

Techniques of Surveying and Cadastral Mapping in Vietnam

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Abstract- Currently, the surveying and cadastral mapping which serve for the land management is important in Vietnam. Formerly, the measurement of cadastral maps in Vietnam is done mostly manually by measuring optical theodolite and afterwards the map is drawn on the paper. Right now with the development of new technologies, many technological applications are used to measure for the establishment the cadastral map in Vietnam; however, the measure of the cadastral map done by technology electronic total station is the most popular to fit topographical conditions of Vietnam. In this method, the cadastral surveying is primarily use by the total station to measure direct in the field, then we use the specialized softwares such as MicroStation, FAMIS and Pronet to handle the measurement data and edit the map. In this study, cadastral mapping and measurement method for a particular area has found its conclusion. It is Cat Trinh Commune, Phu Cat District, Binh Dinh Province, Vietnam. The final result was the survey network diagram with 425 points including 24 high level cadastral points and the completed cadastral map with the total area of 4865.20 ha. There are 63 sheets in the cadastral map of Cat Trinh Commune which consists of 45 map sheets in scale 1: 2000, 18 map sheets in scale 1: 1000. All of them were stored as the digital files on the computer and the printed papers. Beside the cadastral maps, there are the statistical tables of the land area of each object and the purpose of the land use. This is an important document to help the State agencies manage the land correctly, handy and consistently.

Index Terms- *Measuring, Mapping, Cadastral, Cat Trinh Commune, Land Management*

I. INTRODUCTION

Today, the cadastral map is an important component of the cadastral documents in Vietnam as well as many countries in the world. It serves for the State management unification about the land, and provides the information about the space and the property of the land plot. Cadastral map is also a basis for the planning and the economic and social development; the planning, the land use planning; the land price determination, land lease and land acquisition, etc.

Cat Trinh Commune is located in Southern Phu Cat District, Binh Dinh Province, Vietnam. It's about 50 km from Quy Nhon City (Binh Dinh, Vietnam) and its natural area is 4865.20 ha. Cat Trinh Commune is continuing development in all key aspects economy, politics, society etc. However, the government of the state in regards to the land and the area needs to improve clearance, inspection and land dispute resolution. To apply improvement, we need the cadastral map system with the high accuracy which is based on the land management in the area. Therefore, the measurement and the digital cadastral mapping serving for the state government about the land of the commune is an urgent requirement. [11]

In this article, the process is presented as well as the results of the measurement and cadastral mapping following the total station method in Cat Trinh Commune, Phu Cat District, Binh Dinh Province, Vietnam. The measurement results were closely adjusted by Pronet Software. Afterwards, the accuracy of the measurement results has been evaluated and used Microstation and FAMIS Software in order to edit the cadastral map for this commune. In addition to those results, the article also offers to the results of the land statistology following each land user and the administrative boundary. This is considered to be one of the most important factors to help the management and resolution of the land issues in the commune.

II. PROCESS AND METHOD

A. Process

This study was carried out according to process: Collecting documents and data and examining the field and establishing the control network. After founding the control network completely, we had the coordinates of the control points, surveying the field factors in detail (land plot boundary, transportation, hydraulic system, etc.).

The detailed measurement results were put into the computer, and the cadastral map was edited by the specialized softwares such as MicroStation and FAMIS. After that, we checked and compared them with the field then printed the maps. Beside the map sheets of the area studied, there are statistics of the land area of each owner.

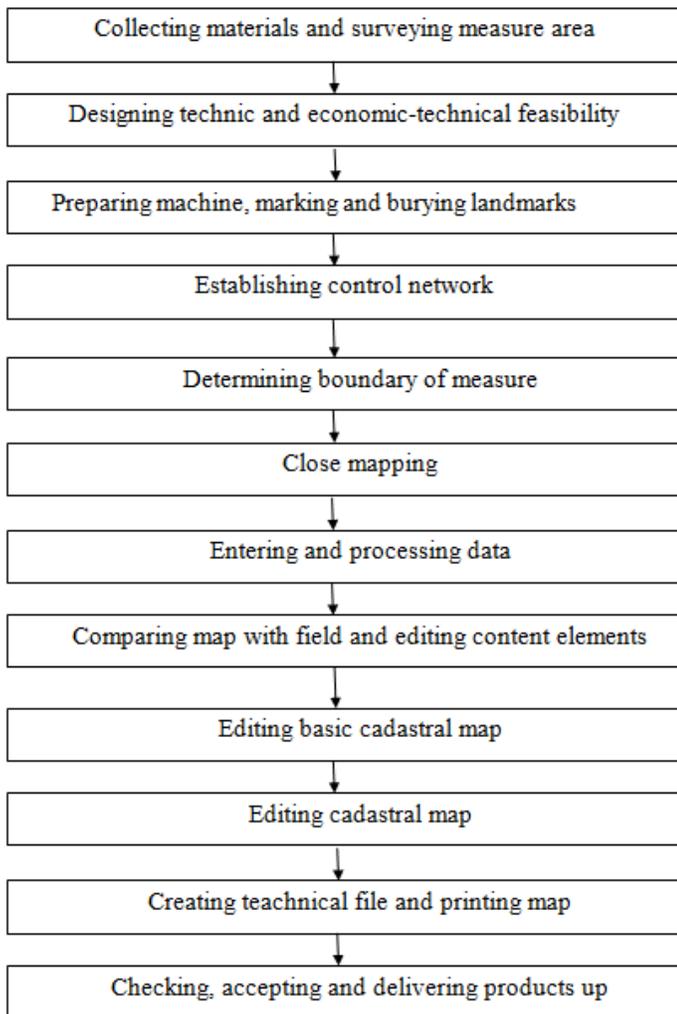


Figure 1. Process of cadastral map Measurement by the total station method in Vietnam [15,19]

B. Method

We used some of the following study methods:

+ *Surveying and collecting data method:* Collecting data from functional agencies such as People's Committee of Cat Trinh Commune, Department of Natural Resources and Environment of Phu Cat District. They are about high points, existing cadastral points, natural economic - social condition of study areas serving for the topics. And we carried out surveying field in order to know the actual conditions of topography in the measurement area and have a plan for the proper measurement.

+ *Surveying field method:* Using the GTS - 239N total station machine to measure the survey control network, the ground control network was measured by the total station method with 2 times, then we took the average value of the measured results. After measuring and calculating the ground control network completely, we carried out measuring the factors in the field in detail.

+ *Handling data method:* The measured data of ground control network in the field were pretreated and formatted, then we used Pronet software to calculate and adjust the control network. Then the results were considered and evaluated for accuracy. If they are ensure about standards of the request, we

conduct the next steps and have the produce results of precise coordinates of control points.

+ *Mapping methods:* Using Microstation and FAMIS Software which are standard for cadastral mapping, taking measured data into software correctly, then using the commands to edit the cadastral maps for the study area.

III. RESULTS AND DISCUSSIONS

A. Generalizing about the research area

Cat Trinh Commune is located in Southern Phu Cat District, Binh Dinh Province, Vietnam. It's about 50 km from Quy Nhon City (Binh Dinh, Vietnam) and its natural area is 4865.20 ha. Its geographic coordinates are from $108^{\circ}15'14''$ to $108^{\circ}15'28''$ east longitude and from $13^{\circ}12'27''$ to $13^{\circ}16'28''$ north latitude.

The North abuts on Cat Hanh Commune, Cat; the South abuts on Cat Tan Commune, Cat Tai; the East abuts on Cat Thanh Commune, Cat Nhon; the West abuts on Cat Hiep Commune and Ngo May Town.

Cat Trinh Commune is an area which has relatively flat topography, almost the area of the commune is plain and the inhabitants are concentrated. These are favorable conditions for inhabitants' lives as well as the surveying and cadastral mapping.

Beside those advantages, there are some difficulties such as the transportation and irrigation system flooded after the rain. It damaged and affected to the production and inhabitants' lives. [11]

B. The establishment of the survey network

1. Surveying and collecting data

To serve for measuring the survey control network as well as the cadastral mapping, we has conducted the survey area to assess the level of advantages and disadvantages of the terrain for the mapping process. In general, the terrain is not too complicated and the division level is not much, so it is not too difficult to arrange the survey network.

The documents and data gathered at the land management agencies of district and commune consist of 24 high level cadastral points distributed evenly across the Cat Trinh Commune; the current land use map of commune which was established in 2010 has been edited and added annually. Moreover, there are also some documents of natural conditions, economic and social, the development orientation of the commune in the next years, etc. These are the necessary and useful documents serving for surveying and cadastral mapping process of Cat Trinh Commune.

Table 1: Coordinate of high level cadastral points of Cat Trinh Commune

No.	Point name	Coordinate (m)	
		X	Y
1	TM15	1532871.274	596631.331
2	TM17	1532502.642	596349.431
3	CT20	1532649.047	596026.545
4	CT07	1532834.367	595940.962
5	CT08	1532547.557	595844.127
6	CT09	1533736.898	595110.200
7	CT10	1533566.085	594952.239
8	PC67	1533425.944	595102.821
9	PC30	1533297.443	595260.224
10	CT04	1533174.875	595373.341
11	CT04	1531937.230	597482.725
12	PM02	1531976.494	597392.159
13	PT01	1532040.390	597407.729
14	CT05	1532027.430	597444.242
15	PM01	1532100.901	597437.115
16	CM06	1532062.805	597537.250
17	CT12	1530079.866	597893.234
18	PC53	1530120.121	597919.320
19	PC40	1530212.355	597824.272
20	PC39	1530229.703	597880.668
21	PC66	1531236.421	597901.899
22	PC28	1531234.850	597952.056
23	CT11	1531438.905	597540.914
24	PT02	1530852.421	597532.570

(Source: Department of Natural Resources and Environment of Phu Cat District) [3]

2. Arranging and measuring survey network

Based on the available documents as current state of land use map combined with field survey, we conducted building survey network for Cat Trinh Commune. First, we based on the distribution of the high level cadastral points combined with the condition of the terrain in order to divide the areas for establishing the kinds of measuring survey network. Depending on the real condition of the terrain of each area to arrange the survey network appropriately, the beginning and ending points of the survey network are the cadastral points at level II or higher.

Survey network of the entire Cat Trinh Commune has 425 points including 24 high level cadastral points used for beginning points for the kinds of theodolite traverse. Survey network is built by the total station method with 2 times and each time with 2 halves of measurement, ensuring in accordance with the regulation of Vietnam Ministry of Natural Resources and Environment.

3. Calculate adjustment for theodolite traverse

After measuring the control network, we had specific data including angles and edges in theodolite traverses of each area in the commune. Then we use the Pronet software to conduct the preliminary calculation and detailed adjustment of survey network. The results are expressed as the following illustration.

THEODOLITE TRAVERSE CHECK

1. Route: DHQN2.1_DHQN2.2_KV1_KV2_KV3_KV4_KV5_KV6_KV7_KV8_DHQN2.1_DHQN2.2

Route length	[S] = 926,267 (m)	N = 9
Azimuth closure	wb = -185"	w(g/h) = 63.25"
coordinate closure	fx = -0,221 (m)	fy = -0,158 (m)
	fp = 0,271 (m)	fs/[s] = 1/3400

Angular error (Ferro)	Mb = 58.502"
Edge error	Ms = 9.041 (cm)
average edge length	s(tb)= 102,849 (m)

Figure 2. Results of calculating survey network preliminary

The entire survey network of Cat Trinh Commune has 425 control points consisting of 24 high level cadastral points known and 401 new established points. Survey network consists of many different theodolite traverses such as traverses closed line and traverses closed loop.

The result of assessment of preliminary calculation for theodolite traverses of Cat Trinh Commune is summarized in the following table:

Table 2: Evaluating results calculated preliminarily of survey network

No.	The technical indicators	Allowed limitation of error	Results	Evaluation
1	Error of closed azimuthal	$\pm 30''\sqrt{n}$	$\pm 5''$ to $\pm 57''$	Qualified
2	Error of closed coordinates	1/3000	1/4800 to 1/3600	Qualified

Through the composite panel and evaluation of results calculated preliminarily of survey network of Cat Trinh Commune, it shows that the results are guaranteed about the technical requirements set out. The calculation errors are much smaller than the allowed errors in the regulation of establishing cadastral map of Vietnam Ministry of Natural Resources and Environment. Therefore, we can proceed to adjust the next steps so as to evaluate the errors of control points in the survey network in more detail.

EVALUATING THE ACCURACY OF THE SURVEY NETWORK

1_weight number error M = 71.54"

2_weakest point (KV4) mp = 0.121 (m)

3_Length of weakest edge : (KV5 _ KV6) ms/s = 1/2000

4_Azimuth of weakest edge : (KV6 _ KV7) ma = 95.19"

ADJUSTMENT VALUE

OR	left	ANGLE between	SYMBOL	right	MEA. VALUE	SO CC	SO H.C	ADJU. VALUE
					o'	m.ph.	(')	o'
1	DHQN2.2	KV1	KV2		171 14 45.00	---	43.94	171 15 28.94
2	KV1	KV2	KV3		141 18 25.00	---	1.34	141 19 26.34
3	KV2	KV3	KV4		135 47 10.00	---	58.78	135 48 8.78
4	KV3	KV4	KV5		74 2 25.00	---	26.01	74 2 51.01
5	KV4	KV5	KV6		235 22 55.00	---	5.11	235 23 0.11
6	KV5	KV6	KV7		82 58 30.00	---	-19.79	82 58 10.21
7	KV6	KV7	KV8		102 12 30.00	---	-13.15	102 12 16.85
8	KV7	KV8	DHQN2.1		300 57 30.00	---	13.01	300 57 43.01
9	KV8	DHQN2.1	DHQN2.2		129 20 60.00	---	-1.93	129 20 58.07
10	DHQN2.1	DHQN2.2	KV1		66 41 45.00	---	11.68	66 41 56.68

Figure 3. Evaluating the accuracy of the survey network

After adjusting the survey network of Cat Trinh Commune on Pronet Software, the result was the composite panels of measured data, adjustment value, the coordinate of the points, the kinds of error, etc. The result of evaluating the technical criteria of the survey network of Cat Trinh Commune is summarized in the following table:

Table 3: Evaluating the results of adjustment for survey network of Cat Trinh Commune

No.	The technical indicators	Allowed limitation of error	Results	Evaluation
1	The length of the shortest edge	≥ 20 (m)	58.50 (m)	Qualified
2	The length of the longest edge	≤ 250 (m)	103.82 (m)	Qualified
3	Error of mean square of traves leg after adjustment	0,020 m	$\leq 0,016$ m	Qualified
4	The smallest angle	$\geq 5^\circ$	45°40'28''	Qualified

The results of calculating the kinds of theodolite traverses of survey network in Cat Trinh Commune with the specification satisfy the than the requirements normative of Vietnam Ministry of Natural Resources and Environment (Table 3). They can be used to edit the survey network for this area and will be as the basis for survey in detail in the future. The results of adjustment are shown in the figure 4:

RESULTS OF CALCULATION FOR THE SURVEY NETWORK

Or di nal	POINT SYMBOL	COORDINATE		LOCATION ERROR		
		X(m)	Y(m)	Mx	My	Mp
1	KV1	1521966.424	604533.868	0.038	0.037	0.053
2	KV2	1521961.798	604445.961	0.061	0.049	0.079
3	KV3	1521881.659	604355.978	0.092	0.050	0.104
4	KV4	1521753.029	604346.726	0.096	0.073	0.121
5	KV5	1521781.202	604481.133	0.057	0.061	0.083
6	KV6	1521730.709	604534.257	0.045	0.071	0.083
7	KV7	1521789.450	604577.746	0.035	0.050	0.061
8	KV8	1521846.808	604527.390	0.029	0.036	0.046

Figure 4. Results of calculation for the survey network by Pronet Software

From the results of the traves points coordinate, we edited the diagram of survey network for the area (Figure 5). The survey network of Cat Trinh Commune consists of 425 points, the traves points are evenly distributed in the commune, the density is ensured to survey in detail.

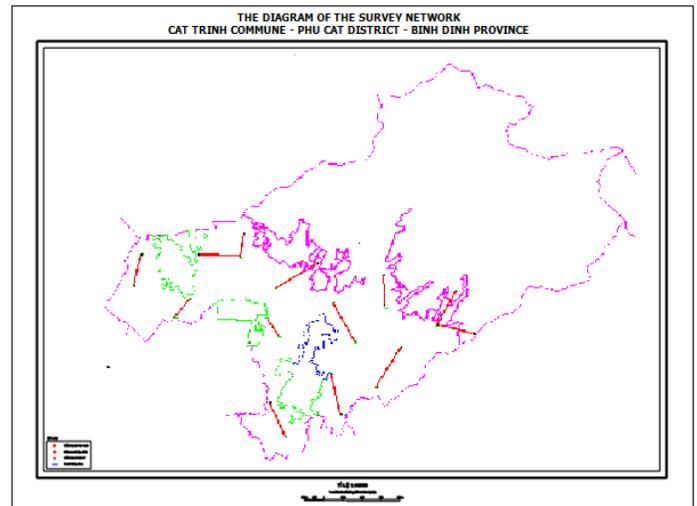


Figure5. The diagram of the survey network of Cat Trinh Commune

C. Surveying in detail and editing cadastral map for Cat Trinh Commune, Phu Cat District, Binh Dinh Province, Vietnam

Using the GTS - 239N total station machine to measure in detail on the actual factors such as boundaries of the parcel, the terrains, hydraulic system, traffic, etc. The detailed surveying data were processed and used to edit cadastral map by MicroStaion and FAMIS Software.

The implementation process consists of the following basic steps: Running FAMIS Software, creating a new design file; Creating measured value description, editing measured value; Connecting the measuring points according to the diagram; Connecting the database map; Creating zones; Entering the original cadastral information; Drawing labels of plots; Drawing the frame of the map; Creating technical documents of parcels; Printing and delivering products up.

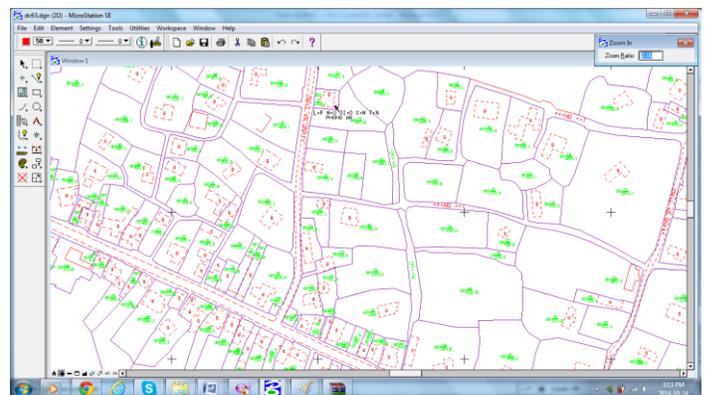


Figure 6. Editing cadastral map by MicroStation Software

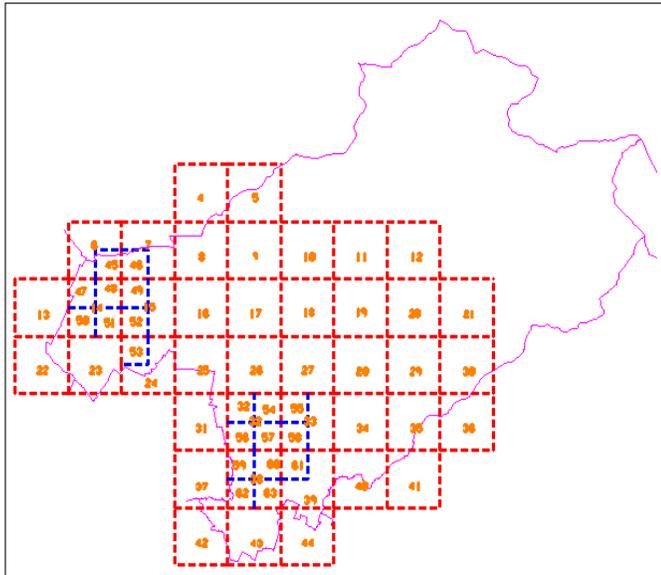


Figure 7. The fragmented diagram of Cadastral Map of Cat Trinh Commune

The cadastral map of Cat Trinh Commune was edited according to the layers of information (level) such as: purpose of land use, hydrology, traffic, numbers of parcel, etc. which help state government to manage land more favorably. MicroStation Software allows us to save over 63 data layers, each layer shows an object of information which we can depend on to display any objects on demand.

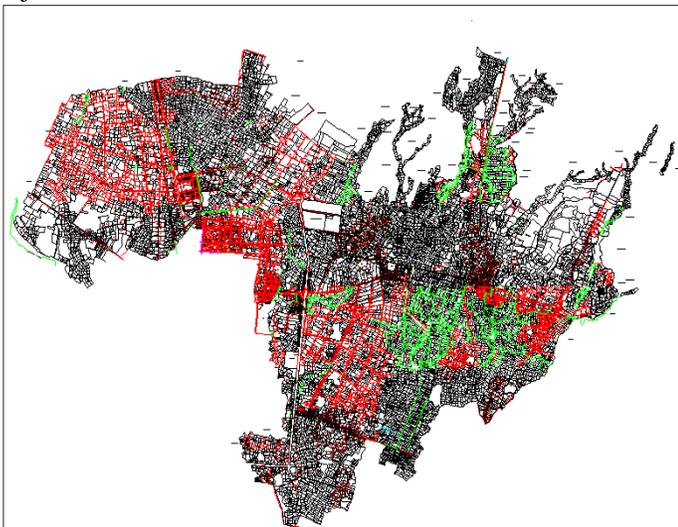


Figure 8. The Cadastral Map in general of Cat Trinh Commune on MicroStation Software

A final technical work before conducting to print map is creating the frame of the map for each cadastral map sheet. With this work, we need to conduct in turn from selecting the landmarks, rate, coordinates of map frame by covering the coordinate fence at the top-left and bottom-right corner of the map sheet, and then proceed to draw the sheet margin.

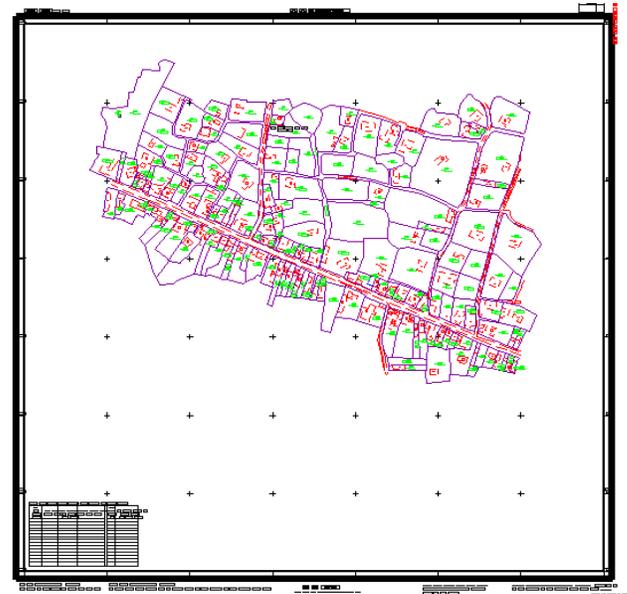


Figure 9. A completed map sheet

After being edited completely, there are 63 map sheets including 45 map sheets in scale 1: 2000, 18 map sheets in scale 1: 1000 of the whole system of cadastral map of Cat Trinh Commune. All of them were edited on 17 layers, each layer stored an information of map sheet. For example, the 10th layer shows the boundary of parcels; the thirteenth layer notes the land type, area and number of plots; the 23rd layer shows the boundary of traffic, etc.; the 63rd layer shows the sheet margin of map. The edition of the information data on each different layer helps the management and using the cadastral map more conveniently through hiding and revealing the layers of information.

No.	Line (From pilot to pilot)	The measured data on the map (m)	The measured in the field (m)	Error (m)	Evaluation
I Line H (from pilot 258 to pilot 246)					
1		200.073	199.809	-0.264	Qualified
2		186.656	186.626	-0.03	Qualified
3		166.118	165.969	-0.149	Qualified
4		146.803	146.842	0.039	Qualified
5		129.073	128.691	-0.382	Qualified
6		104.331	104.272	-0.059	Qualified
7		99.378	99.891	0.513	Qualified
8		54.883	54.703	-0.18	Qualified
9		29.499	29.664	0.165	Qualified
II Line N (from pilot 685 to pilot 515)					
1		231.94	232.39	0.45	Qualified
2		184.89	185.01	0.11	Qualified
3		183.86	183.44	-0.42	Qualified
4		157.02	157.38	0.36	Qualified
5		133.97	133.82	-0.16	Qualified
6		92.18	92.41	0.23	Qualified
7		90.77	90.84	0.06	Qualified
8		53.62	53.59	-0.03	Qualified
9		14.70	14.82	0.12	Qualified
10		11.83	11.88	0.05	Qualified
11		3.22	2.72	-0.50	Qualified

Figure 10. Results of checking the line of land plot

No.	Plot number	Location of land plot edge	Distance of checking (m)	Distance on the map (m)	Error (m)	Evaluation
1	70	South	18.94	18.940	0.00	Qualified
2	71	South	5.17	5.220	-0.05	Qualified
3	72	South	6.05	6.080	-0.03	Qualified
4	73	South	7.94	7.870	0.07	Qualified
5	36	South	23.32	23.380	-0.06	Qualified
6	74	South	10.55	10.600	-0.05	Qualified
7	76	South	16.00	16.060	-0.06	Qualified
8	79	South	5.00	4.960	0.04	Qualified
9	116	North	18.10	18.160	-0.06	Qualified
10	83	South	19.8	19.85	-0.05	Qualified
11	96	West	38.15	38.26	-0.11	Qualified
12	57	West	15.2	15.22	-0.02	Qualified
13	131	North	19.45	19.47	-0.02	Qualified
14	132	North	19.98	19.99	-0.01	Qualified
15	134	North	5	5.06	-0.06	Qualified
16	103	South	23.1	23.19	-0.09	Qualified
17	206	East	19.6	19.58	0.02	Qualified
18	162	North	3.5	3.54	-0.04	Qualified
19	57	West	15.2	15.22	-0.02	Qualified
20	96	West	38.15	38.26	-0.11	Qualified

Figure 11. Results of checking the edges of land plot

The checking in the field consists of the following contents: Comparing the types of land in the field with the map, measuring to check edge map, measuring to check line, measuring random. Through checking and compared the field with the map to assess the accuracy of the map, it shows that the results of measurement ensure the allowed error according to the regulation of Vietnam Ministry of Natural Resources and Environment. Therefore, the cadastral map is built to ensure the precision and it can be used for the management of the State on land (Figure 9, Figure 10).

Table 4: Total of plots, areas, number of owners using land following the administrative boundary of commune according to the current state of cadastral mapping (illustration)

No.	Map sheet number	Total of land plots	Total of owners using land	Area (m ²)
1	1(548593-5)	81	28	101612.2
2	2(548593-6)	142	24	95813.0
3	3(548596-4)	218	43	294893.7
4	4(548593-8)	387	168	364977.7
5	5(548593-9)	497	164	539830.2
6	6(548596-7)	902	215	930515.6
7	7(548596-8)	583	133	611025.5
8	8(548596-9)	203	57	219055.0
9	9(545593-2)	454	164	391611.0
.....				
63	63(545593-8-b)	138	106	85584.2
Total		17.507	4.337	21.381.723

Through the synthesis, we got the total of land plots of Cat Trinh Commune is 17.507 land plots with 4.337 owners using land (Table 4). The next job was the statistics of land for each owners using land, we obtained the result is the statistic table of land containing the information about each land plots following each owners using land, the area and the purpose of using land, etc. This is an important document to set up cadastral notebook and statistical notebook for each locality; thus, it requires the high precision.

Table 5: Statistics following owners using land (illustration)

Land plots	Area (m ²)	Land use purposes	Name of owners using land	Address
1	393.5	ONT	Do Thi Kim Cuc	Phong An Village
2	674.4	ONT	Tran Dinh Sang	Phong An Village
3	256.8	ONT	Phan Ngoc Loi	Phong An Village
4	264.2	LUC	Phan Van Dinh	Phong An Village
5	82.4	ONT	Ho Thanh Tung	Phong An Village
6	132.1	ONT	Ho Van Tha	Phong An Village
7	114.1	ONT	Huynh Thi Nghia	Phong An Village
8	1747.2	LUC	Tran Thi Quy	Phong An Village
9	81.7	ONT	Ho Minh Hoa	Phong An Village
10	241.4	ONT	Huynh Thi Ngoc	Phong An Village
.....				
Total				

After completing the measurement, processing data and editing cadastral map by specialized softwares, the final result we got was 63 cadastral map sheets in scale 1: 1000 and 1: 2000 of Cat Trinh Commune, Phu Cat District, Binh Dinh Province. The map sheets were stored as digital files on a computer and print paper, the total of measured land area is 2138,1723 hectares. This is an important document and useful for the management of state about the land for Cat Trinh Commune as well as the land management agencies at higher levels.

IV. CONCLUSIONS

This theme outlined the process and the method of establishing cadastral map of Vietnam for an area, namely Cat Trinh Commune, Phu Cat District, Binh Dinh Province. It simultaneously showed the method of assessing the accuracy about the concrete targets of the measurement results. By applying the total station method to measure in the field, using the specialized softwares to process data and edit the control network diagrams, we have founded a survey network system including many diagram types with 425 control points. In which, there are 24 high level cadastral points, the measurement errors are guaranteed about the allowed limits. The results of measuring and editing maps, we had 63 cadastral map sheets which consist of 45 sheets map in scale 1: 2000, 18 sheets map in scale 1:1000. Besides, there is a system of statistical tablets for each map sheet and each land use owner. All of them were stored with two types, those are the paper and digital file type. The products above are important documents which help state government about land to registrate the statistics, resolve the land disputes as well as other work on land more easily.

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