Comparative study on Cadastral Surveying using Total Station and High Resolution UAV Image.(HRUAVI)

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Abstract:

The cadastral is methodologically arranged public inventory of data on the properties within a certain country or district based on a survey of their boundaries. The countries of the property and the parcel identifier are normally shown on large scale maps with the help of ground survey techniques.
A cadastral is thus a systematic description of the land units within an area. The description is made by maps that identify the location and boundaries of every unit, and by records.

It is very advantageous if good maps and cadastral information are available before planning and development begins. But this will often takes considerable time. There is an obvious risk that, in the absence of maps, all planning and other enterprises will be greatly delayed or even come to a complete halt because of heavy ground surveying costs. There is a growing need all over the world for land information as a basis for planning, development and control of land resource.

UAVs (Unmanned Aerial Vehicles / Drones) use a combination of GPS navigation technology and modern air survey technologies to offer a mapping method that is fast and affordable (Barnes et al., 2014). The use of UAVs in mapping customary lands, urban lands, etc. may produce a high resolution cadastral map within a limited time of flying. The method is speedy and user-friendly; and produces understandable 2D representation of parcels, as opposed to polygons with no graphical backdrop. The high resolution orthophotos enable the user to identify features that guide in the identification and mapping of parcel boundaries. These features include fences, hedges, footpaths, crop fields, houses, or whatever visible features the local context utilizes.

The principle objective of the project is to compare the cadastral survey done by High Resolution UAV image and that by total station in context of Sri Lanka.Comparisons between parcel boundaries derived from total station Survey and HRUAVI shows good potential of the later for Cadastral Survey. For this, various attributes of the derived parcels such as area, and position from both techniques were compared along with human resource involved and time and cost for the completion of task.
The comparisons show that around 70% of the parcel boundary can be derived with acceptable accuracy and precision meeting the standards of cadastral survey. In addition, use of UAV Data will result in faster updating of Cadastral maps in more economical and convenient manner. From the above findings it’s clear that use of UAV Data can reduce the cost, time and human resources as compared to the total station method.

Keywords: UAV Mapping, UAV Images, Multi-Purpose Cadastral, Orthophotos, Parcel Identification Number.

Comparative study on Cadastral Surveying using Total Station and High Resolution UAV Image.(HRUAVI)

(A Case Study of Bingethenna Grama Niladhari Division in Haputale Divisional Secretariat Division, Badulla District, Sri Lanka.)

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1. Introduction.

1.1. Background

The increasing use of UAVs (Unmanned Aerial Vehicles) for photogrammetry and LIDAR mapping in aerial surveys is not surprising. Using GPS enabled UAVs for aerial surveying is very cost effective in comparison to hiring an aircraft with photogrammetry .Because UAVs are relatively inexpensive.

There is a growing need all over the world for land information as a basis for planning, development and control of land resource. In Sri Lanka is one of the developing countries in the world of what happens when the situation gets out of control.

UAVs (Unmanned Aerial Vehicles) use a combination of GPS navigation technology and model airplane technologies to offer a mapping method that is fast and affordable (Barnes et al., 2014). The use of UAVs in mapping customary lands, urban lands, etc. may produce a high resolution cadastral map within a limited time of flying. The method is speed and user-friendly; and produces understandable 2D representation of parcels, as opposed to polygons with no graphical backdrop. The high resolution orthophotos enable the user to identify features that guide in the identification and mapping of parcel boundaries. These features include fences, hedges, footpaths, crop fields, houses, or whatever visible features the local context utilizes.

Updating land related information is very important so that changes of ownership and division of property can be recorded in a timely fashioned manner for documentation. One advantage of using images (either aerial photographs or HRSI) is that they provide a historical record of the areas that can be revisited in the future to see what changes have taken place. In this way old images can provide valuable evidence where conflicts occur in parcel boundaries. Furthermore, traditional land surveying approaches are time consuming and require lot of efforts. Sometimes it is very difficult to do cadastral survey in remote areas especially in mountainous areas when the weather is harsh. In this case HRSI can be used as an alternative to traditional land surveying approach for spatial data acquisition where most measurements can be done in the office.

This study therefore seeks to testing in Sri Lanka, the applicability of UAV technology in capturing images for surveying and mapping land parcel boundaries agreed with required legal compliance of cadastral mapping under title registration act No.21 in 1998.

Therefore case study was conducted Bingethenna Grama Niladhari division in Haputale divisional secretariat area. The method of parcel based mapping, is a combination of UAV image technology and simple ground survey techniques (Hybrid System).Also this study seeks to understand whether the prevailing challenges associated with conventional surveying and mapping techniques can be overcome.

1.2. Research Problem

In Sri Lanka the title registration was started after passing title registration act No. 21 in 1998. Under this title registration program survey department start to prepare cadastral maps both including private and state lands. The ground survey methods used to prepare cadastre maps under this programme. Since 1998 to 2015 the completed land parcels are nearly 1300000. The estimated land parcels in our country is nearly 20 million. If proceeds this system, nearly 100 years need to cover whole country in cadastral maps.

Therefore, it is of great importance to explore a method of low cost, rapid and acceptable accuracy as close as possible to standards prescribed in the survey regulations is needed.

The problem therefore is that it is unknown whether or not UAV technology can be used to survey and map land parcel boundaries to required legal and technical requirements.

1.3. Objectives

Prime Objectives:

This project has centered its research;

- Comparative study, of parcel boundary delineation from high resolution UAV imagery(HRUAVI) and total station(TS), to assess the use of UAV surveying methods in mapping land parcel boundaries in terms of spatial accuracy, acceptability and affordability and legal compliance.

where;

UAV surveying refers to the process of capturing digital aerial photographs with unmanned aerial vehicles and processing such photographs into an orthophoto on which demarcations can be done.

Land Parcel refers a piece of land belonging to a defined person or group of persons.

Spatial Accuracy is the degree to which spatial data collected matches true to accepted values, based on accepted survey standards.

Mapping refers to the act of creating a graphic representation of a piece of land using spatial data collected from the field.

In order to achieve the above objective, the following sub-objectives, and related questions, are defined:

Objective 1:
To understand the current context regarding Cadastral mapping and UAVs

Question 1:
What are the policies, laws, tenures, administrative approaches, and technologies that inform Cadastral mapping in Sri Lanka?
Question 2:
What are the policies and laws regarding UAV usage in Sri Lanka?

Objective 2:
To design a new GIS based cadastral land mapping approach around UAVs.

Question 1:
What approach can be used to design a new process and what steps are involved to new system?
Question 2:
What system can be used to assess accuracy and affordability?
Question 3:
What do the assessment reveal?

1.4. Research Matrix

The research matrix shows the objectives of the study and the methods to follow in answering the research questions. The data and materials needed for the study are also shown, as well as the anticipated results of each objective.

Table 1 : Research Matrix

Objectives	Questions	Methods	Materials	Anticipated Result
Objective1: To understand the current context regarding cadastral mapping and UAVs	*Question 1:* What are the policies, laws, tenures, administrative approaches, and technologies that inform cadastral land mapping in Sri Lanka currently? *Question 2:* What are the policies and laws regarding UAV usage in Sri Lanka?	Literature review	Surveying Laws Surveying manuals Government Reports Land Acts Aviation Laws/Acts	Determine what the laws say regarding cadastral land surveying in terms of techniques to be used, how surveys are to be done and accuracy standards.
Objective 2: To design a new cadastral land mapping approach around UAVs	*Question 1:* What approach can be used to design the new process and what steps are involved to new system? *Question 2:* What system can be used to assess accuracy and affordability?	Design & Develop workflows UAV survey methods – literature	Arcmap Google Earth Fixed wing UAV Laptop Flight planning software DGPS Total station AutoCAD software	A process depicted in a flow chart Photogrammetric output (orthophoto) GIS generated parcel map of boundaries

2. Literature Review and Concepts

2.1. Cadastre

To give an answer to "where" and "how much" we consider the cadastre. A Cadastre is an official record of information about land parcels, including details of their boundaries, tenure, use, and value (Dale & McLaughlin, 1988).

2.2. Cadastral Surveying and Mapping

Surveying can be defined as the art and science of making measurements of the relative positions of natural and manmade features on the earth's surface, and the presentation of this information either graphically or numerically (Bannister et. al., 1998). Land surveying involves determining the spatial location of points on or near the surface of the earth and displaying them on a map (Cole, 2003). Whereas, according to Low, (2004) mapping is the construction of a real world model on paper from measurements taken in the field.

2.3. General Boundaries

General Boundaries on the other hand are not surveyed accurately and boundary lines are demarcated by existing physical features such as walls fences and hedges. Dale & McLaughlin, (1999) defined general boundaries as the approximate line(s) of the boundary, whereby the precise details can only be established through further investigation. The vagueness of such a boundary system allows for the land register to ignore shifts in the agreed position of the parcel corner (Tuladhar, 1996). This method is appropriate in rural areas of developing countries where accuracy is of little concern. The establishment of general boundaries in these areas can be done through photogrammetric means which is generally more cost effective and efficient than fixed boundary system (Lemmens, 2011). Likewise with fixed boundaries, Dale & McLaughlin, (1999) distinguish three categories as follows:

1. The ownership of the boundary feature is not established, so that the boundary may be on one side of a hedge or the other or down the middle;

2. The boundary is the indeterminate edge of a natural feature such as a forest; and

3. The position of any boundary is regarded as approximate so that the register may be kept free from boundary disputes.

2.4. Fixed Boundaries

Fixed boundaries are those that are determined accurately by a professional land surveyor, boundary corners can as well be traced accurately once lost because boundary corners are monumented and coordinated accurately (Tuladhar, 1996). In addition, fixed boundaries are legally binding when an agreement is reached between two neighbors and as such monuments cannot be moved without a transfer document (Dale & McLaughlin, 1988). Dale & McLaughlin, (1999) distinguish three categories of fixed boundaries:

1. Defined on the ground prior to development and identified - for example, in documents of sale;

2. Identified after development - for example when the line of the boundary is agreed on between neighbors at the time of adjudication;

3. Defined by surveys to specified standards

2.5. Adjudication

Dale & McLaughlin, (1999) defined adjudication as the practice in which existing rights pertaining to a land parcel are authoritatively established. Adjudication is a prerequisite to registration of title and to land consolidation arid redistribution, the process does not alter existing rights or create new ones. Meanwhile; Zevenbergen, (2004) discusses adjudication in a systems approach, noting that adjudication is the first of three functions that a system of land administration should fulfil. Dale & McLaughlin, (1999) further describe Adjudication as the first step in the registration of title to land which encompasses procedures for determining what rights exist on the ground. Adjudication may also be said to be part of the land registration system. Lemmens, (2011) defines adjudication as the process of acknowledging existing rights by an authoritative institute. It is the first stage in the registration of land rights in areas where these rights are not yet officially known. The same author further notes that adjudication is merely concerned with formalising land rights which already exist. It is made up of two aspects, legal and technical. The legal aspect is concerned with the identification of rights and resolving disputes that may arise in the process Dale & McLaughlin, (1999). The technical aspect of adjudication is concerned with the identification of parcel boundaries through cadastral surveying and mapping. Such parcel boundaries are mapped and given a unique parcel identifier (Williamson et al., 2010) As such; this study focuses on the technical aspects of adjudication.

2.7. Cadastral surveying in Sri Lanka.

The survey Department is responsible in preparation of cadastral maps for registration of title in order to fulfil the requirement of section11 of the registration of title act No.21 of 1998.

3. Research Methods

This study employs the scientific research process of conducting research. The scientific process is described in figure 1 as a process consisting of series of actions necessary to carry out research, and the desired sequencing of the steps.

Two kind of literature is going to be examined for this research to be well acquainted with the problem. These two kinds are conceptual literature and empirical literature. Conceptual literature will help to study about theories and concepts of related field. Empirical literature will help review previous studies of related subject.

This research designed taking into consideration the order in which the research objectives are outlined. It take three main stages; Pre field work, field work and post field work as can be seen in figure 1.

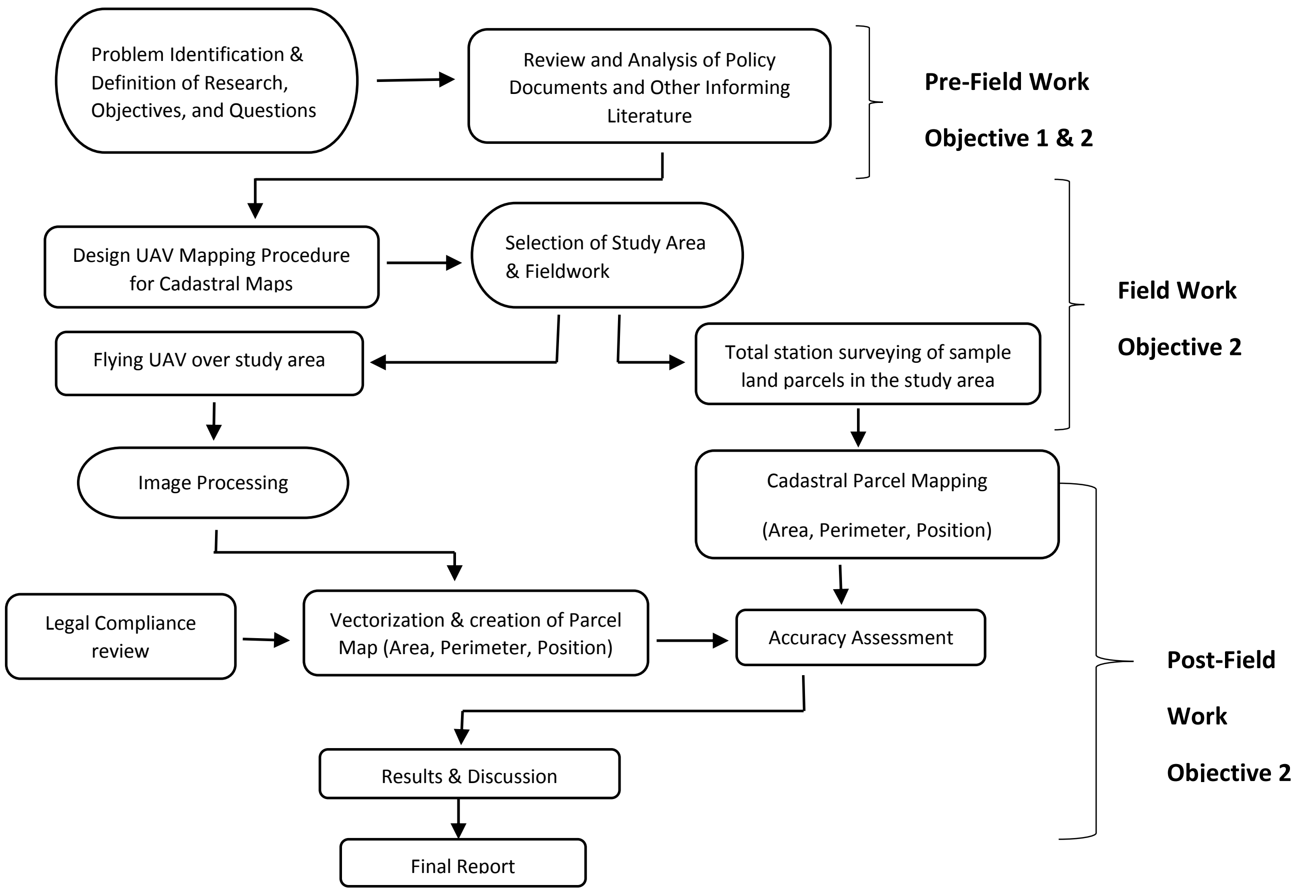

Figure 1: Research Work Flow

3.1. Study Area

The location of the study area in Fig 1 is Bingethenna Grama Niladhari division in Haputale Divisional Secretariat area. It lies in the up country in Sri Lanka. The Grama Niladhari division has almost hilly terrain and crowded land parcels. Most of the land parcels in this Grama Niladhari division belong to state and those are encroachment private lands are situated closed to main road.
This area consists of residential parcels, agricultural parcels predominantly. (*See figure 2*)

Figure 2: Study Area

3.2. Pre-Field Work

During the pre-fieldwork stage, questions to objectives 1 and 2 (Question 1) were answered. Objective 1 aimed to understand the current context regarding cadastral land mapping and UAVs, which was intended at determining the laws, policies, tenures approaches, and technologies that inform cadastral land mapping. To answer this objective a comprehensive analysis of legal documents, policies, reports, manuals and some published articles concerning land in Sri Lanka are going to be reviewed.

Objective 2 is going to design a new cadastral mapping process around UAVs. To achieve at this objective, further review of literature regarding UAV mapping processes is needed to be carried out. To model the new procedure, various process modelling techniques and related articles can be used. *(See table 1: Research Matrix)*

The following research matrix shows the objective 1 & 2 of the study and the methods to follow in answering the research questions. The data and materials needed for the study are also shown, as well as the anticipated results of each objective.

Ground control points (GCP) are needed to be georeferenced of UAV Image and the GCP points should be established at this stage. Hence selecting study area and finding suitable positions to establish GCPs (Ground Control Points) is one of the important activities of this stage. GCPs are pre-signalized points (figure 3). The shape of the signals, its sizes and their distribution over the study area also should be selected in this stage. The maximum and minimum coordinates of study area should be obtained by using Google Earth. This will help to prepare a flight plan for UAV. Prospection diagrams including roads, buildings, and owners' names are prepared under this phase. This prospection diagrams will help to delineate boundaries on image and also vectorization of UAV image.

Figure 3: pre signalized GCP

3.3. Field Work (Acquisition of Cadastral Data by UAV)

During the field work stage questions to objectives 2 (Question 2 and 3) can be answered. Question 3 is to design a new GIS based cadastral land mapping approach around UAVs. (Figure 4).

A fixed wing drone which is owned to the Survey Department of Sri Lanka, can be used to capture the imagery in the study area. It is fitted with a 16 MP camera from Sony and had a payload of 650g. Ground control points can be placed systematically across the area, using differential GPS system.

Figure 4: Unmanned Aerial Vehicle (UAV)

The study area covered 25ha approximately. A flight plan can be designed to cover the study area with an average ground sampling distance (GSD) of 45mm. The ground sampling distance is the ground foot print of image pixel. The flight plan can be uploaded to the UAV system, which can be launched to capture 16MP images with the following specifications: 150m flight height and average air speed of 14m/s, a lateral overlap of 70% and forward overlap of 80%

Also during this field work stage; according to the legal ownership, burring landmarks on the sharp bends of land parcels and taking dead measurements using steel tape or linen tape also come under this stage. Specific form has introduced for this purpose. (*See annexure 1 & 2*) One surveyor and three skilled survey filed assistants can be used for this data collection and marking adjudicated boundaries.

Geographic coordinates of center of the land parcel can be collected using hand-held GPS and should be mark on the parcel sketch. All boundary descriptions should mark on the sketch.

Flying UAV (Unmanned Aerial Vehicle) and capturing photographs of study area is the main activity under this phase.

Determine the accuracy of land parcels in image survey system, it should be compared with true values of area, of same land parcels. Selecting sample land parcels and finding true values of area is next activity of this stage. Ground survey technique can be adopted to find true values of area of sample land parcels. The better system is total station survey. The selected land parcels for test should be included in following categories.

i). Parcel - Fully covered with general boundaries
ii). Parcel - Fully covered with fixed boundaries
iii). Parcel - Fully covered with general and fixed boundaries

3.4. Field Work (Acquisition of Cadastral Data by Total station)

The study area dandified of geodetic control points (GCP) by geodectic branch of Sri Lanka survey department. Using these control points detail traverses were run to acquire cadastral boundaries of high lands as well as paddy lands in study area. The collected boundary points recorded on the total station were transferred into the computer .Appropriate software was used to convert the total station file to CSV(comma separated vale)file. Using this file the Auto Cad drawing was completed in parcel based (figure 5).The final out put were printed in form of maps in order to carryout the field verification to determine the errors during measurements or data processing. Land parcels were verified on the field and errors during measurements or processing were identified. Later those errors were checked and corrected by resurvey.

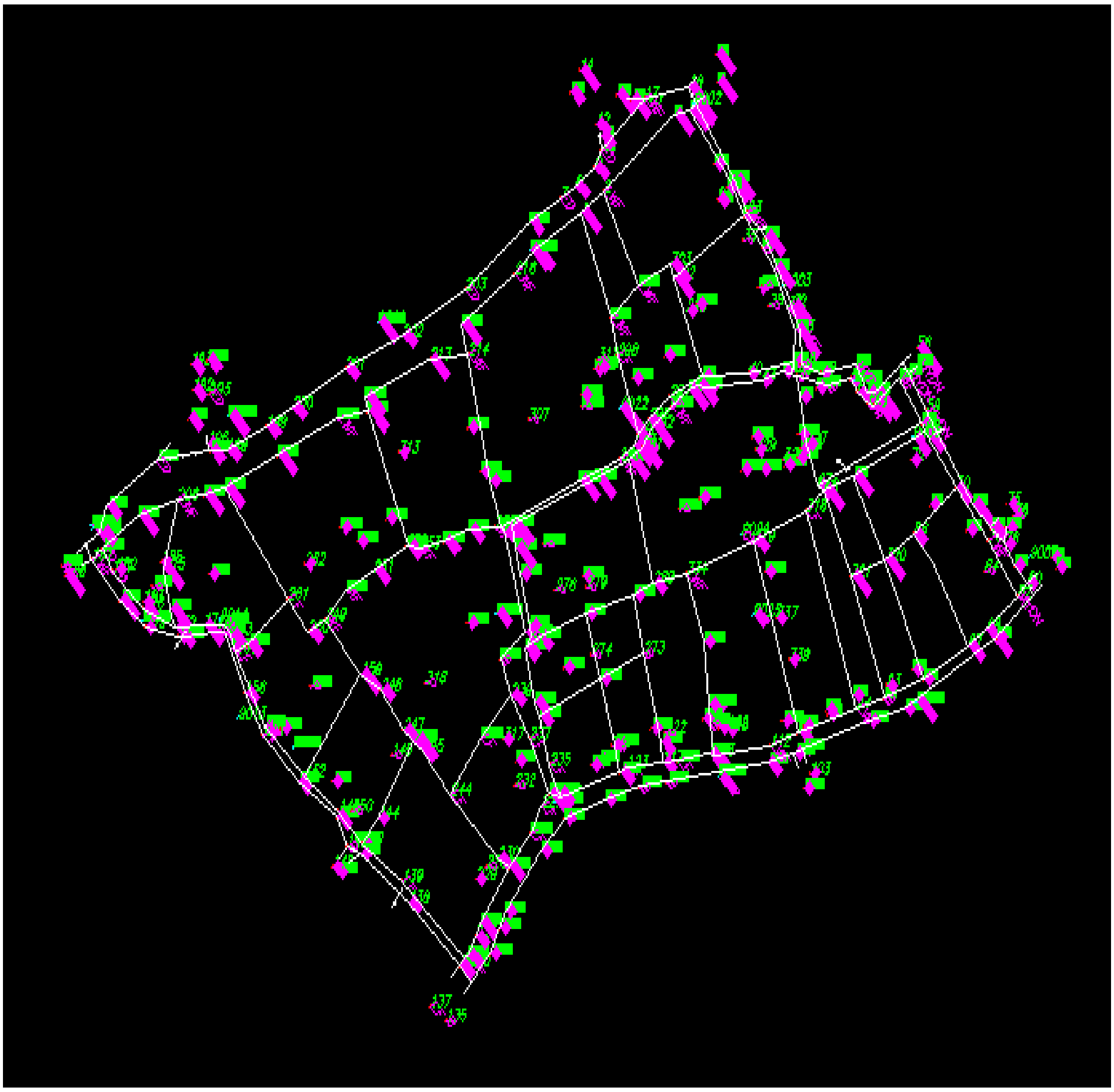

Fig. 5 Auto cad drawing by total station Survey.

3.5. Post Field Work

After completing field work, image processing and analysis take place. After processing the results a Digital Surface Model (DSM) and an ortho-mosaic can be generated(figure 6). For this reason only the ortho-mosaic can be used for further analysis. It can be used in the vectorization of delineated parcel boundaries.

Fig.6 Part of UAV image in study area.

Next stage in the methodology is the quality check. This is the assessment of photogrammetric (orthophoto) results in terms of accuracy. To evaluate the quality of the orthophoto, further analysis should be done.GCPs should be uploaded into ArcMap, where the base layer of generating orthophoto. A manual approach can be applied checked, If the uploaded coordinates of the ground control points fits with their marker on the orthophoto. In cases where the significant differences (mostly in cm) then manually retrieved the coordinates from the center of the mark which is visually represented in the orthophoto. An assumption can be made to use the GCPs collected in the field by GPS as the reference value to use in comparison with the coordinates retrieved from the orthophoto in ArcMap. The root mean square error (RMSE) of the coordinates can be computed in Microsoft Excel. As per the work flow, vectorization is the final stage in the process(*see annexe 3and 4*). In this study, this activity takes place after image processing and quality check. According to the same way as mentioned above, the accuracy of the land parcels can be evaluated. In this stage the parcel boundaries which delineated from image survey and selected same parcels which surveyed by total station can be compared.

Here the assumption is that the total station survey is considered as true values of land parcels.

4.0 RESULTS AND ANALYSIS.

4.1Area Comparison.

The parcels derived from the UAV image were used for analysis and compared with the parcels obtained from total station survey, as these data were used as reference area for the comparison. Area comparison was done with paddy land parcels and high land parcels separately. Matching parcels from both the layers were (digitized parcels and ground survey parcels) extracted and used for analysis. A total of 60 parcels were extracted from the UAV image and used for comparison with the matching parcels derived from total station survey .Table2,3 ,4 and the figure 7 illustrates the percentage error ensued during mismatch between the two parcel layers derived from total station survey and HRUAVI. It can be stated that 70% of the parcels can be marked with acceptable accuracy using HRUAVI .Also when observing the facts from the table 4,34% parcels(22 parcels)derived from UAV image had area deviation less than 2% with respect to ground survey by total station. 25% (15 parcels) derived from UAV image had area deviation less than 2% - 4% with respect to ground survey by total station.15% (10 parcels) derived from UAV image had area deviation less than 4% - 6% with respect to ground survey by total station.

However, significant percentage around 26% parcels (13 parcels) derived from UAV image had area deviation within 6% - 20% with respect to ground survey by total station. This indication shows mismatch between two layers considered to be a large deviation. These large deviations are happened in high land area and due to several factors creating hindrance in deviation of parcels from the UAV image such as Unclear parcel boundaries and high canopy cover over the boundaries.

Surveyed Extent		Digitized Extent		Difference		
Lot	Ha	Lot	Ha	Ha	%	% =
30	0.0477	30	0.0476	0.0001	0.21	0
32	0.0686	32	0.0661	0.0025	3.64	4
33	0.088	33	0.0859	0.0021	2.39	2
34	0.0497	34	0.0482	0.0015	3.02	3
40	0.0226	40	0.0219	0.0007	3.10	3
51	0.1065	51	0.1111	-0.0046	4.32	4
56	0.0305	56	0.0293	0.0012	3.93	4
57	0.0233	57	0.0243	-0.0010	4.29	4
60	0.0475	60	0.0501	-0.0026	5.47	5
62	0.0579	62	0.0604	-0.0025	4.32	4
63	0.0399	63	0.0421	-0.0022	5.51	6
64	0.0307	64	0.0307	0.0000	0.00	0
65	0.042	65	0.0418	0.0002	0.48	0
67	0.057	67	0.0597	-0.0027	4.74	5
68	0.0372	68	0.0373	-0.0001	0.27	0
105	0.0732	105	0.0701	0.0031	4.23	4
106	0.0566	106	0.0528	0.0038	6.71	7
113	0.0175	113	0.0176	-0.0001	0.57	1
120	0.0417	120	0.0445	-0.0028	6.71	7
173	0.0316	173	0.0325	-0.0009	2.85	3
176	0.0676	176	0.071	-0.0034	5.03	5
183	0.0324	183	0.0327	-0.0003	0.93	1
184	0.0526	184	0.0563	-0.0037	7.03	7

Table 2 : Comparison of area deviation

w.r.t. ground survey of high land and HRUAVI.

Surveyed Extent		Digitized Extent		Difference		
Lot	Ha	Lot	Ha	Ha	%	% ≈
213	0.1797	213	0.1835	-0.0038	2.10	2
214	0.1802	214	0.1911	-0.0109	6.07	6
215	0.1294	215	0.1312	-0.0018	1.36	1
216	0.1515	216	0.1563	-0.0048	3.18	3
217	0.2465	217	0.2350	0.0115	4.66	5
218	0.0395	218	0.0417	-0.0022	5.56	6
219	0.0802	219	0.0785	0.0017	2.11	2
220	0.2083	220	0.2063	0.0020	0.97	1
221	0.0917	221	0.0921	-0.0004	0.46	0
222	0.1613	222	0.1623	-0.0010	0.61	1
223	0.3478	223	0.3471	0.0007	0.19	0
224	0.3568	224	0.3675	-0.0107	2.99	3
225	0.1682	225	0.1770	-0.0088	5.26	5
226	0.2548	226	0.2523	0.0025	0.99	1
227	0.1061	227	0.1072	-0.0011	1.04	1
200	0.1422	200	0.1485	-0.0063	4.00	4
201	0.103	201	0.1022	0.0008	0.78	1
202	0.1744	202	0.1792	-0.0048	3.00	3
204	0.1079	204	0.1108	-0.0029	3.00	3
205	0.0854	205	0.0837	0.0017	1.99	2
206	0.1062	206	0.1088	-0.0026	2.00	2
207	0.0896	207	0.0875	0.0021	2.34	2
208	0.0564	208	0.0528	0.0036	6.38	6
209	0.0666	209	0.0678	-0.0012	2.00	2
210	0.1235	210	0.1297	-0.0062	5.00	5
211	0.3209	211	0.327	-0.0061	2.00	2
212	0.056	212	0.058	-0.002	4.00	4

Table 3 : Comparison of Area deviation

w.r.t ground survey of paddy land and HRUAVI

Surveyed Extent		Digitized Extent		Difference	
Lot	Ha	Lot	Ha	Ha	%
29	0.0503	29	0.056	-0.0057	11
31	0.1319	31	0.1093	0.0226	17
37	0.1078	37	0.0937	0.0141	13
66	0.0355	66	0.0411	-0.0056	16
107	0.0104	107	0.0125	-0.0021	20
108	0.0102	108	0.0116	-0.0014	14
109	0.0189	109	0.0238	-0.0049	26
110	0.0441	110	0.039	0.0051	12

Table 4 : Comparison of Area deviation

w.r.t ground survey of high land and HRUAVI

% Error	No. of Parcels	Percentage
<2	22	34
2-4	15	25
4-6	10	15
6-20	13	26
	60	100

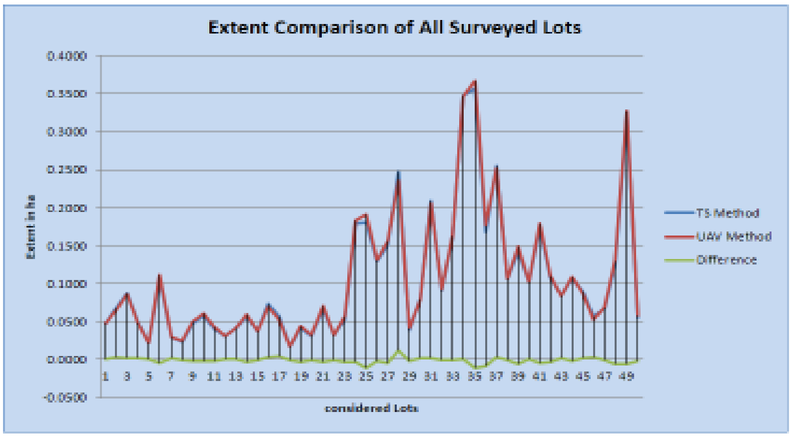

Fig. 7 Plot on Number of parcels against

the percentage error of area

in HRUAVI w.r.t ground survey

% Error	No. of Parcels	Percentage
<2	15	56
2-4	6	22
4-6	6	22
>6	0	0
	27	100

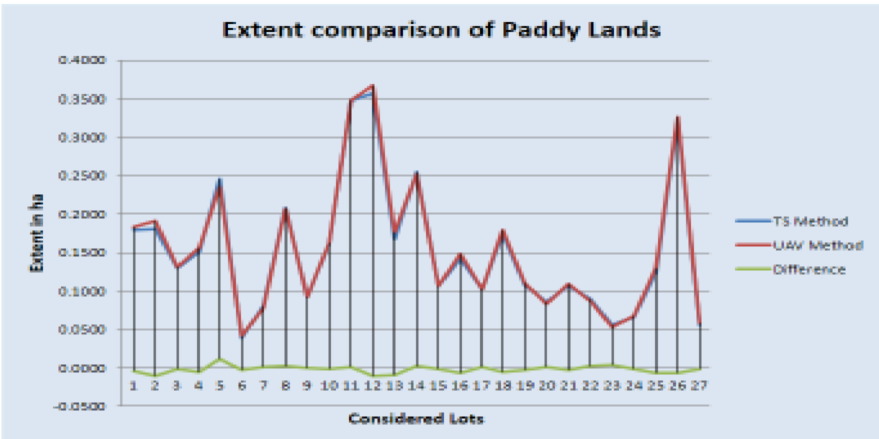

Fig. 7 Plot on Number of parcels against

the percentage error of area in HRUAVI

w.r.t ground survey.

4.2 Position Comparison.

Positional Accuracy of the parcel boundary derived from HRUAVI and ground survey were assessed by identifying the shift in position of the control point coordinates calculated in terms of distance between them . Control point Coordinates and same points derived from HRUAVI Survey were calculated and the distance between them was measured using the Euler's Distance Formula. (a)

Δd-((x-x1) + (y-y1)) ^1/2……………………………(a)

Where Δd is the shift in meters, (x , y) is the coordinate value of the point

From Table 5, we can observe that 8 control derived from HRUAVI had shift less than 10 cm w.r.t TS Survey which shows an accurate match between these two points. Only 2 points derived from HRUAVI had shift beyond 10 cm which shows a minimal mismatch between these 12 control points. . From this it can be depicted that more number of points can be derived with acceptable accuracy using HRUAVI. The standard deviation is 0.05cm.

Object_id	Number	Image cordinate		Ground coordinate		Euler's Distance Fomula					
		x_cordinate	y_cordinate	x1	y1	x-x1	y-y1	(x-x1)2	(y-y1)2	(x-x1)2+(y-y1)2	√
1	1	520804.914	479584.18	520804.9209	479584.0806	-0.0069	0.0994	0.0000	0.0099	0.0099	0.0996
2	2	521336.268	479709.936	521336.3734	479709.9832	-0.1054	-0.0472	0.0111	0.0022	0.0133	0.1155
3	3	521632.343	479784.714	521632.4056	479784.6929	-0.0626	0.0211	0.0039	0.0004	0.0044	0.0661
4	4	521261.92	480274.043	521262.0777	480274.1416	-0.1577	-0.0986	0.0249	0.0097	0.0346	0.1860
7	5	520986.352	479648.756	520986.3758	479648.7650	-0.0238	-0.0090	0.0006	0.0001	0.0006	0.0254
8	6	520967.966	479783.165	520967.9961	479783.1866	-0.0301	-0.0216	0.0009	0.0005	0.0014	0.0370
9	7	521129.872	479643.173	521129.8662	479643.1819	0.0058	-0.0089	0.0000	0.0001	0.0001	0.0106
10	8	521238.402	479618.635	521238.4333	479618.5725	-0.0313	0.0625	0.0010	0.0039	0.0049	0.0699
11	9	521178.169	479479.374	521178.1627	479479.3582	0.0063	0.0158	0.0000	0.0002	0.0003	0.0170
12	10	521873.491	480136.695	521873.4907	480136.7181	0.0003	-0.0231	0.0000	0.0005	0.0005	0.0231
									standard deviation		0.0556

Table5 : Comparison of image control points of HRUAVI

deviation w.r.t coresponding GCP'S

4.2 .1 .Replacing accuracy.

During the field work stage attributes of the land parcels were collected on relevant format. (*See annexure 1 & 2*).The sketch of the land parcel also marked on that format and dead measurements also marked. The accuracy of replacing of this boundary landmarks are depend on the positions of dead measurements were taken. Table 6 shows the accuracy of replacing landmarks. It indicates, if the dead measurements has to be taken to the fixed points the replacing accuracy of land marks are very high.

Lot_No	Dead measurement	Replaced measurement	Different	Dead measurement from
118	4.90	4.80	0.10	Stake to Tree
	0.90	0.80	0.10	Stake to Live Fence
	1.60	1.60	0.00	Stake to Building corner
	25.00	25.15	-0.15	Live Fence
	4.60	4.60	0.00	CP to Building corner
	3.70	3.70	0.00	CP to Building corner
	1.85	2.00	-0.15	Tree to Building corner
	3.30	3.40	-0.10	Stake to Building corner

- Replacing Error can be vary 0 to 15cm.

Table6 : Replacing accuracy

4.3 Time and Cost Comparison.

Table 7 shows the detail time involvement for deriving 500 parcels using HRUAVI method. Parcel Boundary delineation using Total Station requires intensive field observation thus consuming more cost and more time on field and it shows in table7, whereas Parcel Boundary delineation using UAV Image involves less field work and is economical compared to the method using total station. By analysis these two systems, it shows around **1/3** time of TS surveying takes HRUAVI system for 500 lots complete in cadastral maps. (Table 8)

CM No	GN Division	No of lots	Time taken to completed (month)
320269	Dihitideniya	718	17
320270	Kotagaloluwa	379	13
320279	Gamhatha	662	13
320275	Pilapitiya	443	11
320276	Kooradeniya	487	06
320278	Rangoda	584	11
320279	Angunawela	745	36
320271	Meewaladniya	192	04
320272	Ambagasthenna	298	06
320273	Kamburadeniya	618	24
Average		512.6	15

No of months for complete ground survey method for 500 lots = 15

Table7: Time (in months)to be complete 500 lots in total station system.

Source; Sri Lanka survey department cadastral survey division.

For completing 150 lots	UAV Method (in dates)	TS Method (in dates)
Reconissance	3	
GCP	2	
UAV flying	2	
Time for Attribute data collection (days)	12	
Digitizing outer boundary	2	
Digitizing lots	5	
Drawing completing	3	
TL completing	2	
Completing Requisition	2	
Other duties	2	
	35	90
Assumption 500 lots are included in a GN Division		
For completing 500 lots	110	300

Table8: Time to be complete 500 lots in HRUAVI

System and TS system.

4.3.1 Cost Comparison.

The parcel boundary delineation using Total Station, more human resources and machinery equipment are involved in the activities like detail field observation and data processing, whereas less manpower with few machinery equipment can delineate parcel boundary using UAV Image. Table 7 and 8 shows human resources involved in this study using both the Total Station and HRUAVI method respectively. The summary of

Activity	No of days	Cost
Supervising	5.00	23,333.33
Data Collection	12.00	102,000.00
GCP/GPS	2.00	60,000.00
UAV flying	2.00	30,000.00
Digitizing	2.00	3,000.00
Plan work	7.00	17,500.00
Other	5.00	
Total	35.00	235,833.33
No of lots completed		150.00
Cost per lot		1,572.22

- **The cost per lot 11 $.**

actives, No. of days engaged for each activity and cost shown in table 9.

Table9: Cost estimation for HRUAVI method.

4.4 Limitations.

This study was carried out under favorable conditions .Some of the limitations that faced this study area as follows.

(a) Study area comprised of hilly and flat lands almost equally. But mostly highly dense settlement area, high canopy cover, unclear boundaries, small parcels situated in high land area.

(b) Considerably clear parcels were used for the comparison.

(c) Data collection and total station survey was done by apprentice surveyors.
(d) Boundary digitizing was done with the help of both apprentice surveyors and apprentice draftsman. The best digitized parcel boundaries selected from three digitizing officers.

5.0 CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS.

The principle objective of this project is to compare the cadastral survey done by high resolution UAV image and that by total station in context of Sri Lanka. Comparisons between parcel boundaries derived from total station survey and UAV, shows good potential of the UAV cadastral survey. The various attributes of derived parcels such as **area** and **position** from both techniques (High lands and paddy lands separately) were compared along with human resource involved and time for the completion of task.

Today's satellite technologies with high resolution has to be a boon in the field of land surveying for cadastral mapping with high accuracy, cost effective and time efficient manner. High resolution UAV imagery (HRUAVI) also provides clear identification of parcel boundaries and other features due to which conventional and traditional methods of cadastral mapping shifting towards more advanced, reliable and economic methods.

This Study incorporates the potential use of high resolution UAV image for indirect land surveying for cadastral survey to achieve high accuracy with low cost and within small time frame.

The comparisons shows that around 70% of the parcel boundary can be derived with acceptable accuracy. In addition, use of UAV data will result in faster updating of cadastral maps in more economical and convenient manner. From the above findings it's clear that use of UAV data can reduced the cost time and human resources as compared to the total station method.

Also the parcel boundary can be derived with acceptable accuracy with the use of UAV data. However large deviation in parcel areas were due to unclear boundaries with similar spectral response, high canopy cover over the boundaries etc.

Through the obtained results from the comparisons of two techniques in delineating the parcel boundaries shows good potential for UAV use in cadastral surveys, sometimes high accuracy cannot be achieved as that of the total station.

There are some limitations to this techniques as it solely on visual interpretation. In case of highly dense settlement area, shadow region, high canopy cover, unclear boundaries due to similar spectral reflectance, small parcels etc. Similar accuracy cannot be achieved.

RECOMMENDATIONS

Every techniques has its own flaws and benefit.To obscure the flaws of one with the benefits of the other would be the best option to overcome any task with high accuracy at minimal cost.Similar an intergrated approach of both the techniques can be used to achieve higher accuracy in aneconomical manner and can even fasten the process.

The best results can obtain in flat terrain and less canopy cover area.This system can be used to preapre cadastral maps even in unaccesible hilly area ,high jungle etc.

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Annexe1.

FORM FOR STATE LANDS

Date of Survey: DD MM YYYY Questionnaire Number:
Time Started: Time Completed:
Name of Surveyor:

PARCEL FABRIC STUDY QUESTIONNAIRE FOR STATE LANDS

1. INFORMATION FROM THE RECORDS

1.1 Legislation under which the land was given: (See Box 1)

Box 1: Legislation

1- Land Development Ordinance (LDO)
2- Land Grants Special Provisions Act
3- State Land Ordinance (SLO)
4- Land Reform Law
5- Urban Development Authority Act
6- National Housing Development Authority Act
7- Other legislation (Specify in margin)

1.2 Name of Allottee: ....

1.3 Plan Number: .... 1.4 Lot Number: ....
1.5 Document Number: .... 1.6 Date of Issue: ....
1.7 Name of Land: ....
1.8 Name of Town/Village/Settlement and Tract: ....
1.9 Type of Land: 1- Highland 2- Lowland
1.10 Total Extent: .... (Specify units as acres, roods, perches or hectares)

2. CURRENT OCCUPANT OF THE ALLOTMENT

2.1 Who currently occupies the allotment? ....
2.2 How was the land demarcated? (See Box 2)
2.3 What is the occupant's relationship to the allottee? (See Box 3)
2.4 On what basis does the household claim occupancy rights to the land? (See Box 4)

Box 2: Demarcation

1- Plan by private Surveyor
2- Plan by S.G./Government Surveyor
3- Mutually agreed and specified boundaries
4- No recognized or specified boundaries

Box 3: Relationship to Allottee

1- Allottee
2- Immediate family member
3- Relative
4- Outsider (not relative)

Box 4: Occupancy Rights

1- Grant
2- Permit
3- Lease
4- Notarial deed
5- Affidavit
6- Power of Attorney
7- Surrended permit/grant
8- Signed receipt
9- Letter of authority
10- Non-written consent
11- Other (Specify in margin)

3. GENERAL INFORMATION

3.1 Village .... 3.2 G.N. Division: ....
3.3 D.S. Division: .... 3.4 District: ....
3.5 Cadastral Map No: .... 3.6 Parcel No: ....
3.7 Center Coordinate of Parcel: N ....
E

4. SKETCH OF THE PARCEL (Take exact measurements to all bend points.)

Boundaries pointed out by: ....

Boundaries pointed to: ....

....
Signature of Surveyor

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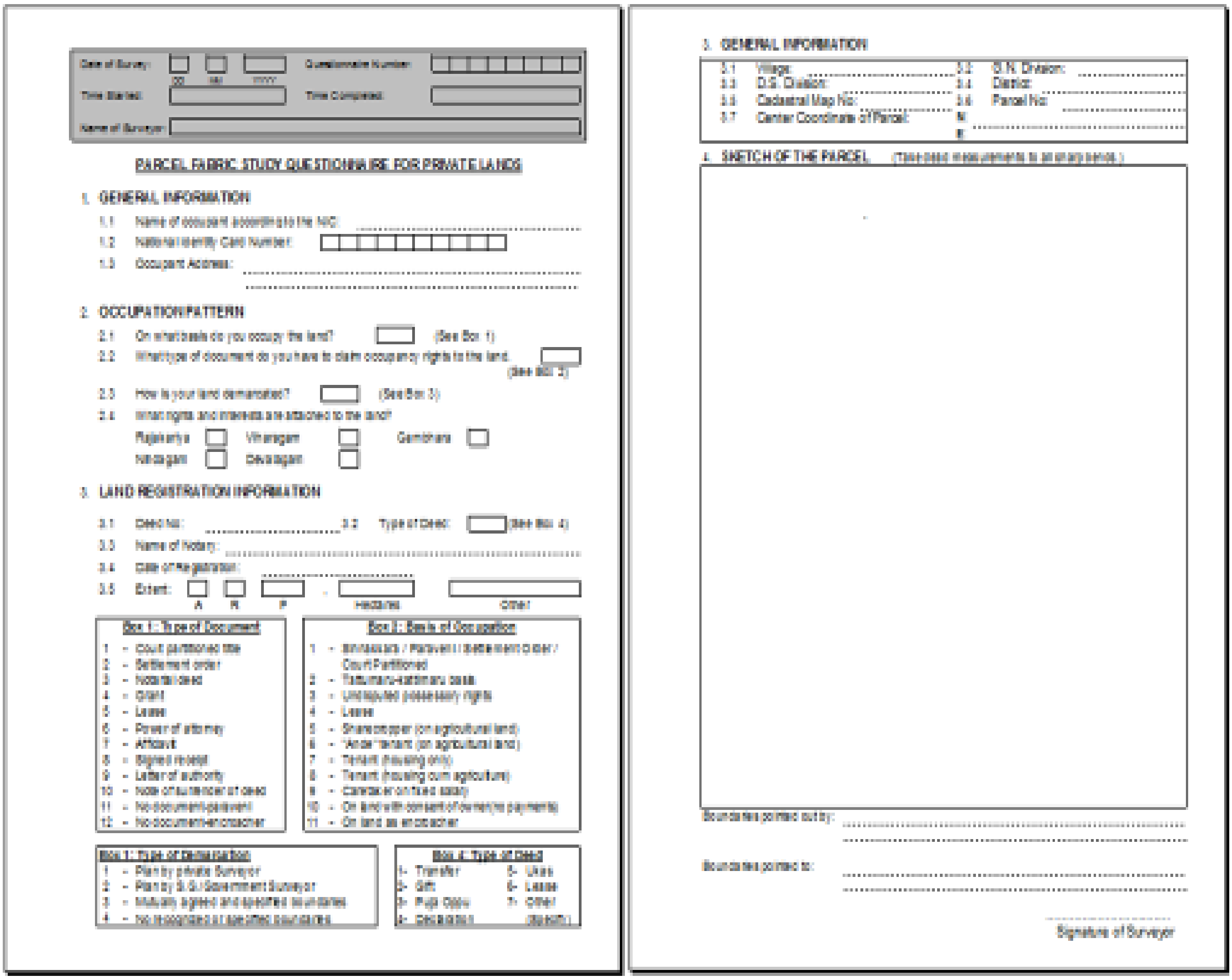
Annexe2

FORM FOR PRIVATE LANDS



Annexe3

LAND PARCELS

Annexe4


Road
Lot 20
Road
Lot 22


Ground
Road
Lot 31
Lot 30
Road
School

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Preference for presentation	Oral Presentation

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