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Development of Land Information Maps (PIBT) Through Community Participation Using Quadcopter UAV (Case Study Desa Pojok, Kec. Tawangsari, Kab. Sukoharjo)

Anggoro Wahyu Widodo, Yanto Budisusanto, and Agung Budi Cahyono

Abstract*—The entire of land parcel in Indonesia is estimated 130million. Only about 45million land, parcels or not more than 35% of all is certified. Because of that, Government make a program called PTSL (Systematic Land Registration) to register land parcels within an area of villages. In this case, information is supporting the implementation of PTSL programme. The information formed of subject/object land parcels and with its boundary. Such information is created above the base map obtained from the process of aerial photoshoot using UAV (Unmanned Aerial Vehicle) and the collection of information through the participation of the community (Pemetaan Partisipatif). Location of the research at Pojok Village, Sukoharjo Regency. This research produced a base map formed from process orthophoto, Land Information Maps (PIBT) from Pemetaan Partisipatif and evaluating about area tolerance (KL=±0,5√L) from field measurement and result digitasi. From the results is known the information of subject/object land parcels as well as total of rice field land parcels is 615 parcels (128,598ha) and yards land parcels is 1,443 parcels (69,378ha). This information is useful for the preparation of land registry. In evaluating areas, 39 sampel accepted in area tolerance KL=±0,5√L. So, PIBT considered becomes a Land Parcels Map (PBT).

***Keywords*—**

I. Introduction

The entire of land parcel in Indonesia is estimated 130million according Sofyan Djalil, Ministry of Agraria dan Tata Ruang / Badan Pertanahan Nasional on 2016 [1]. Only about 45million land parcels or not more than 35% of all is certified. From 130 million land parcel, only about 35% or 45 million are certified. According to him, up to 50 years in advance all areas of land in Indonesia cann't yet have a certificate. However, the Ministry of ATR / BPN targets by 2025 all the land has been registered.

Therefore, it is necessary to register the land throughout the territory of the Republic of Indonesia in a systematic and complete or called the program of Systematic Land Registration (PTSL). Complete systematic land registration is a first-time land registration activity conducted simultaneously covering all objects of land registration that have not been registered in one village / kelurahan area or other name of the same level, and also includes mapping all registered land registration objects in order collect and provide complete information on its parcels [2]. In supporting the PTSL program, it is necessary to have the data of the subject and the object of the land in one unit of the administrative area of the village / kelurahan so that the Land Information Map (PIBT) is established [3]. Land Information Map is a map of the results of land mapping activities through community participation in data collection. This map contains information on 1 (one) or more parcels containing the position of the parcels and information about the parcels and the names of the owners or subjects who control such plots [3]. With the development of remote sensing and photogrammetry technology, there is now a variety of supporting tools in PIBT Complete making activities such as High Resolution Satellite Imagery (CSRT), aerial photographs with aircraft rides and aerial photography using Unmanned Aerial Vehicle (UAV) / drone. In this research will be done to make a Land Information Maps with the basic map obtained through photogrammetry mapping with small format photo method using the drone type quadcopter. In order to obtain complete data, the process of identifying and validating boundaries of parcels is done collaboratively with the active participation of the community, local government or other stake holders. By conducting participatory mapping, the community can be controlled by one area with other adjacent fields so that the potential for land conflicts resulting from land boundary disputes or land ownership disputes due to land plotting errors can be minimized.

This research will produce basic map in the form of orthophoto map of Pojok Village, subject data / object of plot area and its boundaries to be used as information base in making Land Information Map (PIBT) and result of PIBT feasibility evaluation to be submitted to Land Parcels Map (PBT). This information from Land Information Map (PIBT) can be used for the preparation of land and space policies. This land and space policy is like an estimate of the number of fields in 1 (one) administrative area of the village / kelurahan which can further be utilized to support the PTSL

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program. While from PIBT that have fulfilled the requirements and standards of Ministry of ATR / BPN can be cited as Land Parcels Map along with information about plot of land.

II. METHODOLOGY

A. Location

The research sites are located in Desa Pojok, Kecamatan Tawangsari, Kabupaten Sukoharjo, Jawa Tengah with geographically coordinated coordinates located at 7º42’49,02”LS dan 110º48’04,59”BT.

Figure1. Location Research in Desa Pojok [4].

B. Data

The data required in this study were obtained from:

1) Map of orthophoto as base map in making land information map. The data consists of aerial photography data using the QuadCopter vehicle / drone Dji Phantom 3 Advanced and GPS measurements with GPS Geodetic Topcon Hiperpro for Ground Control Point (GCP) and Check Point / Independent Check Point (ICP) for accurate map test.
2) Participatory mapping with community / local government in the process of identification and validation of land parcels.
3) Data measurement land parcels.

This study uses aerial photography software, and ArcGIS 10.5 in the processing and making of Land Information Map.

C. Processing Data

Stages of data processing in this study are as follows:

1. Licensing and Preparation

Here is the permission to conduct research on the location because it relates to the land data and involves the community / local government. Preparation here is in making drone fly plan and ground control / Ground Control Point (GCP) and Check Point / Independent Check Point (ICP) points.

2. Measurement of GCP

Ground Control Point (GCP) measurements use a Geodetic type GPS to obtain values from the coordinates of the ground.

3. Aerial Shooting

This stage is the acquisition of aerial photographs using the QuadCopter / drone Dji Phantom 3 Advanced vehicle that is done to get photo data from the research location.

4. Orthorectification

It is a georeferencing stage using GCP coordinate data GPS measurement results by rectifying the object image on the model.

5. Aerial Photo Processing (Making Orthophoto)

Stages of orthophoto manufacture include:

a. Photo alignment
b. Geometry modeling
c. 3D Texture Formation
d. 3D coordinate transform
e. Orthomosaic

6. Collection of Subjects / Objects and Validation of Land Boundaries Through Community Participation

At this stage is also called participative mapping, where digging information about the subject / object land parcels. Subject here means the owner / ruler of the land parcels, may be individuals or legal entities. While the objects are the land parcels belonging to the right to property, the right to use, the right to use the building and the right to use, the land of management rights, the wakaf land or the unregistered.

At this stage people have an important role in data collection. Because local people, especially rural areas will know exactly about the plots of land in the area. The people here can be with local residents as well as with village apparatus. Then identify the boundaries of the plot either directly above the hardcopy of the orthophoto base map that has been obtained or in the computer to adjust the field conditions. After doing the identification, delineation of the soil plots and the subject data from the plots of land.

7. Measuring Land Parcels

Measurements were made on 39 sample areas. Therefor 15 parcels for yards land parcels and 24 parcels for rice field land parcels.

8. Digitization and Making Land Information Map

After collected data of the subject / object and boundary then entry the attribute for the land parcels in ArcGIS 10.5. So that the Land Information Map (PIBT) is generated.

9. Analysis of Results and Conclusions

At this stage, an analysis of orthophoto map making is made to map land information. After the analysis is obtained, it will be drawn conclusions regarding the making of the land information map with conclusion about land information map be a land parcels map.

III. RESULT AND DISCUSSION

A. Flight Plan

Flight plan using pix4d app. The making of this flight path is to plan the flight path of QuadCopter vehicle / drone so that the result of the photo as planned. Here QuadCopter vehicle / drone flies with a height of 150 meters above the research location of 259,335 hectares. Total photos produced 1803 pieces that are divided into 17 flight missions.

B. Result GCP/ICP Measurement

Ground Control Point (GCP) measurements were carried out at 10 points spread in the village of Pojok. This GCP measurement uses GPS Geodetic with static method. In this measurement the base used is CORS Solo (CSLO). Duration of each observation session is done for ± 30 minutes. The data used in this research are planimetric coordinate data (X, Y). The following is the distribution of GCP Points:

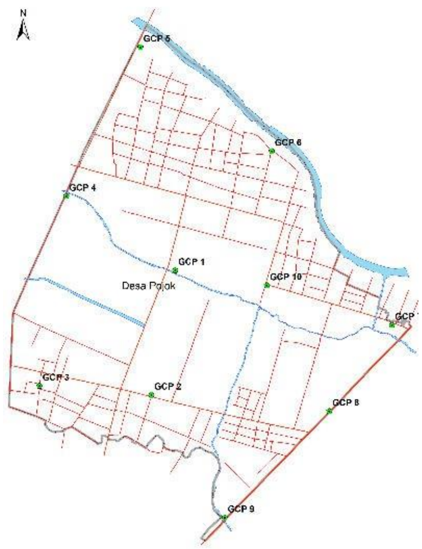

Figure 2. GCP Point Spreads.

TABLE 1.
COORDINATE GCP POINTS

Name	X (m)	Y (m)	Z (m)
GCP 1	477759,098	9147021,460	252,109
GCP 2	477642,115	9146406,279	252,742
GCP 3	477091,240	9146451,431	251,201
GCP 4	477222,128	9147386,550	251,988
GCP 5	477587,362	9148120,915	252,048
GCP 6	478234,282	9147608,023	253,105
GCP 7	478826,127	9146750,648	253,37
GCP 8	478517,809	9146326,269	253,638
GCP 9	478002,789	9145801,849	254,454
GCP 10	478210,497	9146946,437	253,297

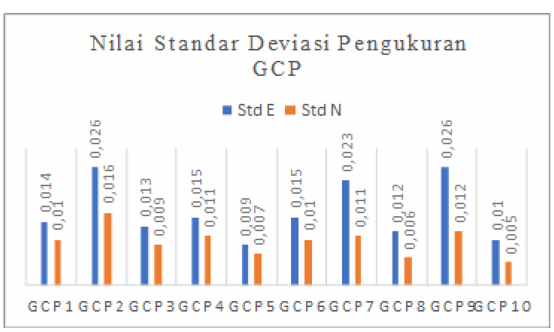

Figure 3. Standard Deviation Coordinate GCP Points.

From Figure 3 it can be seen that the largest standard deviation value is on GCP 2 and GCP 9 with a value of 0.026 and the smallest standard deviation value is on GCP 10 with a value of 0.005.

TABLE 2.
COORDINATE GCP POINTS

Name	X (m)	Y (m)	Z (m)
ICP 1	478223,940	9146457,818	252,086
ICP 2	477747,945	9146380,015	251,671
ICP 3	477604,018	9146734,652	250,745
ICP 4	477497,604	9146439,673	252,862
ICP 5	477040,594	9146981,802	249,942
ICP 6	477429,400	9147819,043	251,623
ICP 7	477920,798	9147861,861	252,571
ICP 8	477819,985	9147379,387	252,583
ICP 9	478192,517	9147278,285	252,374
ICP 10	478486,568	9146873,775	252,465
ICP 11	478645,615	9146475,274	253,183
ICP 12	478268,696	9146114,914	253,176

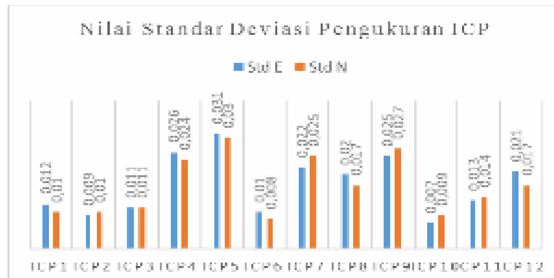

Figure 4. Standard Deviation Coordinate GCP Points.

From Figure 4 it can be seen that the largest standard deviation value is on ICP 5 with a value of 0.031 and the smallest standard deviation value is on ICP 10 with a value of 0.007. The coordinates data from GCP which are 10 points are used in the georefencing process on the photo model, while for the 12 points of ICP coordinate data will be used as the comparative point in the process of planimetric accuracy test.

C. Geoferencing

In this process is to provide the coordinates of the measurement results into the model that still coordinates the image.

TABLE 3.
RMS ERROR SHIFT ON GEOREFERENCING PROCESS

Name	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP 1	0.878	-0.459	-1.178	1.539	0.961 (26)
GCP 2	-4.619	1.561	-2.639	5.544	0.772(3)
GCP 3	-0.276	-3.148	-0.617	3.22	0.942(12)
GCP 4	2.505	-3.104	4.217	5.805	0.983(10)
GCP 5	3.294	-3.109	2.71	5.309	0.988(20)
GCP 6	2.619	3.738	2.711	5.309	0.988(20)
GCP 7	2.469	3.716	-0.151	4.464	0.996(36)
GCP 8	-1.976	2.226	1.732	3.444	0.888(24)
GCP 9	-3.197	0.599	1.895	3.765	0.991(17)
GCP 10	-2.631	3.085	-5.537	6.862	0.978(21)
Total	2.708	2.729	2.808	4.761	0.936

From Table 3 above shows that the largest control point RMSE at point GCP 10 equal to 6,862cm and RMSE the smallest control point that is at point GCP 1 equal to 1,539cm.

D. Result Orthophoto

The formation of orthophoto is through several stages, such as: Alignment Photo, Dense Cloud formation, Mesh formation, Texture formation, and Orthomosaik. Here are the results orthophoto Pojok Village, Kec. Tawangsari, Kab. Sukoharjo:

Figure 5. Result Orthophoto.

E. Coordinate ICP Model and Field Measurement

Independent Check Point (ICP) is used in accuracy testing of Ground Control Point (GCP). This accuracy test is obtained from the difference of coordinate ICP Model with coordinate ICP field. The largest difference in the coordinates X is at point ICP 6 of -0.631 m and at the coordinates Y is at the point ICP 3 of 0.577 m.

TABLE 4.
COORDINATE ICP MODEL AND COORDINAT ICP FIELD MEASUREMENT

Nama	Koordinat ICP Model		Nama	Koordinat ICP Lapangan	
	X (m)	Y (m)		X (m)	Y (m)
ICP 1	478223,953	9146457,798	ICP 1	478223,940	9146457,818
ICP 2	477747,997	9146380,053	ICP 2	477747,945	9146380,015
ICP 3	477604,002	9146734,644	ICP 3	477604,018	9146734,652
ICP 4	477497,684	9146439,569	ICP 4	477497,604	9146439,673
ICP 5	477040,482	9146981,715	ICP 5	477040,594	9146981,802
ICP 6	477429,466	9147818,946	ICP 6	477429,400	9147819,043
ICP 7	477920,741	9147861,961	ICP 7	477920,798	9147861,861
ICP 8	477820,095	9147379,429	ICP 8	477819,985	9147379,387
ICP 9	478192,639	9147278,202	ICP 9	478192,517	9147278,285
ICP 10	478486,586	9146873,815	ICP 10	478486,568	9146873,775
ICP 11	478645,598	9146475,372	ICP 11	478645,615	9146475,274
ICP 12	478268,743	9146114,888	ICP 12	478268,696	9146114,914

F. Planimetric Accuracy Test

To perform a planimetric accuracy test, the result of the difference of each ICP coordinate model with ICP field then calculated RMSEr by the formula:

$$RMSEr = \sqrt{\frac{\sum D(X_{model} - X_{lapangan})^2 + \sum D(Y_{model} - Y_{lapangan})^2}{n}} \quad (1)$$

From the calculation obtained RMSEr value of 0.099901 meters. Accuracy standards according to NMAS (National Map Accuracy Standard) are as follows:

$$Horizontal\ Accuracy\ NMAS = 1{,}575 * RMSEr \quad (2)$$

So, the resulting value of 0.151599 meters for horizontal accuracy test. Then tested the results as follows:

TABLE 5.
TESTING CE90 FOR MAP ACCURACY SCALE 1:1000 [5]

Ketelitian	Hasil Uji	Ketelitian Peta Skala 1:1000		
	CE90 (m)	Kelas I	Kelas II	Kelas III
Horisontal	0,512	0,2	0,3	0,5

G. Subject / Object Collection and Land Boundary Validation Through Community Participation

Collection subject / object of land parcels and validation or so-called participative mapping here directly done with the community on hardcopy orthophoto base map that has been obtained from the previous process. In collecting this data for rice field information subject / object land parcels and validation obtained through farmer groups. For residential areas information subject / object land parcels and validation obtained through local communities and local village government.

Figure 6. Participative Mapping with Local Village Government.

In Figure 6, in the collection of land data in the form of subject / object of land parcels and validation of the boundary is done with the local village government.

H. Digitization and Making of Land Information Map

Digitization is done on ArcGIS 10.5 software. In the research village, in general the area is only divided into residential areas with a total field of 1.443 fields and rice fields with a total field of 615 fields.

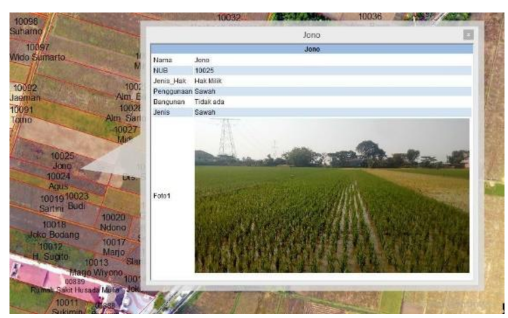

Figure 7. Land Parcels with its information.

From Figure 7 can be known about the information from the land parcels. The information is the name of the owner, NUB (Field Number), Type of Rights, use of field, field condition (contained building or not), type of field (rice field / yard) and photograph the condition of the location of the field.

I. Measurement Land Parcels

Measurement of parcels using tape measure above the land parcels owned by local residents / villages. For the measured, include rice fields parcels and land yards parcels with a total sample of 39 fields. Rice fields yards parcel and land yards parcels with no buildings on it measured the sides and diagonals, whereas if there is a building on it then the measured sides and triangles at each corner to be used as a reference in the depiction to be produced diagonally. Broad calculations use the principle of the lengths of the sides of the triangle.

Figure 8. Measuring with Local Government (Pak Bayan).

J. Analysis of Measurement Land Parcel with Digitized Result

Testing standards for planimetric area accuracy are guided by Regulation of the Peraturan Menteri Negara Agraria / Kepala Badan Pertanahan Nasional Nomor 3 Tahun 1997 tentang Pedoman Teknis Ketelitian Peta Dasar Pendaftaran.

The first step in testing this widespread accuracy is to calculate the wide difference between the area on the orthophoto with the actual area in the field. The width is the area of 39 samples of land taken. Then the wide difference is tested using the fault tolerance formula as follows:

$$KL = \pm 0.5\sqrt{L} \quad (3)$$

TABLE 6.
RESULT SAMPEL OF LAND PARCEL FOR PLANIMETRIC AREA ACCURACY

Area Accuracy	Land Parcels	Accepted	Rejected
±0.5 √L	Rice Field Parcels	24	0
	Yard Field Parcels	15	0
	Total	39	0

The accuracy of the area of land parcels is calculated by finding the area difference of a land parcels using two methods. Where one method is used as reference benchmark and assumed to have better accuracy. Based on the Peraturan Menteri Negara Agraria/ Kepala Badan Pertanahan Nasional No.3 Tahun 1997 tentang Ketentuan Pelaksanaan Peraturan Pemerintah No.24 Tahun 1997 tentang Pendaftaran Tanah area accuracy tolerance, the result of the resulting analysis can be seen in Table 7.

TABLE 7.
RESULT OF TOLERANCE FAULT PMNA/NO.3/1997 WITH ITS SAMPEL LAND PARCELS

Land Parcels	Accepted	Rejected	Tolerance (%)
Rice Field Parcels	24	0	0
Yard Field Parcels	15	0	0
Rice Field Parcels	24	0	0
Yard Field Parcels	15	0	0

From the Table 6 and Table 7, known all sampel from rice field land parcels and yards land parcel are accepted in tolerance fault area (KL= ± 0.5 √L), tolerance fault 10% and tolerance fault 4%. So, PIBT considered becomes a Land Parcels Map (PBT).

IV. CONCLUSION

1. A map of the aerial photographer has been constructed using drone type quadcopter as a base map for Land Information Map (PIBT) having a horizontal precision (CE90) base map on a scale of 1: 1000 in class 1.
2. Data collection to obtain the subject / object of land and validation involves participation from the community of 14 people, 3 of which are village apparatus and 11 others are local residents. Data subject of land parcels related to the owner's name, type of rights, use of plot of land as well as the type of plot of land (rice field / yard). As for the data object of the field of land in the form of spatial data from the plot of land.
3. Land Information Map (PIBT) that has been created is dominated by rice fields with a total area of 128.597 hectares consisting of 615 parcels of land and residential areas with a total area of 69,378 hectares consisting of 1,443 fields.
4. On the wide-ranging testing of planimetric accuracy carried out on 39 samples, all samples met or received within the wide error tolerance (KL = ± 0,5√L based on Regulation of the Minister of Agrarian Affairs / Head of the National Land Agency Number 3 of 1997 on Technical Guidelines for the Thoroughness of Map Basic Registration) with the smallest difference in the area of 947.54 m2 of 0.17 m2 with tolerance of ± 15.39 m2 and the largest difference in the area of 1831.84 m2 of 3.34 m2 with tolerance of ± 21.40 m2 for the plot rice fields. For the smallest plot of land, the width of the yard is 361,97 m2 with 0,21 m2 with tolerance of ± 9,51 m2 and the biggest difference in area of 349,57 m2 is 1,29 m2 with tolerance ± 9,35 m2. In fault tolerance 10% and 4% all sampel also accepted, because all the tolerance fault result <1%. So, PIBT considered becomes a Land Parcels Map (PBT).

APPENDICES

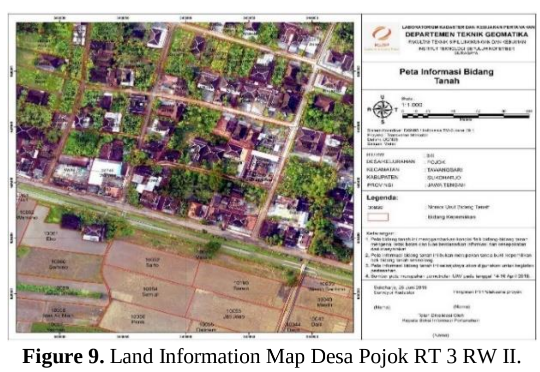

Figure 9. Land Information Map Desa Pojok RT 3 RW II.

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