Geometric Accuracy Assessment of Land Registration Maps for Supporting the Program of Systematic Complete Land Registration Using QuickBird Satellite Imagery

Deviantari, U. W.[1] and Cahyono, A. B.[2]
Department of Geomatic Engineering, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia
E-mail: dianada87@gmail.com,[1] agungbudicahyo@gmail.com[2]

Abstract
Based on the Regulation of the Ministry of Agrarian Indonesia No. 3 of 1997 article 12 paragraph 1 states the measurement and mapping for the manufacture of registration base maps is carried out by terrestrial, photogrammetric or other methods. Other data used in the study are with spatial resolution of 0.6 meters and 2.4 meters in panchromatic band and multispectral bands, respectively. By using of Quickbird imagery, geospatial information for complete land administration purposes is built faster terrestrial methods. Data processing is carried out by the CE90 accuracy test process in accordance with Perka BIG Number 15 of 2014. The comparation of the distance measured in the field and in the satellite imagery was also conducted and statistical t-test was adopted to investigating the significant difference between these two measurements. The results of this study indicate that the standard deviation value obtained from the distance measurement in the field shows large planimetric accuracy which is equal to 0.245 meters with 17 samples of object. This planimetric accuracy value meets the scale of 1: 1000, the tolerance is greater or equal to 0.3 mm on the map scale. The value of horizontal accuracy is 0.725 meters according to the maximum value of CE90. Based on the regulations issued by the Minister of Agraruan Affairs, Indonesia, Quickbird satellite imagery is an alternative method that can be used for making a registered base map scale of 1:25000 and 1:10000 because the accuracies derived from the satellite imagery meet the requirement given by the The Implementation Of Government Regulation No.24/1997.

1. Introduction

Land administration is the processes of determining, recording and disseminating information about the tenure, value and land use when implementing land management policies. The land administration system is a basic foundation for the spatial enablement of a society it includes land registration, cadastral surveying and mapping, fiscal, legal and multi - purpose cadastres and land information systems (UNECE, 1996). Based on the Regulation of the Ministry of Agrarian Indonesia No. 3 of 1997. The land registration map is a map that describes land or fields for land accounting purposes. The basic map of land registration is the basic map that used for making land registration maps which contain basic technical points and geographical elements. Preparation of base maps to support land administration activities by means of terrestrial and photogrammetric do not cover all of Indonesia. Because there are many unregistered plots of land and technical base points that have not yet been installed, which should be a binding point for detailed measurements of these plots of land.

Land registration map is the map that describes land or fields for land accounting purposes. The basic map of land registration is a basic map for making land registration maps that contain basic technical points and geographical elements. Based on Regulation of the State Minister for Agrarian and Spatial Planning/Head of the National Land Agency No. 6/2018 concerning the program of Systematic Complete Land Registration is the land registration process for the first time carried out simultaneously and it includes all objects of registration of land that has not been registered in a village area or other names of the same level. Through this program, Indonesian government provides a guarantee of legal certainty or land rights owned by the community. The development of high-resolution satellite image technology such as Quickbird Satellite Imagery which has a resolution of up to 0.6 m makes it easy to integrate basic land maps for existing land registration. By using high resolution satellite imagery for complete land administration needs, more rapid development will occur.

In providing a basic data map for land registration, real coordinates are needed with the appropriate method in order to achieve high geometric accuracy. Gresik Regency is one of the centers of economic growth in East Java. Gresik regency is a buffer zone of Surabaya Regency which has a high level of economic growth and it is also one of the economic buffers of East Java in the future (Yusuf, 2016). A high level of growth is needed by a complete, good and right arrangement of land administration. So that land administration is perfectly completed, good and right.

By using high-resolution satellite imagery, geospatial information for completing the land administration purposes will be built faster than terrestrial methods. Wotan Gresik Village is one of the villages chosen as a pilot project for integrated land administration services in Indonesia. All land parcels in Wotan Village were carried out for mapping but there are still many land parcels that have not been certified (Mahmudah and Meirinawati, 2017). Land administration program was adopting for determining the land boundaries that belong to villagers. This limitation is based on a proven and accurate base map. In the fulfilment of the program, an accurate basic map which obtained by a fast method is required, and the satellite imagery should be an alternative way for making a base map. The data study aims to find out and evaluate the basic maps in derived from high resolution satellite imagery to be used in land administration purposes based on The Implementation of Government Regulation N0.24/1997 about Land Registration in supporting the Indonesian government program.

2. Methodology and Data Analysis

2.1 Study Area

The study area located in this research is in Wotan Village, Paceng District, Gresik Regency Indonesia. The geographic location of Gresik Regency is between the latitude of 6°49′S to 7°24′S and the longitude of 112°22′E to 112°40′E. The data used in the study were high resolution satellite imagery of Gresik Regency the horizontal control points and the data obtained from the National Land Agency office in Gresik Regency, East Java Province (Figures 1)

2.2 Pan-Sharpening Satellite Imagery

The spatial resolution of satellite imagery can be increased by Pan-Sharpening technique. This technique is carried out to sharpen the spatial resolution of features depicted in high resolution satellite imagery. Resulting increase the amount of information that can be interpreted visually (Siwi, 2014). This technique is done by combining panchromatic band with a resolution of 0.6 meter and multispectral bands with spatial resolution of 2.4 meters. The output of pan sharpening is an imagery with 0.6 meter spatial resolution. Image cutting is carried out in accordance with the scope of the study area. The distribution of control points must be considered according to the specified conditions

2.3 The Strength of Figure (SoF)

The geometric strength of a good triangular network is determined by the small SoF value ensuring even accuracy in the entire network. The lower the SoF values, the better the strength of network. The SoF is determined by the following equation.

$$SoF = \frac{\{(trace)A^T.A\}^{-1}}{U}$$

Equation 1

Where SoF= Strength of Figure, A= Design Matrix, U= A number of redundants. The values of each parameter for calculating the SoF shown in Table 1, and the locations of the points in the network illustrates in Figure 3.

Table 1: The Calculation of the strength of figure (SoF)

Number of Points	**9 Points**
Total Baseline	17 Baseline
Number of size (N-size)	34
Number of Parameters (N-Parameters)	14
U= (N-size) - (N-Parameters)	20

The value of SoF is 0.381. The value of SoF has met the required tolerance of less than 1, so the design of the SoF network is considered strong (Andina and Taufik, 2015).

2.4 *Geometric Correction*

According to Mather (1987), geometric correction is the transformation of remote sensed imagery. Image geometric correction is the purpose of registering images to maps or transforming of coordinate image systems to maps, which produce images with certain projection systems (Purwadhi, 2001). Geometric correction is implemented in order to improve image quality. Geometric correction was carried out by setting up ground control point data (GCP) obtained from the National Land Agency. The number of GCP was 9 points distributed throughout the study area (Figure 4). The position of GCP (Ground Control in the satellite imagery) must be the same as the actual position in the field. Therefore, in here, high resolution imagery was used. In the process of geometric correction, of the 1st order polynomial geometric correction method (Affine transformation) was adopted. The Root Mean Square Error (RMSE) calculation is intended to determine accuracy of Geometric correction. RMSE calculation results must be ≤ 1. The smaller the result of RMSE, the better the accuracy (Parmadi et al., 2016).

Figure 1: Wotan Village in Gresik Regency

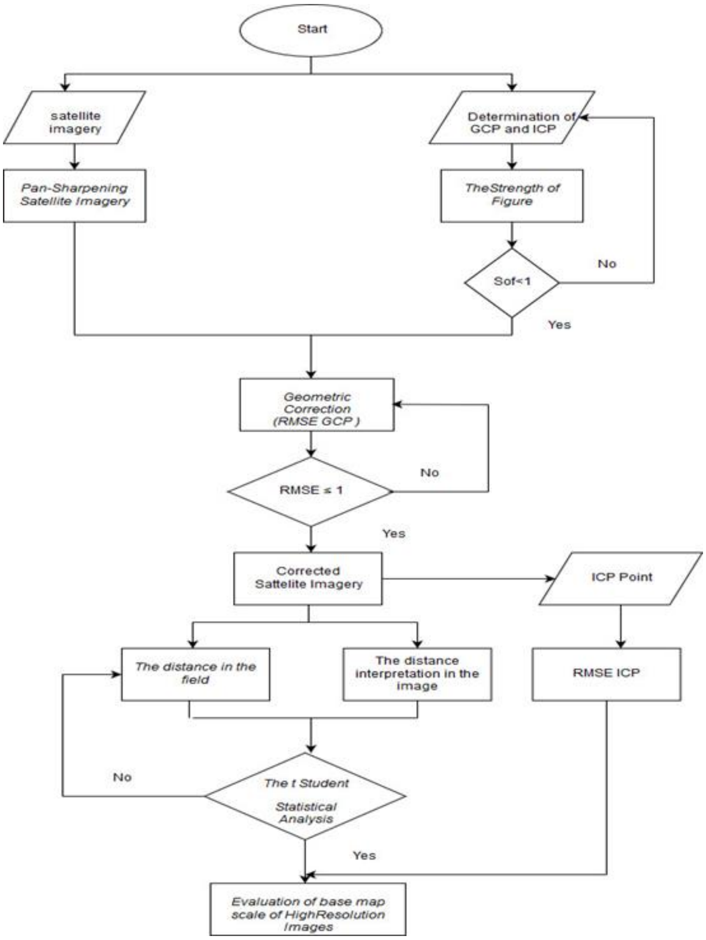


Figure 2: Research Flowchart

Table 2: The results of RMS error

No	**Ground Coordinate (m)**		**Satellite Imagery Coordinate (m)**		***Predict* (m)**		***Error^2***		**RMS *Error***
	x	**y**	**x**	**y**	**x**	**y**	**X^2**	**Y^2**	
1	194606.20	739496.60	16418.35	1178.53	16417.99	1178.59	0.130	0.004	0.365
2	192972.30	733273.00	13673.70	11598.50	13674.16	11598.34	0.212	0.026	0.487
3	188974.50	727055.70	6966.38	22006.69	6966.26	22006.63	0.014	0.004	0.134
4	195163.80	730730.40	17345.40	15854.58	17346.02	15854.74	0.384	0.026	0.640
5	201924.10	724826.80	28676.83	25739.41	28676.51	25739.08	0.102	0.109	0.460
6	200657.20	734879.30	26557.81	8907.71	26557.43	8907.19	0.144	0.270	0.650
7	188714.60	729563.80	6533.28	17807.97	6533.13	17808.14	0.023	0.029	0.227
8	202639.90	730287.20	29878.45	16595.23	29878.96	16595.99	0.260	0.578	0.915
9	196908.50	725719.20	20267.81	24244.63	20267.56	24244.56	0.063	0.005	0.260
						Total	1.332	1.049	0.460

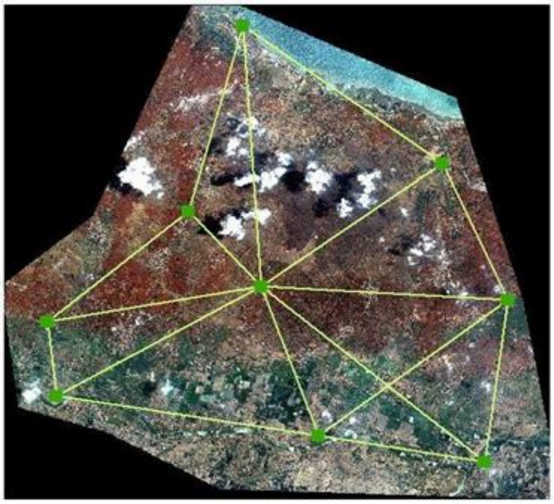
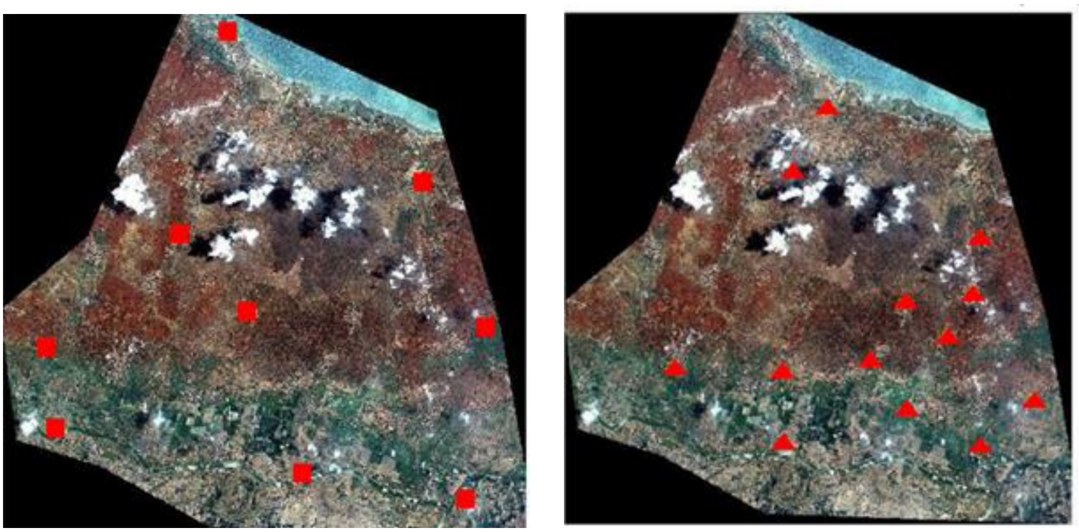


Figure 3: Strength of figure desain



a) b)

Figure 4: Distribution of GCPs (a), Distribution of ICP (ICPs)

RMSE is a parameter used to evaluate the value of the results from observations / measurements of actual values or values that are considered true (Table 2). The amount of RMSE in the two-dimensional field is as follows:

$$RMSE = \sqrt{RMSx^2 + RMSy^2}$$

Equation 2

Where:
RMSE = the standard deviation of the residuals
RMSx = Average squared residuals in X direction
RMSy = Average squared residuals in Y direction

RMSE generated from 9 GCPs spreads evenly in the study area of 0.460 which has met the given tolerance of ≤ 1pixel. Positioning accuracy test refers to the difference in coordinates (X, Y, Z) between the test points on the map and the actual coordinate of the points on the ground surface of the soil. The RMSE of ICP value aims to see whether an image is suitable to be used for further processing (Table 3). To determining the maximum scale of the image for making thematic maps, the circular circle of 90% was set (Apriyanti et al., 2017).

2.5 Distance and Area Measurement in the Field
It is necessary to compare the distances as well as areas measured in the field and the distances and areas satellite imagery that will later be needed in determining planimetric accuracy. In order to determine distances and areas in the image, digitization was performed in the object which is easy to be interpretedThe distances and areas in the field were measured by using measurement tape. In this study, 17 objects of distance measurement of land parcel were measured.

2.6 Statistical Test
T-test is a statistical analysis technique used to compare average values of two dataset. Test whether certain values differ significantly or not with the average of a sample. The t-test is appropriate for the sample size lower than 30. The determination of t-test is illustrated in equation below (Blank, 1982):

$$x_1 = \mu - ((t_n, \frac{1}{2\alpha} * \sigma v)/\sqrt{n}$$
$$x_2 = \mu + ((t_n, \frac{1}{2\alpha} * \sigma v)/\sqrt{n}$$

Equation 3

Where:
x_1 = lower measurement value
x_2 = upper measurement value
μ = mean
α = *level of significance*
σv = standard deviation
n = number of samples – 1

Statistically it is stated that Ho (*the null hypothesis is a type of hypothesis used in statistics that proposes that no statistical significance exists in a set of given observations*) is accepted if the calculation results are at –t < X < t with certain degrees of freedom.

2.7Evaluation of Base Map Scale
The evaluation is carried out by calculating the scale of the map numerically based on a comparison between the values of horizontal accuracy by standardizing the accuracy of the map specified. Provisions for the accuracy of geometry map of Indonesian Topography Map on the Regulation of the Head of Geospatial Information Agency No. 15 of 2014 suggests the technical guidelines for accuracy of basic map as shown in Table 4. The Circular Error 90% (CE90) is a measure of horizontal geometric accuracy which is defined as a radius of a circle which indicates that 90% of the error or difference in horizontal position of an object on a map with a position that is actually considered is not greater than that radius. The base map position error does not exceed the accuracy value with a confidence level of 90%. The value of 90% is a large amount of trust which from the total amount of data that has been agreed upon. The CE90 value can be obtained by the equation referring to the USNMAS (United States National Map Accuracy Standards) as follows:

$$CE90 = 1.5175\ x\ RMSE_r$$

Equation 4

Where: RMSEr: *root mean square error* for x and y (horizontal)

3. Results and Discussion

3.1 Geometric Accuracy Analysis
The number of test points is 13 according to the provisions given by the Geospatial Information Agency (BIG) for the coverage area of the study <250 km^2, which is a minimum of 12 points. Horizontal Accuracy values are obtained using CE90 which is calculated from the RMSE value of image resolution after geometric correction. Horizontal accuracy value with a level of confidence is at the level of 90% (Geospatial Information Agency, 2014).

Table 3: The results of ICP Point

No	ICP Point	ICP Coordinate (GPS) (m)		ICP Coordinate (Interpretation) (m)	
		X_GPS	Y_GPS	X_Citra	Y_Citra
1	CP1	195894.940	737064.320	195894.934	737063.927
2	CP2	194870.460	735102.500	194870.728	735102.023
3	CP3	200960.470	733023.640	200960.166	733023.307
4	CP4	200661.560	731224.310	200661.698	731224.737
5	CP5	198319.390	730756.220	198319.827	730756.374
6	CP6	190931.440	728758.990	190931.692	728758.487
7	CP7	194461.970	728534.900	194462.299	728534.568
8	CP8	197450.990	728913.850	197451.364	728913.445
9	CP9	199771.130	729725.530	199771.320	729725.273
10	CP10	194517.270	726241.960	194517.220	726241.417
11	CP11	198469.670	727271.260	198469.509	727271.458
12	CP12	200979.570	726092.800	200979.068	726093.076
13	CP13	202618.970	727723.670	202618.595	727723.774

Table 4: Classification of Map Geometry Accuracy of RBI (Head of Geospatial Information Agency, 2014)

No	Scale	**Map Accuracy of RBI**		
		Class 1	**Class 2**	**Class 3**
		CE90 (m)	**CE90 (m)**	**CE90 (m)**
1	1 : 1.000.000	200	300	500
2	1 : 500.000	140	150	250
3	1 : 250.000	50	75	125
4	1 : 100.000	20	30	50
5	1 : 50.000	10	15	25
6	1 : 25.000	5	7.5	12.5
7	1 : 10.000	2	3	5
8	1 : 5.000	1	1.5	2.5
9	1 : 2.500	0.5	0.75	1.25
10	1 : 1.000	0.2	0.3	0.5

The result of ICP RMSE value at 13 test points is 0.469 meters. This value shows the magnitude of the average error of all interpretations from the test point. The value of horizontal accuracy is 0.725 meters which indicates the magnitude of the error or the difference in the horizontal position of the object on the map with the position considered to be actually not greater than the radius (Table 5).
Where:

$$\text{RMSEr (13CP)} = \sqrt{\Sigma(X_{GPS} - X_{CP})^2 + (Y_{GPS} - XY_{CP})^2 / \Sigma\text{point}}$$

Equation 5

3.2 The t Student Statistical Analysis

The t Student statistical analysis is obtained from the results of distance measurements in the field with distance interpretation measurements (Blank, 1982). There are 17 plots of land measured in Wotan Village.T-test Student method uses a confidence level of 95% with a level of significance (α = 5%)and a degree of freedom of 16, so the value from the student's t-test table, t = t_2: 0.025 = 4.303.

The statistical test process of the t-test method resulted in the received values from 17 distance measurement experiments, but 1 experiment was rejected so that the data was considered as blunder and was not used for the next process. This is happened possibly due to the length of the object distance measurement is relatively too short so that the process of identification and interpretation becomes more difficult. By using t-test student method, *Ho* will be accepted if $X_1 < X < X_2$ (Table 6).

Table 5: The calculation results of horizontal accuracy of satellite images

ICP Point	Distance between ICP (GPS) with ICP (Interpretation) (m)	$(X_{GPS} - X_{cp})^2 + (Y_{GPS} - Y_{cp})^2$ (m)
CP1	0.393	0.155
CP2	0.547	0.299
CP3	0.451	0.204
CP4	0.449	0.201
CP5	0.463	0.214
CP6	0.562	0.316
CP7	0.467	0.218
CP8	0.552	0.304
CP9	0.320	0.102
CP10	0.545	0.297
CP11	0.255	0.065
CP12	0.573	0.328
CP13	0.389	0.151
Total (13CP)		2.856
Average (13CP)		0.459
RMSE (13CP) (m)		0.469
CE90 (13CP) (m)		0.739

Table 6: The results of the t-student statistical with α = 5%

Name of Land Parcel	Distance Image (avg) (m)	Distance Field (m)	x1 (m)	x2 (m)	*Ho*
D02	29.459	29.540	28.102	30.978	Accepted
D03	57.075	56.850	56.303	57.397	Accepted
D04	50.608	50.330	49.492	51.168	Accepted
D05	67.549	67.310	66.983	68.637	Accepted
D06	27.799	27.510	26.369	28.651	Accepted
D07	68.557	68.350	67.317	69.383	Accepted
D09	69.325	69.030	68.192	69.868	Accepted
D10	68.596	68.360	67.630	69.090	Accepted
D12	29.278	29.650	29.035	30.265	Accepted
D13	11.632	11.340	10.646	12.034	Accepted
D14	22.290	22.380	21.513	23.247	Accepted
D16	24.447	24.500	24.034	24.966	Accepted
D17	21.757	22.010	21.205	22.815	Accepted
D18	31.987	31.710	30.726	32.694	Accepted
D20	7.959	9.380	8.122	10.638	Rejected
D22	45.472	45.180	43.475	46.885	Accepted
D23	43.719	43.520	42.533	44.507	Accepted

Table 7: The distance differences between in the field and image interpretation

No	Name of Land Parcel	Distance Image (m)	Distance Field (m)	ΔD (m)
1	D02	29.459	29.540	0,081
2	D03	57.075	56.850	-0,225
3	D04	50.608	50.330	-0,278
4	D05	67.549	67.310	-0,239
5	D06	27.799	27.510	-0,289
6	D07	68.557	68.350	-0,207
7	D09	69.325	69.030	-0,295
8	D10	68.596	68.360	-0,236
9	D12	29.278	29.650	0,372
10	D13	11.632	11.340	-0,292
11	D14	22.290	22.380	0,090
12	D16	24.447	24.500	0,053
13	D17	21.757	22.010	0,253
14	D18	31.987	31.710	-0,277
15	D22	45.472	45.180	-0,292
16	D23	43.719	43.520	-0,199

Table 8: Class 2 of standard value

Accuracy	Class 1	Class 2	Class 3
Horizontal	0,2 mm x scale	0,3 mm x scale	0,5 mm x scale

Accuracy	Horizontal Accuration Test	Class 2 of Standard Value		
		1 : 1000	1 : 2500	1 : 10000
Horizontal	0.725	0.3 m	0.75 m	3 m

Information:

▭ : The standard value of accuracy that has been fulfilled

3.3 Results of Distance Measurement

The results of distance measurements in the field compared to the results of the distance interpretation in the image then obtained the standard deviation from the results of the distance measurements made (Table 7). The following is the value of standard deviation from distance. From the table above shows the magnitude of the differences of distance measurement in the field and the satellite imagery. The difference value obtained from each distance measurement shows that the smallest difference in distance because the measurement was performed on the side of the building object so that it is easy to do the interpretation process and measure the distance in the field. Whereas for the D12 object contains the largest distance difference value because the object is covered by vegetation so that the large difference occurred, especially when measuring distance in the field. The range of the difference between distances measured in the field and in satellite imagery is -0.295 to 0.372 meters.

3.4 Evaluation of Base Map Scale of High Resolution Images

Distance measurement, the value of planimetric accuracy was obtained from standard deviation which is 0.245 meters. This planimetric accuracy value meets the scale of 1: 1000, the tolerance given is greater or equal to 0.3 mm on the map scale. For the results of calculating geometry accuracy on the base map of land registration using 17 GCP test points, there are in class 2 (according to Table 4). The following are the results of the calculation (Table 8).

Based on the equation 4, the maximum accuracy that must be met for the horizontal accuracy test is 0.725m, so that the horizontal accuracy test value in the satellite imagery is in accordance with the accuracy standard. For geometric accuracy on the base map (Quickbird) has met the standards on a scale of 1: 2500. The results of this study are in accordance with the Regulation of The State Minister of Agrarian Affairs No. 3/1997 Provisions on The Implementation of Government Regulation N0.24/1997 About Land Registration in Article 17, Basic Map Land registration can be made by fulfilling the requirements of the map having a scale of 1: 1000 for urban areas, 1: 2500 for agricultural areas and 1: 10000 for plantation areas.

4. Conclusion

The results of geometric calculations show that horizontal accuracy of the use of image data as a base map using 17 samples points obtained horizontal accuracy values of 0.725 meters. The value of planimetric precision fulfills the inside 1: 2500, where the amount of tolerance given is greater than or equal to 0.3 mm on the map scale. This study shows that QuickBird satellite imagery can be used as a basemap in the Land Registration Maps used in Program of Systematic Complete Land Registration with the scale of 1:2500 according to The Implementation of Government Regulation N0.24/1997 about Land Registration

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