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HORIZONTAL COORDINATE ACCURACY OF GOOGLE EARTH ON THE COVERAGE OF SMALL ISLANDS OF MAKASSAR CITY, INDONESIA

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ABSTRACT

The presence of high-resolution satellite imagery on Google Earth provides an opportunity for the availability of maps that can be used as a reference for accurate coordinates. Google Earth has been developed to contain high-resolution images, but it warns users about the accuracy of the data regarding the coordinates of the objects covered. Coordinate inaccuracies have the potential to cause problems when used for navigational purposes, or in technical tasks requiring high accuracy such as surveying and mapping applications. Despite these warnings, users are often forced to refer to Google Earth as a reliable data source due to the absence of other data sources. The purpose of this study is to evaluate the accuracy of Google Earth's horizontal coordinates and determine the maximum map scale that can be made based on coordinate data from Google Earth on the coverage of small islands in the Makassar City area. The method used is to compare the object coordinate obtained from Google Earth and the coordinate measured in the field at the same object point. The calculation results show the $RMSE_H$ is 2.49 meters and the horizontal accuracy is 4.28 meters. These results indicate that the horizontal coordinates on Google Earth can be referenced to produce a map with a maximum scale of 1: 10,000.

Keywords: Google Earth, accuracy, small island, Makassar

INTRODUCTION

Since 2005, the internet-based “Google Earth” computer software has been launched, which displays satellite images covering the earth's surface. Google Earth depicts the earth as seen from a high altitude. The image displayed on Google Earth has a resolution that varies according to the zoom in level. At first the images in Google Earth were an image recorded 3-4 years earlier, with a moderate resolution (30 meters). Currently, Google Earth has been displaying images that have been recorded relatively recently, which is less than 1 year, with a very high resolution so that users can easily recognize natural objects or the human built environment (Farah and Algarni, 2014). High-resolution imagery is now available on Google Earth, allowing users to quickly distinguish between major land cover types and human-built environment components such as residential areas, industrial buildings and road networks.

Google Earth images can be downloaded for free as image files. The image displayed on Google Earth has undergone several processing steps, including stretching and contrast sharpening. Many tools are available in Google Earth that allow users to collect spatial data and even add information to the displayed image, such as personal remarks and photos. (Potere, 2008; Farah and Algarni, 2014; Amran, 2017).

Google Earth has been developed to contain high-resolution images (Collin et al., 2014), but it warns users about the accuracy of the data regarding the coordinates of the items covered. Google does not have a policy stating that Google Earth data is accurate in any particular location. Coordinate inaccuracies have the potential to cause problems when the data is utilized for navigation, or in technical jobs requiring high accuracy, such as surveying and mapping. Despite these warnings, many users are forced to still consider Google Earth as a reliable data source due to a lack of other data sources. This is a significant disadvantage of using Google Earth in high precision and risk associated. As a consequence, before adopting Google Earth imagery in such applications, it is essential to evaluate its positional accuracy.

The assessment of positional accuracy is an important tool for determining the quality of spatial datasets (Girres and Touya, 2010). It establishes how closely distinct items position correspond to their real locations on the ground (Congalton and Green, 2008). Accurate maps, or at least maps with established accuracy, are required for effective resource mapping. Previous studies that evaluated the positional accuracy of GoogleEarth include (Potere, 2008), (Becek et al., 2011), (Mohammed et al., 2013) and (Goudarzi and Landry, 2017). Unfortunately, almost all researchers do not provide a clear estimate of accuracy but they actually suggest that Google Earth coordinates be used with caution.

A real-world entity's position is determined by a set of numbers in a certain coordinate system. Then, positional accuracy is defined as the proximity of such values to the genuine position of the thing in that coordinate system (Guptill, Morrison, 1995), and is generally classified into two categories: (a) horizontal, and (b) vertical positional accuracies. However, the focus of this research is on determining the horizontal positional accuracy of Google Earth over the small islands of Makassar City, Indonesia.

There are small islands rich in marine resources inside Makassar City's administrative territory. Of course, resource management necessitates the availability of precise resource maps with high accuracy. The official map currently available is the Indonesian Coastal Environmental Map (Peta Lingkungan Pantai Indonesia) published by the Indonesian Geospatial Information Agency with a scale of 1: 50,000. At this scale, specific resource information cannot be included on a map. Satellite imaging can provide more detailed maps, but it requires accurate coordinate reference.

The presence of high-resolution satellite imagery on Google Earth provides an opportunity for the availability of maps that can be used as a reference for accurate coordinates. This study aims to evaluate the accuracy of Google Earth's horizontal coordinates on the coverage of small islands within the Makassar City area, and determine the maximum map scale that can be made based on coordinate data from Google Earth.

MATERIALS AND METHODS

The research was conducted in April – October 2021 in the study area covering small islands in the Makassar City area (Figure 1). The horizontal positional accuracy of Google Earth was investigated by comparing the object point coordinate retrieved from Google Earth with the field coordinate measured at the same object point. Coordinates of the object points in Google Earth were determined by hovering the mouse pointer on the most likely target location of the GPS markers in relation to the field observations. The research was conducted in accordance with the research flow in Figure 2

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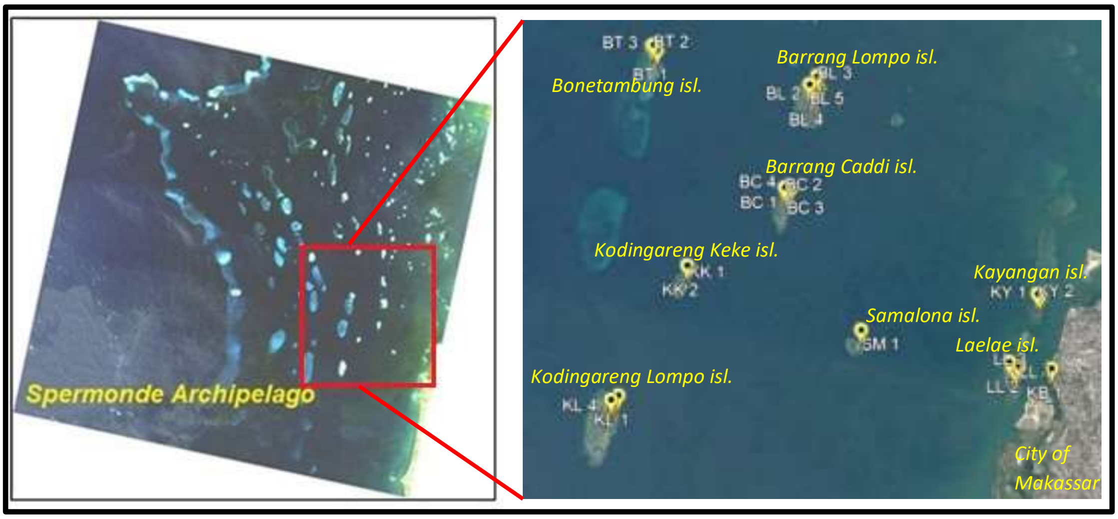

Figure 1. Research Area

Objects Selection and Coordinates Measurement

Coordinate measurements were carried out on selected objects on the mainland of the small islands of Makassar City. The objects were stationary thing that does not change readily. Coordinate measurement using GPS with UTM coordinate system, WGS 84 datum. Google Earth adopts a geographical coordinate system based on the reference ellipsoid of the World Geodetic System of 1984 (WGS 84), which is the same datum as the Global Positioning System (GPS). The recorded coordinates were the results of averaging measurements continuously for 30 minutes at each object point. The selected islands for coordinate measurement are Kodingareng Lompo Island, Kodingareng Keke Island, Barrang Caddi Island, Barrang Lompo Island, Bonetambung Island, Samalona Island, Lae-lae Island and Kayangan Island.

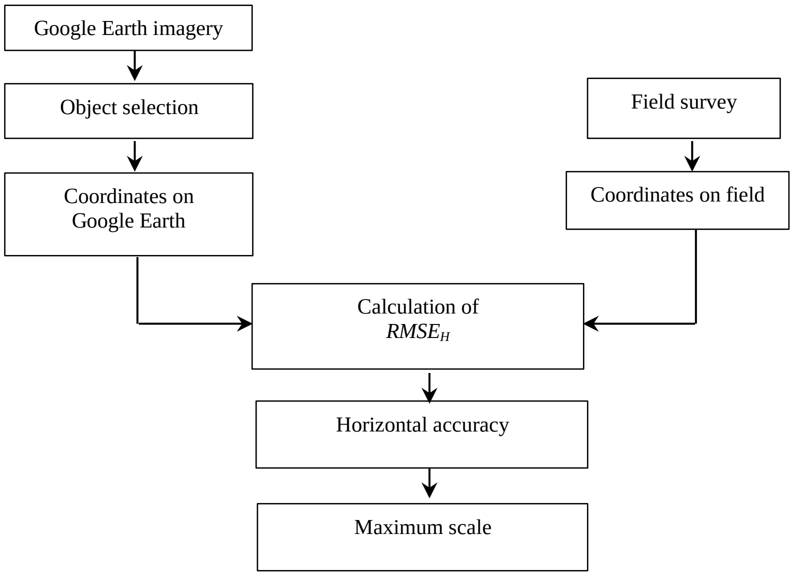

Figure 2. Research Flowchart

Calculation of horizontal coordinate shift and accuracy

The accuracy of the horizontal coordinates is the root mean square error (RMSE) between the map coordinates and the coordinates measured in the field (ASPRS, 1990). The RMSE is the sum of all errors made during the map-making process, starting from field surveying, compiling map data and finishing the map. The RMSE limit values for Class-1 maps are presented in Table 1. For Class-2 and Class-3 maps, the RMSE limit values are multiplied by 2 and 3.

Table 1. RMSE Limit for Class-1 Map

RMSE Limit (meter)	Map scale
0,0125	1 : 50
0,025	1 : 100
0,050	1 : 200
0,125	1 : 500
0,25	1 : 1.000
0,50	1 : 2.000
1,00	1 : 4.000
1,25	1 : 5.000
2,50	1 : 10.000
5,00	1 : 20.000

The RMSE in the x and y directions are:

$\mathrm{RMSE_x} = \sqrt{\sum \frac{(x_{GE}-x_{check})^2}{n}}$ and

$\mathrm{RMSE_y} = \sqrt{\sum \frac{(y_{GE}-y_{check})^2}{n}}$

Where:
x_{GE}: easting on Google Earth
y_{GE}: northing on Google Earth
x_{check}: GPS easting
y_{check}: GPS northing
n: number of sample points.

The total horizontal RMSE is:

$\mathrm{RMSE_H} = \sqrt{\mathrm{RMSE_x}^2 + \mathrm{RMSE_y}^2}$

If $\mathrm{RMSE_x} = \mathrm{RMSE_y}$ then:

$\mathrm{RMSE_H} = \sqrt{2\ \mathrm{RMSE_x}^2} = \sqrt{2\ \mathrm{RMSE_y}^2} = 1{,}4142\ RMSE_x = 1{,}4142\ RMSE_y$

If the error is normally distributed and the error components are independent of each other, the horizontal accuracy at the 95% confidence level is: (FGDC, 1998)

$\mathrm{Accuracy_H} = 2{,}477\ \mathrm{RMSE_x} = 2{,}477\ \mathrm{RMSE_y}$

$\mathrm{Accuracy_H} = (2{,}477 / 1{,}4142)\ \mathrm{RMSE_H}$

$\mathrm{Accuracy_H} = 1{,}7308\ \mathrm{RMSE_H}$

If $\mathrm{RMSE_x} \neq \mathrm{RMSE_y}$ then:

$\mathrm{Accuracy_H} = 2{,}477 * 0{,}5 * (\mathrm{RMSE_x} + \mathrm{RMSE_y})$

$\mathrm{Accuracy_H} = 1{,}2385\ (\mathrm{RMSE_x} + \mathrm{RMSE_y})$

RESULTS AND DISCUSSION

Coordinate measurements were taken at 25 points spread over the small islands of Makassar City. The horizontal coordinate shift (ΔH) at each measuring point is presented in Table 2. The differences in the Northings (ΔY) and Eastings (ΔX) measured at each site, as well as their positional errors, are also shown.

In terms of Google Earth's horizontal accuracy, Table 2 shows that Google Earth images have a mean horizontal shift of around 2.37 m, with lower inaccuracies in the north than in the east. The maximum horizontal shift was 2.94 m, while the minimum horizontal shift was 0.63 m. The calculation of accuracy show that:

$RMSE_X = 2{,}07$ m

$RMSE_Y = 1{,}38$ m

$RMSE_H = 2{,}49$ m, and

Horizontal accuracy $= 4{,}28$ m

The results above show that the coordinates of the Google Earth's image, especially the coverage of small islands of the Makassar City, can be referenced to produce a map with a maximum scale of 1: 10,000. At this scale, resource maps can contain all of the information needed for small island's resource management.

The positioning accuracy of Google Earth imageries varies around the world which could be the consequence of mosaicking different image sources. Becek et al. (2011) tested the accuracy of the Google Earth position of more than 1900 control points located on five continents around the world. The study concluded that the error could be up to 1.5 km in some cases. While Mohammed et al. (2013) tested the accuracy of Google Earth's position on 16 control points located in the state of Khartoum, Sudan, obtained the result that the error for horizontal coordinates was 1.59 m. The availability of data that encourages professionals to do research in order to verify and assess positional Google Earth derived data encourages users from various disciplines to use Google Earth for positional data extraction. Making some form of field check can help to ensure the accuracy of Google Earth retrieved positional data. Google Earth is a powerful and appealing source of positional data that may be utilized for research and preliminary studies with sufficient accuracy and at a low cost.

Table 2. Shift of horizontal coordinates

Island	Point	Field check		Google Earth		Shift		
		X (m)	Y (m)	X (m)	Y (m)	ΔX	ΔY	ΔH
Kodingareng Lompo	KL 1	751340.85	9430656.81	751343.76	9430656.42	2.91	-0.39	2.94
	KL 2	751139.86	9430215.48	751142.66	9430215.18	2.80	-0.30	2.82
	KL 3	751035.27	9430207.12	751038.12	9430206.77	2.85	-0.35	2.87
	KL 4	751077.10	9430507.61	751079.89	9430507.29	2.79	-0.32	2.81
Kodingareng Keke	KK 1	753798.96	9435157.96	753799.02	9435158.60	0.06	0.64	0.64
	KK 2	753740.30	9435198.32	753740.35	9435198.95	0.05	0.63	0.63
Bonetambung	BT 1	752668.34	9442747.29	752665.57	9442748.10	-2.77	0.81	2.89
	BT 2	752529.50	9442949.18	752526.79	9442949.93	-2.71	0.75	2.81
	BT 3	752466.23	9442912.59	752463.58	9442913.19	-2.65	0.60	2.72
Barrang Lompo	BL 1	758413.86	9441410.48	758415.83	9441412.47	1.97	1.99	2.80
	BL 2	758222.04	9441437.81	758223.99	9441439.56	1.95	1.75	2.62
	BL 3	758322.27	9441857.82	758324.22	9441859.80	1.95	1.98	2.78
	BL 4	758172.10	9441173.22	758174.08	9441175.16	1.98	1.94	2.77
	BL 5	758046.66	9441558.76	758048.62	9441560.68	1.96	1.92	2.74
Barrang Caddi	BC 1	757402.86	9437901.59	757401.15	9437900.12	-1.71	-1.47	2.25
	BC 2	757180.08	9437938.02	757178.40	9437936.57	-1.68	-1.45	2.22
	BC 3	757254.59	9437717.46	757252.88	9437716.11	-1.71	-1.35	2.18
	BC 4	757365.91	9438033.56	757364.21	9438032.17	-1.70	-1.39	2.20
Samalona	SM 1	759871.82	9432952.42	759870.51	9432951.82	-1.31	-0.60	1.44

Kayangan	KY 1	766184.31	9434176.10	766184.69	9434178.59	0.38	2.49	2.52
	KY 2	766078.69	9434226.52	766079.04	9434228.77	0.35	2.25	2.28
Laelae	LL 1	765422.56	9431697.00	765420.08	9431697.93	-2.48	0.93	2.65
	LL 2	765081.22	9431849.95	765078.72	9431850.65	-2.50	0.70	2.60
	LL 3	765340.28	9431478.69	765337.90	9431479.44	-2.38	0.75	2.50
Kayu Bangkoa	BK1	766566.70	9431624.49	766565.97	9431625.78	-0.73	1.29	1.48

CONCLUSION

The calculation results show the $RMSE_H$ is 2.49 meters and the horizontal accuracy is 4.28 meters. These results indicate that the horizontal coordinates on Google Earth, especially the coverage of small islands of the Makassar City, can be referenced to produce a map with a maximum scale of 1: 10,000.

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