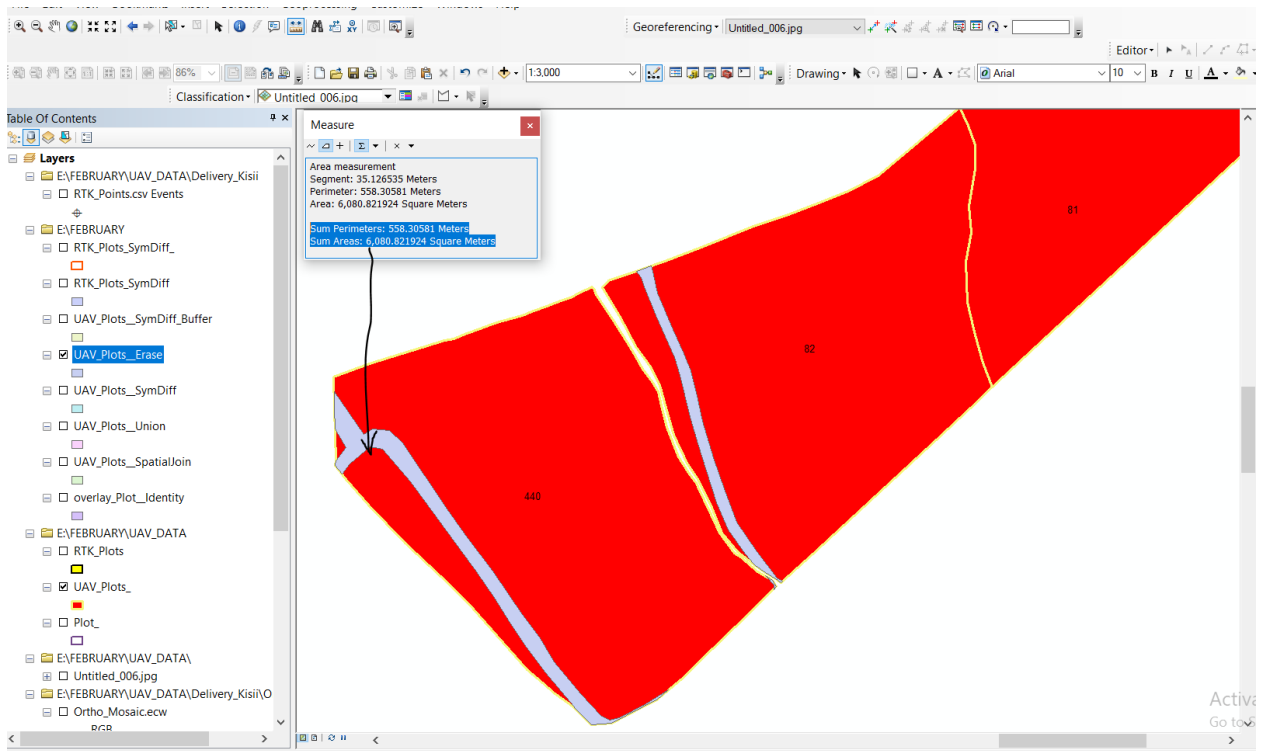
Figure 5. 3 Part 2 of the overlaid UAV derived parcel with Digitized RIM that has shifted

Sum Perimeters of the part of figure 5.3 by the arrow is 558.31 Meters. The Sum Areas of the same part is 6,080.82Square Meters as represented. This is the portion of land that exists as a difference between the roads in the RIM in relation to the road in the UAV derived polygon with ID No 440. Thus the shift resulted as a result of the use of new technologies in surveying. That is the RTK technology as well as the UAV technology. The UAV technology has high spatial resolution imagery with a resolution of 5cm. The products from this survey were used to generation parcels of land which were compared with the RIMs digitized parcels. Hence the discrepancies were noted.

5.2 Data

The data that was captured with the UAV Technology was from one part of the settlement scheme. The land was a gentle slope. The data used was not from different terrain that is the steep slope, gentle slope as well as the flat land of the settlement scheme. This means that the results to be obtained would be of better value. This is due to the wide variety of data sets in the area and the elevation levels of different terrains.

5.3 Comparison of the UAV derived Parcels with RIM parcels

The UAV derived parcels were checked by the RTK derived parcels whereby they overlaid each other with minimum differences in terms of area sizes, boundaries, and perimeters. The UAV derived parcels were then compared with that of the RIM derived parcels. It was noted that there was a shift in the boundaries of the UAV derived parcels in relation to the RIM digitized parcels. Similarly, the areas were measured and noted that there was a difference as the sizes of those parcels from UAV derived were larger than those parcels digitized from RIM. Also, the perimeters were different. The possible reasons for the significant differences are the level of technology used as a method of survey. For example, the UAV imagery is of 5cm resolution hence, its accuracy is higher as compared with the RIM derived maps which have the positional accuracy of ± 0.30 m at a scale of 1:10000.

Also, the conventional tools that were involved in the mapping of the settlement schemes like the Plane Table are quite different from modern technology like the RTK and UAV Technology. The modern technologies in terms of accuracies are higher. For example, the RTK positional accuracy is ± 0.03m. Similarly, the UAV has the capability of taking flights at varying heights and is not affected by the clouds.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

❖ The Mapping Process in a Settlement Scheme

It is noted that an area was first identified by the government, and then the land was allocated to a specific group of people in different portions. Then fallows were created to mark as the boundary line. After this, they planted hedges that were to be air visible. The aerial survey was made in which the maps were post-processed to obtain the PIDS. After photo enlargement, the PID through photogrammetric processes was designed to produce RIMs that were adopted as the true map for the cadastral survey and were stored in the land registry under the department of adjudication.

❖ Generation of UAV Imagery

The UAV imagery was obtained from the flight of the UAV. The images obtained from the UAV were processed to generate an Ortho-rectified image of the area of study. The software that was used in the post-processing of the data is the UASMaster. The images were combined through block adjustment as all the parameters of the camera in both interior and exterior orientation were applied. Then the Digital Surface Model was generated from which, the contours were generated that were used to produce the Digital Terrain Model. It's then from the Digital Terrain Model that the Ortho-mosaic Image was produced. Thus Ortho-rectified image was generated.

❖ Overlaying of UAV Derived parcels with the Digitized RIM parcels

The UAV derived parcels were then compared with that of the RIM derived parcels. It was noted that there was a shift in the boundaries of the UAV derived parcels in relation to the RIM digitized parcels. The shift in the perimeter is 558.31 Meters while the shift in the area of the same section was 6,080.82Square Meters.

6.2 Recommendations

❖ The method of capture

The phantom UAV that was used in the capturing of the images in the study area is rotary UAV. The rotary drone is one type of UAV. We have fixed-wing UAVs. If both of the

UAVs were to be used, then the result from each compared would be better to weigh the best UAV in surveying at a given terrain.

❖ **Processing**

In the post-processing of data, the data was restricted to UASMaster software that is automated. The merits of Inpho UASMaster are; it is a package that is advanced by Trimble for data photogrammetric processing. Ground control points are uploaded from a CSV file and you have full control of the processing. It has a detailed manual guide on every stage for data processing. The character lines are fully supported and it is convenient as it paints the point clouds as well as 3D models colours similar to what an elevation map has.

The shortcoming of Inpho UASMaster is that the software requires a file that has camera parameters like coordinates and altitude. It will not read this information from EXIF data. The interface of UASMaster is extremely confusing as the software is biased to those that can use and handle Trimble products with the technical know-how of UAV and camera details. Also, the output result may be unsatisfactory as the processing is possible with the default setting. Similarly, one has to enter all the camera parameters if the camera is not in the equipment DB. Furthermore, it is hard to talk about the processing quality of the software since the trial version allows you to perform photo orientation only.

Therefore, with this in mind, I recommend that in image processing other software to be used like PIX4D, Photoscan, Drone2Map, Photomod UAS, WebODM, and Drone Mapper to test their capability.

I recommend the use of UAV Ortho-rectified imagery and the UAV platform to the County Government of Nyamira. This is because UAV Ortho-rectified imagery is a result of the suitability of the UAV platform. The UAV imagery has high spatial resolution and is geometrically accurate than the conventional methods of survey. The UAV platform is generally viable economically in the registration of land in Kenya as well as acquiring geospatial data. Thus increase land registration and updating of its extent in a cadastral survey like land registration that has been proven to be capable in it (Koeva et al., 2016).

REFERENCES

Anderson, A. (2017). Making Spatial Decisions Using ArcGIS Pro: A Workbook. By Kathryn Keranen and Robert Kolvoord, Esri Press, 2017; 376 Pages. Price $69.99, ISBN 9781589484849. *ISPRS International Journal Of Geo-Information*, *6*(9), 279. DOI: 10.3390/ijgi6090279

Bates, M., & Sorrenson, M. (2004). Origins of European Settlement in Kenya. The American Historical Review, 75(5), 1503. DOI: 10.2307/1844583

Dakeyne, R. (2004). The pattern of settlement in Central Nyanza, Kenya. Australian Geographer, 8(4), 183-191. DOI: 10.1080/00049186208702378

Brach, M., Chan, J., & Szymanski, P. (2019). Accuracy assessment of different photogrammetric software for processing data from low-cost UAV platforms in forest conditions. *I forest - Biogeosciences And Forestry*, *12*(5), 435-441. https://doi.org/10.3832/ifor2986-012

Choi, Y., You, J., & Cho, G. (2015). Accuracy Analysis of UAV Data Processing Using DPW. *Journal Of Korean Society For Geospatial Information System*, *23*(4), 3-10. https://doi.org/10.7319/kogsis.2015.23.4.003

Ekaso, D., Nex, F., & Kerle, N. (2020). Accuracy assessment of real-time kinematics (RTK) measurements on unmanned aerial vehicles (UAV) for direct georeferencing. *Geo-Spatial Information Science*, *23*(2), 165-181. DOI: 10.1080/10095020.2019.1710437

GONG, A., He, X., Lei, T., & LI, J. (2016). Fast Image Processing Method of UAV without Control Data. *Geo-Information Science*, *12*(2), 254-260. https://doi.org/10.3724/sp.j.1047.2010.00254

Harrison, A. (2012). A comparative study of settlement schemes in Kenya. Agricultural Administration, 8(4), 322-323. DOI: 10.1016/0309-586x(81)90051-0

Hellen, J. (2010). A Geography of Africa: Regional Essays on fundamental characteristics, issues, and problems, The Geography of Modernization in Kenya: A Spatial Analysis of

Social, Economic and Political Change and Settlement Schemes in Tropical Africa: A Study of Organizations and Development. International Affairs, 46(2), 385-387. DOI: 10.2307/2613884

Hong, I. (2016). Image Processing for Micro UAV with Open Source Software. *Journal Of The Korean Cartographic Association*, *16*(3), 139-151. https://doi.org/10.16879/jkca.2016.16.3.139

Jones, N., & Sorrenson, M. (2001). Origins of European Settlement in Kenya. The Geographical Journal, 135(3), 435. DOI: 10.2307/1797371

Koeva, M., Muneza, M., Gevaert, C., Gerke, M., and Nex, F. (2016). Using UAVs for map creation and updating. A case study in Rwanda. Survey Review, (50:361), 312-325. DOI: 10.1080/00396265.2016.1268756

K. Wanyoike: P. (2001). The Role of the Registry Index Map (RIM) in Land Management in Kenya. *International Conference On Spatial Information For Sustainable Development Nairobi, Kenya*, (TS19.2), 2-8. Retrieved 14 August 2020, from.

Legislature. (2012). *LAND REGISTRATION ACT* (pp. 9-15). Nairobi: the National Council for Law Reporting with the Authority of the Attorney-General.

Ministry of Lands and Physical Planning. (2017). Sessional paper No.1 of 2017 on National Land Policy (pp. pg 33-35). Nairobi: Republic of Kenya.

Mumbone, M. (2015). Innovations in Boundary Mapping: Namibia, Customary Land, and UAV's (Degree of Master of Science in Geo-information Science and Earth Observations). The University of Twente.

Nadarajah, N., Paffenholz, J., & Teunissen, P. (2014). Integrated GNSS Attitude Determination and Positioning for Direct Geo-Referencing. *Sensors*, *14*(7), 12715-12734. DOI: 10.3390/s140712715

Odwe, P., Mwasumbi, A., & Wayumba, R. (2017). Application of Unmanned Aerial Vehicles in Strengthening Land Rights for Youths in Kenya. Retrieved 27 February 2020,

from http://www.uneca.org/sites/default/files/uploaded documents/LPI/CLPA_2017/Presentations/peter-odwe-clpa-2017-paper.pdf.

Ogechi Ochori, B., & Odera Achola, P. (2015). Improvement of area accuracy in general boundary areas in Kenya: A case study of Juja – Kiambu County. *Kabarak Journal Of Research & Innovation*, *Volume 3*(ISSN 2305-784X (print), 1-4. Retrieved 14 August 2020, from https://www.researchgate.net/publication/287215698.

Ondulo, J., Wayumba, G., and Aduol, F. (2015). Accuracy Assessment of Preliminary Index Diagrams (PIDS) From High-Resolution Orthoimages In Kenya. International Journal Of Scientific Research And Engineering Studies (IJSRES), Volume 2(2349-8862), 38-43. Retrieved from https://pdfs.semanticscholar.org ›

Paffenholz, J., & Bae, K. (2012). Geo-referencing point clouds with transformational and positional uncertainties. *Journal Of Applied Geodesy*, *6*(1). DOI: 10.1515/jag-2011-0010
Redkey, E., & Sorrenson, M. (2015). Origins of European Settlement in Kenya. International Migration Review, 6(3), 348. DOI: 10.2307/3002480

Siriba, D., Voß, W., and Mulaku, G. (2011). The Kenyan Cadastre and Modern Land Administration. Fachbeitrag, (136(3), 177-186. Retrieved from https://geodaesie.info › files › Privat › zfv_2011_3_Siriba_Voss_Mulaku

Subbo, W. (2014). Settlement Schemes as Centres of Socio-Economic Change: The Case of Nyansiongo Scheme Nyamira District, Nyanza Province, Kenya. Discovery And Innovation, 15(1). DOI: 10.4314/dai.v15i1.15631

Tampubolon, W., & Reinhardt, W. (2014). UAV Data Processing for Large Scale Topographical Mapping. *ISPRS - International Archives Of The Photogrammetry, Remote Sensing And Spatial Information Sciences*, *XL-5*, 565-572. https://doi.org/10.5194/isprsarchives-xl-5-565-2014

Taylor, D. (2006). Changing Land Tenure and Settlement Patterns in the Fort Hall District of Kenya. Land Economics, 40(2), 234. DOI: 10.2307/3144357

Wayumba, G. (2013). An Evaluation of the Cadastral system In Kenya and A Strategy for Its Modernization (Ph.D.). The University of Nairobi.

Wayumba, G. (2019). The White Highlands and the Establishment of the African Settlement Schemes in Kenya. International Journal Of Innovative Studies In Sciences And Engineering Technology (IJISSET), Volume: 5(ISSN 2455-4863), page 3-9. Retrieved 2 March 2020, from www.ijisset.org

Wilson, A. (2016). Bismarck, Europe, and Africa: the Berlin Africa Conference 1884-1885 and the onset of partition. Choice Reviews Online, 27(07), 27-4005-27-4005. https://doi.org/10.5860/choice.27-4005

Zhou, G., & Reichle, S. (2015). UAV-based multi-sensor data fusion processing. *International Journal Of Image And Data Fusion*, *1*(3), 283-291. https://doi.org/10.1080/19479832.2010.497343

APPENDICES

REPUBLIC OF KENYA

THE PRESIDENCY

MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERMENT

Telegrams: "DISTRICTER" Borabu
Telephone/Fax: 020-2443469

DEPUTY COUNTY COMMISSIONER
BORABU SUB-COUNTY
P.O BOX 1
NYANSIONGO

When replying please quote
REF: ED/12/15 vol.1/83

12th February , 2020

Assistant County Commissioner
-BORABU DIVISION

RE: OMEKE JEREMIAH STUDENT NO.F56/12475/2018
RESEACH AUTHORIZATION.

Reference is made to a letter Ref.F56/12475/2018 from University of Nairobi Department of Geospatial & Space technology, dated 3rd February, 2020 authorizing **OMEKE JEREMIAH** to carry out research on *"UAV mapping of settlement scheme with PID superimposed"*.

The planned research will be conducted in Borabu sub- County Borabu ward from 12th February, 2020 up to **31st March, 2020.**

Kindly accord him the necessary assistance.

EVANS MOMANYI
FOR; DEPUTY COUNTY COMMISSIONER
BORABU SUB-COUNTY

Copt to:
Sub - County Director of Education
P.O.BOX
BORABU

UNIVERSITY OF NAIROBI
DEPARTMENT OF GEOSPATIAL & SPACE TECHNOLOGY
P.O. Box 30197- 00100 Nairobi, Kenya
Telephone: +254 20 4910000/+254 20 491 3525
Email: surveying@uonbi.ac.ke

Our Ref: F56/12475/2018

3rd February, 2020
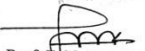
To Whom It May Concern

RE: <u>MSC. GIS DATA COLLECTION: OMEKE JEREMIAH- F19/12475/2020</u>

This is to confirm that the above mentioned is an MSc. Geographic Information systems student in the Department of Geospatial and space Technology, University of Nairobi. He is carrying out research for his MSc. project entitled: *"UAV Mapping of Settlement Scheme with PID Superimposed"*.

Any assistance you may offer him in respect of the said research will be highly appreciated. Should you have any questions regarding his research, please contact the Department.
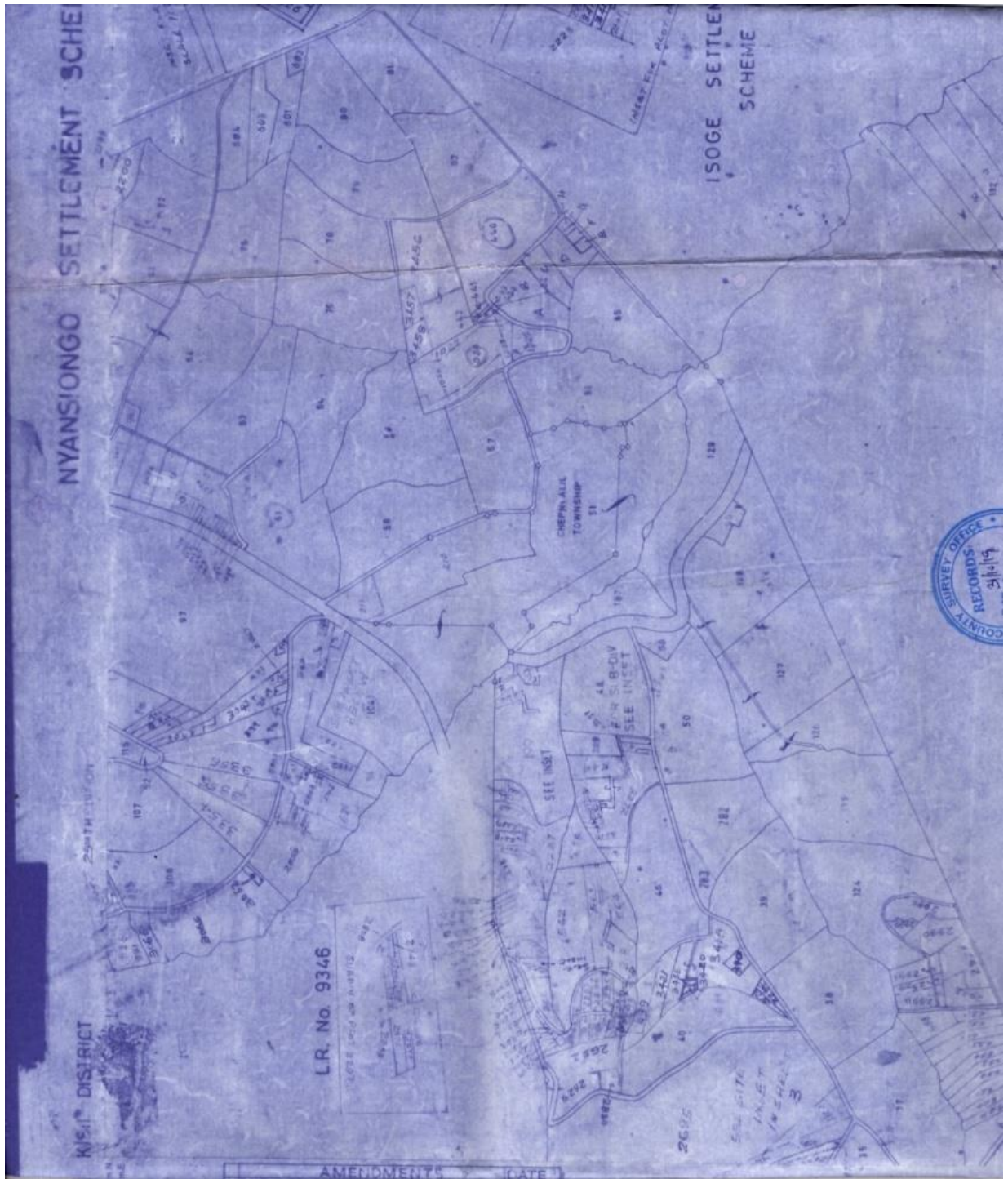
Yours faithfully,

Prof. F N. Karanja
Chair
Department of Geospatial & Space Technology

Nyansiongo Land Parcel Aerial Survey

	KISII parameters									
P	0.3049572		Q	1.56E-04						
NO	10000232.1		EO	722694.4749						
Cassin		UTM								
n(f)	e(f)	N	E	H	LABEL			WGS84		
-290165.5	-36537.9	9911749.765	711506.6393	9911449.378	711587.8	-300.387	81.13767	9911449	**711587.8**	
-277492.200	-7361.400	9915610.021	720406.2033					9915310	**720487.3**	KIJAURI
-284502.500	-18337.100	9913473.894	717057.9892					9913174	**717139.1**	A.I.KIRO
-296064.000	-11419.800	9909947.051	719165.6631					9909647	**719246.8**	A.I.LINE
-291053.400	-14417.600	9911475.538	718252.2453					9911175	**718333.4**	PELL
-284548.000	-1932.300	9913457.455	722060.7439					9913157	**722141.9**	A.I.4
-286750.600	-237.400	9912785.492	722577.2717					9912485	**722658.4**	A.I.3
-292099.90	3878.700	9911153.541	723831.6702					9910853	**723912.8**	A.I.I

0										
-289666.000	930.500	9911896.237	722932.9757					9911596	**723014.1**	NARANGAI
-290868.800	16705.000	9911526.97	727743.335					9911227	**727824.5**	ISOKE
-303208.100	6990.700	9907765.529	724778.9612					9907465	**724860.1**	KONGERER
-294070.100	-3725.000	9910553.902	721512.5593					9910254	**721593.7**	RIV
-283360.800	-2845.700	9913819.643	721782.3815					9913519	**721863.5**	S
-278666.800	7385.500	9915249.514	724903.1931					9914949	**724984.3**	R.3
-278529.300	7534.900	9915291.422	724948.7751					9914991	**725029.9**	R.2
-282939.000	11672.500	9913946.006	726209.877					9913646	**726291**	E
-283750.100	9959.400	9913698.922	725687.3281					9913399	**725768.5**	C
-290919.400	8434.800	9911512.831	725221.2701					9911212	**725302.4**	DX
-292177.300	-13745.200	9911132.691	718457.1229					9910832	**718538.3**	HOP

-290214.400	-6184.300	9911730.11	720763.1805					9911430	**720844.3**	SKIP
-292943.200	-5976.900	9910897.911	720826.0022					9910598	**720907.1**	SWAMP
-288098.900	800.100	9912374.156	722893.4541					9912074	**722974.6**	WALK
-280100.500	9861.300	9914811.91	725657.9821					9914512	**725739.1**	FORD
-280719.100	12897.300	9914622.789	726583.7355					9914322	**726664.9**	AMANGWEIT.O.P
-280648.200	12910.200	9914644.408	726587.6805					9914344	**726668.8**	AMANGWEIT.I.P.C

Table: List of coordinate Conversion