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Horizontal Accuracy Assessment of Rectified Map, Case Study: Map of Boundary Areas of Konak Forest at Rejang Lebong Regency, Bengkulu Province

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Abstract
Spatial archives in the form of analog maps still encountered in several work units, however, as times progressed, the quality of these maps decreased in terms of the materials used which could affect their accuracy. There are several techniques used in converting from analog to digital maps, including scanning technique, and a unification coordinate system with the rectification method. This study aimed to find out the horizontal accuracy and the accuracy class of rectified maps. The data used was an analog map of a map of the boundary demarcation of the Konak Forest area, Rejang Lebong Regency scale 1:1000. The analog map was produced more than 30 years ago. The steps carried out in this study were preparing data from scanning analog maps, setting coordinate systems, input GCP, control rectification, calculating RMSE and CE values, analyzing, digitizing, layout. The result of the rectification map shows the use of 4GCP produces the best value with RMSE 0.14m and CE90 0,20 and the horizontal accuracy is class 1 on a scale of 1:1000. 6GCP produces RMSE 0.5m and CE90 0.75 and the horizontal accuracy is class 3 on a scale of 1:2500. 10GCP produces RMSE 0.6m and CE90 0.95 and the horizontal accuracy is class 3 on a scale of 1:2500.

Keywords: hoizontal accuracy, C90, RMSE, rectification

1. Introduction

The existence of archives or important documents of the past in the form of maps that are still in hardcopy form and sometimes we still find. However, as time goes on, the quality of the document will decrease. Digital technology that is increasingly developing makes it easy for us to convert analog to digital maps quickly [1,2]. One of the advantages of digital maps is that the quality of the document remains good or does not change.

There are several ways to convert analog maps to digital, one of which is through the scanning process, and to equalize the coordinates on the analog map to a digital map, rectification is carried out. In this study, the rectification was applied to the map of the Inauguration of the Forest Area of HL Konak, Rejang Lebong Regency. The map is an archive of the Ministry of Forestry made in the 1990s which is still in hardcopy.

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At the rectification stage, the coordinates of the analog map are needed as input. To determine the accuracy of the rectified map against analog maps, it is necessary to asses the accuracy [3]. The accuracy in this study is a horizontal accuracy assesment regarding to the regulation of the head of the Geospatial Information Agency (BIG) Number 15 of 2014 concerning Technical Guidelines for Base Map Accuracy.

The values used in the horizontal accuracy analysis are RMSE and CE 90. This RMSE value describes the difference between points on the rectified map and points on analog maps, the lower the RMSE value, the smaller the difference [4]. Circular Error (CE 90) is a measure of horizontal geometric accuracy which is defined as the radius of a circle which indicates that 90% of the error or difference in the horizontal position of objects on the rectified map with the position on the analog map is not greater than that radius.

The purpose of this study was to find the horizontal accuracy and the horizontal accuracy class of the rectified map base on variations of 4 GCP, 6GCP and 10 GCP.

2. Materials and Methods

2.1 Map Data

Rectification is using data from analog map scanning (Map of Forest Area Boundaries of Konak, Rejang Lebong Regency in 1990). The rectification is using 4GCP, 6GCP, 10GCP.

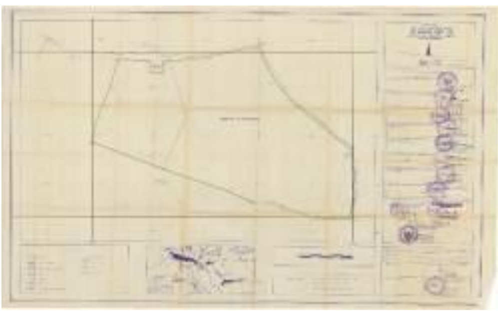

Figure 1. Scanned Map

2.2 Theory

2.2.1 Analog Map

Printed maps are analog maps, a map plotted on media, such as paper or mylar [2]. The analog map is known as conventional map. An analog map is a map is in printed form. In general, an analog map is made using cartographic techniques so that it already has spatial references such as coordinates, scale, cardinal directions, and others. Usually analog map is represented in vector format [5].

2.2.2 Conversion Analog to Digital Map

Data conversion is changing data from one form to another [2]. The equipment used to convert analog data to digital is called a scanner, while the method is known as scanning. A scanned Map is a paper map that is scanned into digital format. Scanned maps are usually in TIFF, SID, JPEG, and other formats [6].

2.2.3 Map Accuracy

Map accuracy is a value that describes the degree of correspondence between the position and attributes of an object on the map with the actual position and attributes. Base map accuracy includes geometric accuracy and attribute/semantic accuracy.

Geometric accuracy is a value that describes the uncertainty of the coordinates of the position of an object on the map compared to the coordinates of the object's position which is considered to be the actual position. One component of geometric accuracy is Horizontal Accuracy [1].

Table 1. Horizontal Accuracy

No	Scale	Accuracy of RBI Map		
		Class 1	Class 2	Class 3
		Horizontal (CE 90 in m)		
1	1:1.000.000	200	300	500
2	1:500.000	200	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	4	7,5	12,5
7	1:10.000	2	3	5
8	1:5000	1	1,5	2,5
9	1:2500	0,5	0,75	1,25
10	1:1000	0,2	0,3	0,5

Table 2. Horizontal Accuracy based on the class

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

2.2.4 Standart of Map Assessement

Positional accuracy analysis uses the root mean square error (RMSE), which describes the value of the difference between the test point and the actual point. RMSE is used to describe accuracy including random and systematic errors. The RMSE value is based on the Eq. 1 below:

$$RMSE_{horizontal} = \sqrt{D^2/n} \quad (1)$$

$$D^2 = \sqrt{RMSE_{x^2} + RMSE_{y^2}} \quad (2)$$

$$D^2 = \sqrt{\frac{D[(Xdata-Xcek)^2+D(Ydata-Ycek)^2}{n}} \quad (3)$$

where :

n = total number of checks on the map
D = the difference between the coordinates measured in the field and the coordinates on the map
x = X-axis coordinate value
y = Y-axis coordinate value

The CE 90 value is then calculated by the formula as on the equation 4.

$$CE\ 90 = 1{,}575 \times RMSE_r \quad (4)$$

2.2.5 Delineation and Digitization

Delineation is a process on providing the arc or temporary boundary feature for the area above the map [4]. Digitization is a process of converting analog data into digital data where attributes can be added containing information from the object in question.

2.2.6 Digital Map

A digital map is a map in the digital fotmat that can be assesed by using hardware or software [7].

2.3. Step of Work

2.3.1 Setting Coordinate System

This stage was used to set the coordinate system used and the input of the coordinate points from the analog map. The purpose of the input coordinates is to know the distribution of the coordinates on the map and at the same time, it can be used for next processing.

2.3.2 Rectification

The process of rectification or geometric correction is an activity that aims to equalize the points on the map/geographical reference whose coordinates are known and the scanning process has been carried out in mapping software [3]. The result or value of rectification is represented by the RMS error value. In this research, the rectification is according to 4 GCP, 6GCP and 10GCP.

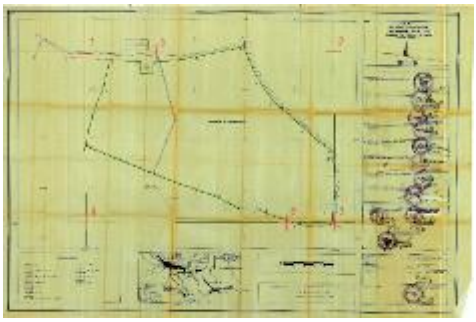

Figure 2. Distribution 4 GCP

Figure 3. Distribution 6 GCP

Figure 4. Distribution 10 GCP

3. Result

After the rectification process, then calculating RMSE and CE based on the GCP variations. The RMSE value was created by using formula 1, while

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CE90 with formula 2 and 4. The results was presented on Table 3-5 and Fig. 5-6 below.

Table 3. Horizontal Accuracy Calculation (4GCP)

Point Name	X (basic map coordinate)	X (check map coordinate)	Dx	(Dx)2	Y (basic map coordinate)	Y (check map coordinate)	Dy	(Dy)2	(Dx)2 +(Dy)2
1	232690.294	232690.184	0.110	0.012	9596171.606	9596171.676	-0.070	0.005	0.017
2	233091.684	233091.777	-0.113	0.013	9596172.679	9596172.601	0.078	0.006	0.019
3	233092.403	233092.293	0.110	0.012	9595896.100	9595896.179	-0.079	0.006	0.018
4	232691.094	232691.146	-0.112	0.013	9595895.026	9595894.947	0.079	0.006	0.019
								jumlah	0.07
								rata-rata	0.02
								RMSE	0.14
								CE 90	0.20

Table 4. Horizontal Accuracy Calculation (6GCP)

Point Name	X (basic map coordinate)	X (check map coordinate)	Dx	(Dx)2	Y (basic map coordinate)	Y (check map coordinate)	Dy	(Dy)2	(Dx)2 +(Dy)2
1	232690.294	232690.435	-0.141	0.020	9596171.606	9596171.279	0.327	0.107	0.13
2	233091.684	233091.728	-0.064	0.004	9596172.679	9596172.486	0.193	0.037	0.04
3	233092.403	233091.904	0.499	0.249	9595896.100	9595896.628	-0.528	0.279	0.53
4	232691.034	232690.923	0.111	0.012	9595895.026	9595895.097	-0.071	0.005	0.02
5	232805.432	232805.227	0.205	0.042	9596171.000	9596171.521	-0.521	0.271	0.31
6	233014.000	233014.611	-0.611	0.373	9595896.987	9595896.389	0.598	0.358	0.73
								jumlah	1.76
								rata-rata	0.25
								RMSE	0.50
								CE 90	0.76

Table 5. Horizontal Accuracy Calculation (10GCP)

Point Name	X (basic map coordinate)	X (check map coordinate)	Dx	(Dx)2	Y (basic map coordinate)	Y (check map coordinate)	Dy	(Dy)2	(Dx)2 +(Dy)2
1	232690.294	232690.435	-0.141	0.020	9596171.606	9596171.279	0.327	0.107	0.13
2	233091.684	233091.728	-0.064	0.004	9596172.679	9596172.486	0.193	0.037	0.04
3	233092.403	233091.904	0.499	0.248	9595896.100	9595896.628	-0.528	0.279	0.53
4	232691.034	232690.923	0.111	0.012	9595895.026	9595895.097	0.071	0.005	0.02
5	232805.432	232805.227	0.205	0.042	9596171.000	9596171.521	-0.521	0.271	0.31
6	233014.000	233014.611	-0.611	0.373	9595896.987	9595896.389	0.598	0.358	0.73
7	232943.320	232943.439	-0.119	0.014	9595896.667	9595896.241	0.426	0.181	0.20
8	232818.187	232818.257	-0.070	0.005	9595895.502	9595895.782	-0.220	0.048	0.05
9	232912.576	232912.128	0.448	0.200	9596172.982	9596172.414	0.568	0.323	0.52
10	233012.989	233013.156	-0.167	0.028	9596172.989	9596172.575	0.414	0.171	0.20
								jumlah	2.73
								rata-rata	0.38
								RMSE	0.62
								CE 90	0.95

Table 6. RMSE, CE, Horizontal Accuracy based on the class (4GCP, 6GCP,10GCP)

GCP	RMSE	CE90	map accuracy scale 1:1000			map accuracy scale 1:2500		
			Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
4	0,14	0,20	0,2	0,3	0,5	0,5	0,75	1,25
6	0,50	0,76	0,2	0,2	0,2	0,5	0,75	1,25
10	0,62	0,95	0,2	0,2	0,2	0,5	0,75	1,25

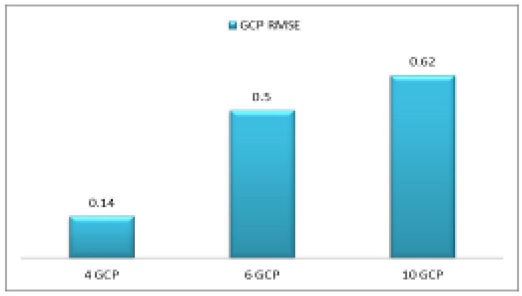

Figure 5. Comparison of the RMSE 4GCP, 6GCP, and 10GCP

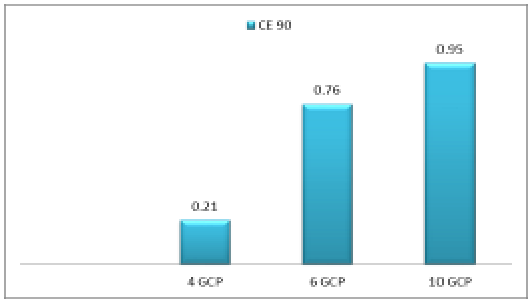

Figure 6. Comparison of the CE 4GCP, 6GCP, and 10GCP

Based on table 3, the 4GCP shows the largest error at GCP number 4 with the value of 0,019m and the smallest error at number 1 of 0,017m. Based on table 4, the 6GCP shows the largest eror at GCP number 6 with value of 0,73m and the smallest error at number 4 of 0,02. Based on table 5, the 4GCP shows the largest error at GCP number 4 with value of 0,73m and the smallest error at number 6 of 0,02m.

Also, Fig. 5 and Fig. 6 show the 4GCP may produces the RMSE 0,14 and CE90 0,20, the horizontal accuracy class 1 scale 1:1000, while the 6 GCP produces RMSE 0,50 and CE90 0,76, the horizontal accuracy class 3 scale 1:2500. Then the 10 GCP produces RMSE 0,62 and CE90 0,95, the horizontal accuracy class 3 scale 1:2500.

4. Conclusion

A horizontal accuracy of the rectified map is 0,14m and the horizontal accuracy is class 1 a scale 1:1000. Comparison of the result with 3 RMSE and CE values, the use of 4GCP produce the high best accuracy. The large number of GCP has not shown better accuracy so far.

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