Solving Village Border Problem Using UAV-RTK Based On One Map Policy In Situjuah Banda Dalam, West Sumatera; an alternative to village boundary acceleration

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Abstract. A village is a unitary legal community that has territorial boundaries. The absence of clear territorial or village boundaries can lead to an unclear division of village assets, resulting in conflict between villages and districts. Nagari Situjuah In the District of Sipuh, Limo Nagari, Kabupaten Limapuluh Kota is one of the villages that do not have clear boundaries. This research aimed to produce an indicative boundary of Nagari Situjuah Dalam using aerial photographs of UAVs following the regulation of Perka BIG Number 3 of 2016. The research was carried out in several stages. The data was acquired using UAV RTK referred to BIG's Geodesy Control Network. The measurement results show that the aerial photograph of Nagari Situjuah Banda Dalam using UAV has a spatial resolution of 10.1 cm with horizontal accuration of 1.04 m at 90% confidence and a total RMSEr of 0.69 m2

Keywords: Map of Boundary Village, UAV

1 Introduction

Indonesian Law No. 6 of 2014 Concerning the Village affirms that the village is a unitary legal community that has territorial boundaries that have the authority to regulate and manage the government, the interests of the local community based on community initiatives, rights of origin, and or traditional rights recognized and respected in the system government of the Republic of Indonesia. The development of an area also in line with the use of the management budget is a strong current from the centre (topdown) to be used and absorbed precisely at the village level, following applicable regulations. This is often hampered by unprepared planning at the village level, especially in the provision of rural geospatial information that can facilitate the process of policymaking as well as village guidelines to consider rural development plans, including for mitigation and disaster risk reduction needs.

The development of mapping technology has now reached an advanced level where advanced sensing, as in photogrammetry using Unmanned Aerial Vehicle / UAV, is reinforced by researchers and practitioners' high interest in conducting aerial geometry accuracy studies [1]. Accuracy is a major factor that prioritizes the use of this technology in addition to

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considering other aspects such as relatively low prices, efficiency, more detailed information, and high mobility [2]. This is in line with the development of Global Positioning System (GPS) technology for the need for geometric correction both with Real-Time Kinematic (RTK) and Static methods in various weather and time conditions[3].

The village mapping was conducted in Nagari Situjuah Banda Dalam Kecamatan Situjuah Limo Nagari Kabupaten Limapuluh Kota Provinsi West Sumatra. Nagari Situjuah Banda Dalam has eight villages or Jorong consisting of Jorong Banda Dalam, Gurun, Tangah Padang, Padang Ambacang, Koto Baru Lurah Pantai, Sungai Jilatang, Subarang Tabek, Koto Laweh with a total area of 11.71 km2. The village‘s topography, which dominates the hills, becomes a challenge for the team to map using UAVs. Also, the country is not close to military areas or airports, which are prohibited areas for flying UAVs. Thus, the research of this study aims to map the State of Banda Dalam by using Unmanned Aerial Vehicle (UAV) and testing the degree of accuracy with GNSS.

2 Method

2.1 Aerial Imagery and Global Positioning Design

Materials used include; (i) Geodetic Control Network Data (JKG) belonging to the Geospatial Information Agency (BIG); and (ii) a 1:50,000 Scale Topographical Map of Indonesia. The tools used include; (i) DJI Phantom 4 Pro RTK b; (ii) Hi-Target V90 Geodetic GPS; (iii) Markers of tie points which are also recorded by the aircraft's camera during the acquisition process; (iv) handheld GPS; (v) A set of computers with special specifications for processing raster data; (vi) PIX4D software for aerial photo processing; and (vii) ArcGIS software for GIS data processing.

The research was designed through the planning stage, where the planned ground control points were adjusted to the research location. The ground control point must be within a radius of under 60 Km from the Geodetic Control Network (JKG) Indonesian Geospatial Reference System (SRGI) anchor point owned by the Geospatial Information Agency (BIG), which can be accessed at http://srgi.big.go.id/ srgi2/jkg [4].

The image acquisition process was carried out using a field survey method using the DJI Phantom 4 Pro UAV. The type of UAV is the DJI Phantom 4 Pro rotary-wing Quadcopter (4 rotors). This type of UAV has several advantages in high maneuverability in maintaining position (hover) and changing the direction of flight around the center of rotation, as well as being able to move more stably and be able to fly vertically so that shooting in certain areas such as densely populated areas or hilly topography region can be done more easily [5]. In addition, the sidelap – overlap effect (overlapping area) can also be fulfilled properly because the UAV speed is not too high, so the resulting aerial photos are also better. The flight path is created using the Drone Deploy online application in the area to be recorded. Based on the scope of activities, the area recorded using the UAV is 3,400 Ha. The flight path design has a maximum ride height of 400 meters above the ground with a spatial resolution of 11 cm. then, the acquisition of ground control points with GPS Geodetic was carried out. The Real-Time Kinematic (RTK) method is used with one base unit and refers to BIG's Geodetic Control Network. Ground Control Point (GCP) and Independent Check Point (ICP) are used to measure geometric accuracy related to coordinates in the aerial photo recording area. GCP and ICP measurements are carried out after the identification of the appropriate object through satellite imagery with several conditions such as having a clear object appearance in the image, located on the ground surface, not the shadow of an object, the object is permanent and stationary and has no chance of changing position, the colour of the object must be contrasted with the surrounding environment, and there is access to the location of the object in question. Field data is then processed using image mosaic techniques using the PIX4D application and GCP data taken in the field.

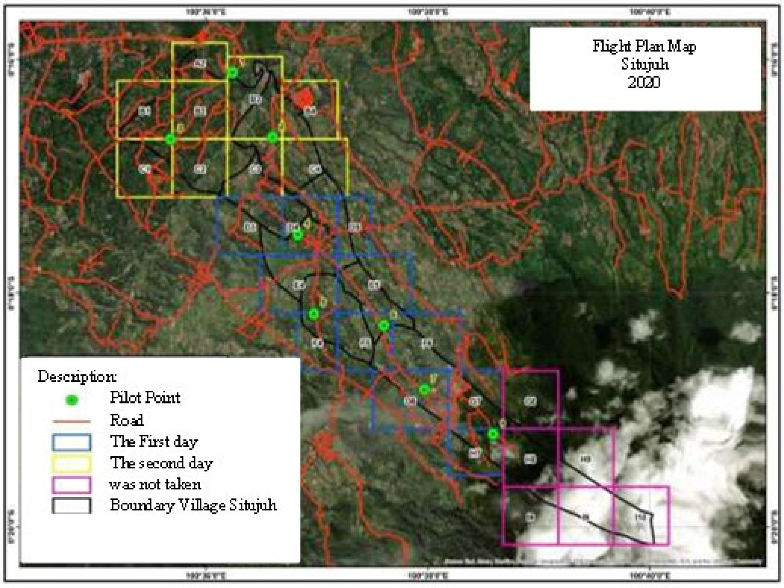

Fig. 1. UAV Flight Plane

Identifying village boundaries was done in an indicative way by gathering authorized sources and understanding the boundaries of each village area. The village map database is obtained by drawing boundaries (delineation) on aerial photographs with informants in the focus group discussion (FGD) agenda. This method of drawing boundaries is a cartometric method, namely a method of tracing or drawing boundaries on work maps and measuring or calculating point positions, distances and area coverage using base maps and other maps as a complement [6].

2.2 Accuracy Assessment

The Geometry Accuracy Test was carried out to determine the accuracy value of orthorectified aerial photographs. The test refers to the difference in coordinates (X,Y,Z) between the test point on the image or map and the actual location of the test point on the ground surface as measured using a Geodetic GPS. Accuracy measurement uses root mean square error (RMSE) or circular error, where the coordinates (X, Y) of the test point and the actual position in the field need to be taken into account. This accuracy test technique refers to Perka BIG No. 3 of 2016 [7], where the level of horizontal accuracy of village maps has provisions based on the scale of the map to be issued. Measurement of accuracy using the root mean square error (RMSE) or circular error where what needs to be taken into account is the coordinates (X, Y) of the test point and the actual position in the field. The RMSE of images was computed using:

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{N} \left(P_{\mathrm{cp}} - P_{\mathrm{image}}\right)^2}{N}}$$

Where *Pcp* and *Pimage* are the x, or y, or horizontal position (xy) for GCPs or independent checkpoints (ICPs) and the image locations, respectively. Errors at GCPs are a proxy for errors within the geo correction model, while errors at ICPs are an approximate measure of overall planimetric accuracy across the image. CE90 indicates that feature positions are located in imagery within the stated accuracy 90% of the time and is estimated by rank ordering the radial errors from smallest to largest and selecting the radial error corresponding to the 90th percentile, as detailed by Davis and Wang (2003).

The map accuracy value is the CE90 (circular error) value for horizontal accuracy, which means that the map position error does not exceed the accuracy value with a 90% confidence level.

Description: RMSEr= Root Mean Square Error at horizontal x and y positions. The level of accuracy in question is presented in the following table.

Table 1. Horizontal accuracy in several map scale

Map Scale	Horizontal Accuracy		
	Class 1	Class 2	Class 3
1:10.000	2	3	5
1:5.000	1	1.5	2.5
1:2.500	0.5	0.75	1.25

The village map accuracy value is the CE90 (circular error) value for horizontal accuracy, which means that the village map position error does not exceed the accuracy value with a 90% confidence level. The stages of testing the horizontal accuracy of the village map used in this activity, in addition to referring to the Head of BIG Regulation Number 3 of 2016, also refer to SNI 8202 – Basic Map Accuracy.

3 Results and Discussion

The aerial photo shooting that has been carried out resulted in a total of 9,700 photos with a spatial resolution of 14 cm/pixel. Some of the aerial photos experienced exposure, and some experienced blur caused by technical disturbances and surrounding weather disturbances in the form of high wind speeds. Other technical problems can be overcome in taking aerial photos, so the next step is to digitally correct aerial photos to improve their quality. The photos obtained are subjected to a selection or sorting process to reduce poor photo quality or experience errors due to technical and weather factors. Of the 9,700 photos, 8,650 were selected with decent quality for processing. In this process, the process of sharpening and making orthorectification is carried out. For the sharpening, vignetting, and brightness stages of aerial photos, GIMP 2.10 software was used.

The final result of the aerial photography in this activity produces a spatial resolution of 10.1 cm. This indicates that the resulting orthophoto has great detailed spatial information. Based on the report's results, there were no missing or missed areas from the recording, so these results can be categorized as good when viewed from data availability for the entire coverage area. The quality of aerial photos is not good when viewed from the authenticity of the shape on the ortho compared to in the field, especially for vegetation objects. Several appearances of vegetation do not match the original, namely different shapes and vegetation restrictions that are too general. The quality of orthophoto geometrically can be seen from the GCP accuracy value. So to get orthophotos with good quality, a scheme for selecting the distribution of the best GCP points is carried out and reducing or eliminating GCP. The scheme is carried out by repeatedly adjusting the selection of the number and distribution of GCPs until the best accuracy value for each GCP and for all GCPs is produced. Several GCP points with high RMSE values were eliminated to obtain the best aerial photo geometry quality. This process resulted in a horizontal error value of 2.71 cm. Geometric accuracy tests of aerial photographs were done by taking data from 12 ICP points. The details of the intended ICP point are presented in the following table.

Table 2. Ground Control Point taken from the field

ICP Point	Distance to corresponding GPS Point (m)	Geodetic GPS ICP Coordinates		ICP coordinates (interpretation)		$(XGPS-XCP)^2$	$(YGPS-YCP)^2$	$(XGPS-XCP)^2 + (YGPS-YCP)^2$
		X	Y	X	Y			
S4f	0.703143131	682422.888	9965091.476	682423.351	9965092.005	0.214389372	0.28002089	0.494410262
S6f	0.689951273	681831.641	9965236.242	681861.058	9965236.613	0.338821783	0.137210976	0.476032759
S9	0.715477718	681049.262	9966363.627	681049.976	9966363.587	0.510333069	0.001575296	0.511908366
S12	0.913868253	680631.282	9966839.370	680630.435	9966839.714	0716846702	0.118308482	0.835155184
ISB0525_R	0.731805787	669969.083	9985022.307	669969.559	9985021.751	0.226815015	0.308724695	0.535539710
ISB0409	0.634296399	665135.742	9980372.963	665136.313	9980372.688	0.326613393	0.075718529	0.402331922
ISB0407	0	682678.322	9988162.085	682678.322	9988162.085	0	0	0
ISB0404	0.9663099199	687798.953	9984312.043	687799.879	9984311.778	0.85755749	0.070002577	0.927560066
ISB0403	0.190791906	683881.995	9980935.527	683882.154	9980935.421	0.02501562	0.011199989	0.036401552
ISb0530_R	0	676109.366	9965980.420	676109.366	9965980.420	0	0	0
ISB0549	1.190627	676000.274	9983255.850	676001.464	9983255.850	1.417592653	0	1.417592653
ISB0522	0	666861.232	9993187.064	666861.232	9993187.064	0	0	0
12						Total		5.64
						Average		0.47
						RMSEr		0.69
						Horizontal accuracy of 90%		1.04

After being processed using the formula and test matrix, the RMSEr value is 0.69, while the horizontal accuracy value with a 90% confidence level is 1.04 cm. The results of the calculation of the aerial photo geometric accuracy test show that the accuracy level of aerial photographs as a data source is very high as part of the map data source for village maps. Based on BIG's standard classification of map accuracy, the resulting village map was classified into class 1 level of accuracy with a 90% confidence level.

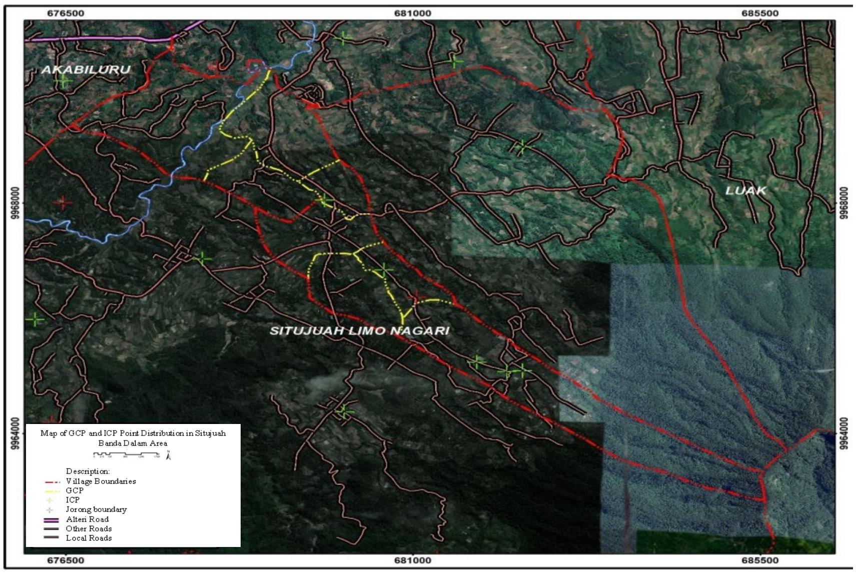

Fig. 2. Distribution of GCP and ICP Point

The process of delineating regional boundaries was carried out by gathering leaders, border village guardians, village heads and officers from the sub-districts in Focus Group Discussion (FGD) activities. The process of drawing boundaries is done manually by drawing boundaries on an aerial photo mosaic image that has been printed at a scale of 1:5000. The FGD was held at the Situjuah Banda Dalam Kenagarian Office, Situjuah Limo Nagari District, Limapuluh Kota District, attended by 12 people consisting of the head of the jorong and the wali nagari who have direct boundaries. The following is a map of the agreed delineation results.

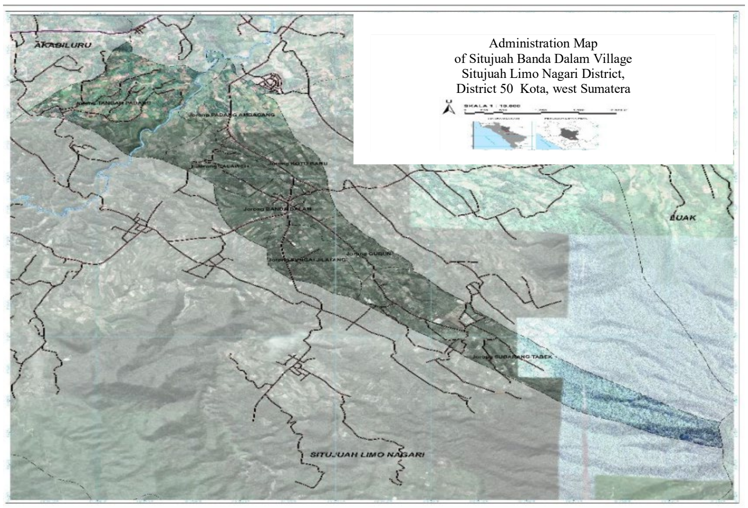

Fig. 3. FGD’s based Village Boundary

The results of delineating the village boundaries of the area are not only in the form of an administrative map but also the area of each jorong in the nagari and the area of the nagari itself. The table shows that the area of Nagari Situjuah Banda Dalam is 1,246.13 Ha.

4 Conclusion

An aerial photo of Nagari Situjuah Banda Dalam has a spatial resolution of 10.1 cm with a class 1 geometry accuracy of the BIG basic mapping standard of 1.04 m at 90% confidence and a total RMSEr of 0.69 m. Village mapping using aerial photographs from UAVs with the CE90 accuracy test can be used as an alternative for making village maps because it has good geometric accuracy standards following BIG Head Regulation No. 3 of 2016 concerning Technical Specifications for Presentation of Village Maps which have advantages regarding flexibility, efficiency and better data updating than CSRT.

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