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Incremental Improvement of High-resolution Satellite Imagery For Participatory Mapping in Land Registration

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Abstract. Fit for purpose land administration (FFP-LA) has a purpose to inventory all of the land parcels. One of the methods in fit for purpose land administration is participatory mapping. Participatory mapping involves the people in the area mapping to create land's parcel map. The people create a map with their knowledge about spatial objects in their area using a satellite image with high-resolution or aerial photo. The purpose of participatory mapping is to create a full land parcels map that has been validated for geometry boundaries and features by the owner or the people around it. But in some circumstance, the data in that map cannot be an input data for land administration, cause there is some standard for satellite image with high-resolution or aerial photo that should be followed. The standard was attached in Government's Law no. 24/1997 and The Ministry of Agrarian Affairs's Law no. 3/1997. In this research, incremental improvement for the high-resolution satellite imagery with some constraints, that is low cost, fast and good enough output and there will analyse a sample of output participatory mapping using high-resolution satellite imagery.

1. Introduction

Agrarian reformation is the new way to decrease poverty and economic gap in Indonesia[1]. Implementation of agrarian reformation is to certify all of land parcels in Indonesia[1]. In Basic Law of Agrarian Principles no. 5/1960, clause 19 regulate the process of land registration follows in three step:

1. Surveying, mapping and bookkeeping land parcel;
2. Registration rights of land parcels and transition of rights;
3. Giving certificate as a powerful evidence[2].

Indonesia has too many islands and the area is 1,913,578.68 km². With assumption all of areas should be registered as land parcels following the regulation, it will take many years and pricey. This condition can relate to specification of cadastre mapping in Indonesia that regulate in the Regulation of the Minister of Agrarian Affairs (PMNA) no. 3/1997 concerning Implementation Provisions of Government Regulation no. 24/1997 concerning Land Registration, in clause 12 subsection 1 stated that surveying and mapping to create the basic map of land administration can be held in terrestrial method, photogrammetric method and etc.[3] and in clause 13, subsection 1 in the same regulation stated that the basic registration map can be made using another map that has a scale 1: 1,000 or



greater for urban areas, 1: 2,500 or greater for agricultural areas and 1: 10,000 or smaller for large plantation areas and meeting the required planimetric accuracy of 0.3 mm from the map scale[3]. With this accuracy, cadastral mapping Indonesia use terrestrial method.

Federation of Surveyors (FIG) and World Bank introduced a system for land registration as known as Fit for Purpose Land Administration (FFP-LA)[4]. Fit for purpose land administration is an approach concept that use to achieve certain goals related to land administration. This concept has four key principles:

1. General boundaries rather than fixed boundaries
2. Aerial imageries rather than field surveys
3. Accuracy relates to the purpose rather than technical standards
4. Opportunities for updating, upgrading, and improvement[4]

This concept can be suitable for the condition of Indonesia. Identification of land parcel in Indonesia using high-resolution satellite imagery can be fast and not too expensive for initial identifying land parcels. The incremental improvement will be applied to this method especially for cadastral mapping in Indonesia.

Cadastral mapping specification in Indonesia refers to Government Regulation no. 24/1997 and then explained in Regulation of the Minister of Agrarian Affairs (PMNA) no. 3/1997. Some of them have been mentioned before. The reference system and projection system regulated in this regulation, in clause 3, stated that [3]:

1. For national coordinate system use National Transverse Mercator projection coordinate system, with width of zone is 3° (three degrees) and called TM 3°
2. The central meridian of TM 3° zone is located 1.5° east and west of the central meridian of the UTM zone concerned.
3. The scale factor (k) in meridian central is 0,9999
4. Pseudo origin is used in east (x) = 200,000 meter and north (y) = 1,500,000 meter
5. Mathematical model of earth as reference is spheroid with WGS1984 datum, parameter a = 6,378,137 meter and f = 1/298.25722357
6. For using other projection systems can be allowed with Ministry approval.

In Government Regulation no. 24/1997, clause 1 subsection 14 stated that the land administration map is map that consists basic technical point, geographic object such as river, road, building and physical boundaries of land parcels[5].

Fit for purpose land administration has three frameworks that be basic of this concept, spatial framework, institutional framework and legal framework[4].

- Spatial framework is a concept and basic techniques for large-scale mapping that indicate how land divided into spatial unit or parcel that has been used for particular or occupancy.
- Institutional framework is about good land management, framework policy, institutional arrangements, structure of organization, use of local resources, partnership, division of responsibilities and efficient and accountable workflow of governments.
- Legal framework. Land registration is all about relationship between human, place, rights, policy, institutional and regulation that regulate that relationship. This regulation and legal framework should be flexible and be planned in administration line.

In fit for purpose land administration, using aerial photo is more highly recommended than field surveys. Because it didn't need much time and the price is lower than field surveys. In aerial photo, almost of parcels boundaries can be known visually and the coverage can be larger[6].

Building spatial framework in fit for purpose land administration didn't need national geodetic reference frame. The boundaries of land parcels delineated in available aerial photo. The boundaries that have been collected can be tied up with national geodetic reference frame for the next stage[6]. Reference point that will be tied up with national geodetic reference point be measured with Global Navigation Satellite System (GNSS) method. The reference point should be in the aerial photo that have been used, so that the aerial photo that have been used connected with national geodetic reference frame.

Building spatial framework cannot be done in one process, however, there must be an effort to facilitate updates sporadically for ensuring reliable and completeness of data. This updating process reflected the principle that the available data is matching with latest condition, both physically and rights of land parcel. If there is supportive budget, it will be very possible to do incremental improvement to generate qualified spatial framework in accordance with cadastral mapping specification that has been applied in a country and integrated with land administration system.

In Indonesia, satellite imagery entitled to be released by National Aeronautics and Space Institute (LAPAN) based on The Law no. 21/2013 about space. Clause 18, in The Law no. 21/2013 stated about categorization of satellite imagery, divide into three class; low resolution, medium resolution, and high-resolution. For cadastral mapping in Indonesia, should use high-resolution satellite imagery. Now, LAPAN provides satellite imagery with resolution less than 1 meter. There is four satellite imagery that can be classified to high-resolution satellite imagery class; Pleiadés, Quickbird, Geo-Eye, and Worldview. Characteristic of those can be seen in Table 1, Table 2, Table 3 and Table 4.

Table 1. Characteristics of Pleiadés satellite imagery.

Characteristics		Pleiadés
Spatial Resolution (m)	Panchromatic	0.5
	Multispectral	2
Temporal Resolution (day)		1 day
Spectral Resolution	Panchromatic	480-830 nm
	Multispectral	Blue (430-550 nm)
		Green (490-610 nm)
		Red (600-720 nm)
		<u>Near Infrared (750-950 nm)</u>
Orbit height		694 km

Table 2. Characteristics of Quickbird satellite imagery.

Characteristics		Quickbird
Spatial Resolution (m)	Panchromatic	0.65
	Multispectral	2.62
Temporal Resolution (day)		8.3 days
Spectral Resolution	Panchromatic	450-900 nm
	Multispectral	Blue (450-520 nm)
		Green (520-600 nm)
		Red (630-690 nm)
		<u>Near Infrared (760-900 nm)</u>
Orbit height		450-482 km

Table 3. Characteristics of Geo-Eye satellite imagery

Characteristics		Quickbird
Spatial Resolution (m)	Panchromatic	0.46
	Multispectral	1.84
Temporal Resolution (day)		1-3.5 days
Spectral Resolution	Panchromatic	450-800 nm
	Multispectral	Blue (450-510 nm)
		Green (510-580 nm)
		Red (655-690 nm)
		Near Infrared (780-920 nm)
Orbit height	684 km	

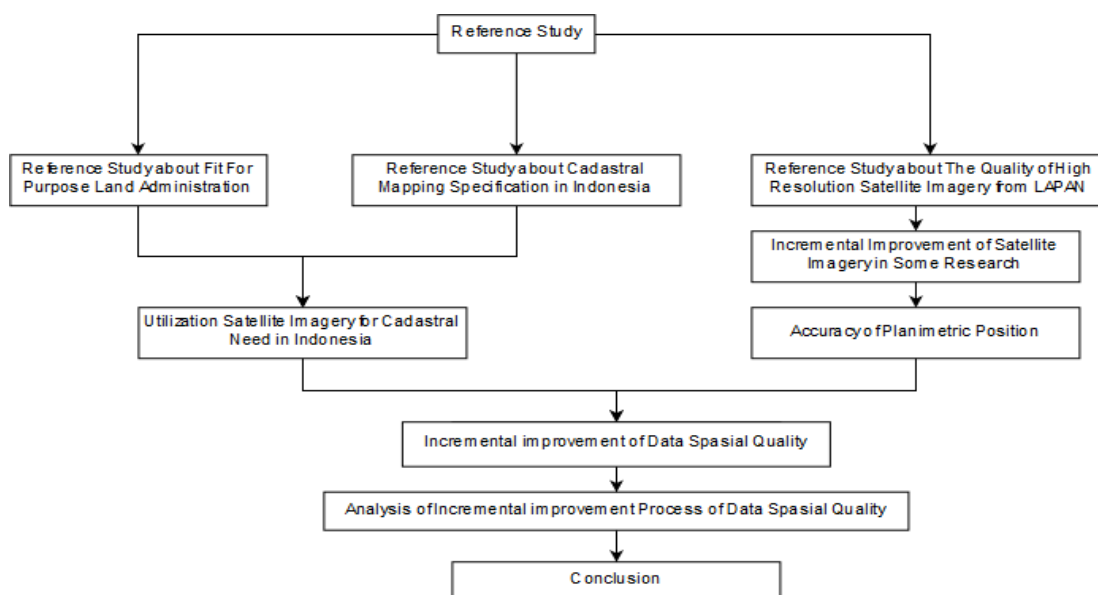
Table 4. Characteristics of worldview satellite imagery

Characteristics		Worldview-2	Worldview-3
Spatial Resolution (m)	Panchromatic	0.46	0.31
	Multispectral	1.84	1.24
Temporal Resolution (day)		1-3.2 days	< 1 days
Spectral Resolution	Panchromatic	450-800 nm	450-800 nm
	Multispectral	Coastal (400-450 nm)	Coastal (400-450 nm)
		Blue (450-510 nm)	Blue (450-510 nm)
		Green (510-585 nm)	Green (510-585 nm)
		Yellow (585-625 nm)	Yellow (585-625 nm)
		Red (625-705 nm)	Red (625-705 nm)
		Red Edge (705-745 nm)	Red Edge (705-745 nm)
		Near Infrared 1 (745-860 nm)	Near Infrared 1 (745-860 nm)
		Near Infrared 2 (860-1040 nm)	Near Infrared 2 (860-1040 nm)
		Orbit height	770 km

Characteristics of satellite imagery cannot exactly tell the quality of those spatial data, there should follow some steps to know precision and accuracy value of data. Precision is a description of accuracy and purity in measurement, can be seen by proximity of the group data regardless of correction or truth of the data [7]. Accuracy is a description about correction of measurement result and computability the true value[7]. One of the methods to know precision and accuracy of data is Root Means Square Error (RMSE). RMSE is square root of average of residual squares between dataset coordinate and independent coordinate that have higher accuracy for same point. The value of RMSE calculated by verifying some points that have been corrected to the true point or the point that have been georeferenced in certain projection system. The spatial data is good if the RMSE value is small.

2. Method, Data and Result

To carry out incremental improvement there are some steps to do, those steps shows in Figure 1.

**Figure 1.** The method that used

Planimetric accuracy can be obtained by position check and distance check. Position check generally is done by placing independent checkpoint infield that can be identified in satellite imagery. Distance check generally uses digitation data on the image and then comparing to direct measurement in the field.

Determination of planimetric accuracy is carried out by several previous research using high-resolution satellite imagery; Quickbird, Worldview-2, Pleiades 1B and Geo-Eye. For Quickbird, conducted in Gresik as domain research, after geometric correction generated RMSE 0.469 m by distance check with coverage area 192,885 km² and have 13 ground control point. This RMSE is qualified to map with scale 1:1,000 that need accuracy 0.3 m[8]. For Worldview-2, the high-resolution satellite imagery that covered Kediri region with area 63,404 km² has RMSE 0.619 m with 12 ground control point. This satellite imagery fulfill the standard of imagery with scale 1:2,500[9]. And for Pleiades 1B, the domain research in Bulak with area 871.25 km² using 23 independent checkpoint generated RMSE 0.648 m, this can fulfill the standard of map with scale 1:2,500 and 1:10,000[10]. For same place of domain research, but with Geo-Eye satellite imagery and also using 23 independent checkpoint generated RMSE 0.506 m, and this is fit to map with scale 1:2,500 and 1:10,000[10].

High-resolution satellite imagery can include about 66.25% of total area non-forest Indonesia. Around 34.866% of area non-forest is plantation area. Based on, Regulation of the Minister of Agrarian Affairs (PMNA) no. 3/1997, the plantation area of Indonesia can be mapped with scale 1:10,000 using high-resolution satellite imagery.

3. Case Study

For knowing how the people of certain area use satellite imagery to create a map and applying the concept of fit for purpose land administration. There is case study to carried out about that. In fit for purpose land administration, there is some method that can be used, one of them is participatory mapping. Based on, fit for purpose principles that prefer to use satellite imagery than field surveys so this participatory mapping will use satellite imagery that given by Garut PTSL team in Karang Mulya area. This satellite imagery is imagery from bing that has 15 meters resolutions but doesn't have

clouds cover any longer. This image is free and can be accessible to everyone so that was easy to use by citizen. The participatory mapping method executes to some activity that is training and mapping simulation. Those activities executed by people of Karang Mulya village, Karang Pawitan, Garut. For this time, represented by fifteen people.

3.1. Training

This activity is to introduce map and satellite imagery to people. Satellite imagery is a media that use for participatory mapping, because of that the needed is ability to interpret satellite imagery well. This satellite imagery can be interpreted based on its color, texture, size, shape, pattern, shadow and location. After that, the people learn how to identify and delineate parcels boundaries based on that can be seen in satellite imagery. To make certain about the boundaries of parcels, the agreement of the parcel's owner is importantly needed. This part agrees with section 17 point 2 in The Government's Law no. 24/1997 about Land Registration, its says "When determining land parcels boundaries in systematic or sporadic land registration based on the agreement of stakeholders of land parcel"[2].

The people have an important role in land registration process. Because of that, this activity can be the trigger to make the people be initiative and be active in participation of land registration. After this training, the people are given chances to identify and delineate land parcels boundaries.

3.2. Mapping Simulation

The mapping simulation activity is an activity carried out by the people to apply the material given during training. In this activity, the people were given a satellite image of the Karang Mulya village area. Satellite imagery that is used as a basis for the people for mapping simulation, is printed in the size of an A2 paper so that the parcel looks clearer and easier to identify. Everyone is given the opportunity to identify the parcels they have. The identification process can be said to be successful because the people are able to identify the location of their parcels by making public facilities and social facilities as a reference.

Then the activity continued with delineating the boundary of parcel represented by the village officials because the parcel that was sampled for delineation was the Karang Mulya village office. This sample is chosen based on the size of the parcel that is large enough and easily identified from the print satellite image.

Two delineations and interpretations of the boundary of village office were carried out by two village officials. The results of the manual calculation of the extent of each parcel boundary interpretation have a quite different value. Figure 2 has a parcel area of 474 m² while Figure 3 has an area of 306 m².



Figure 2. This figure is delineated by one of the officers, before training



Figure 3. This figure is delineated by another officer, after training

However, these two values have a large enough difference with a definitive value that is the broad value measured directly in the field with the people, which is 482 m².

4. Discussion

High-resolution satellite imagery can be fully applied in Indonesia still on scale 1:10,000. This is must high-resolution satellite imagery with spatial resolution less than 1 m and geometric correction regard to quality of ground control point and equal distribution of it's in mapping area. And for scale 1:2,500 can be applied in some area in Indonesia. With this result, cadastral mapping for rural and plantation area can be done using high-resolution satellite imagery on scale 1:10,000 and 1:2,500. But this is preliminary research and should develop to reach and applied cadastral mapping with fit for purpose land administration concept.

The fit for purpose approach carried out by participatory mapping method in this case study needs to be further developed so that it can be used in land registration activities due to inappropriate boundary interpretations made by the community as the subject of participatory mapping so as to produce a different geometry from the real one. This is due to limited training time and the quality of satellite imagery used. In the future, it is necessary to develop training methods that support the community's ability to interpret the boundaries of parcels in satellite imagery or aerial photographs.

In addition, the quality of satellite images with a higher resolution is also needed, which is equal to 1-5 meters so that the boundaries of the parcels visible more clearly. These conditions also meet the technical specifications in Article 17 subsection 1 of the Regulation of the Minister of Agrarian Affairs (PMNA) Number 3 of 1997 concerning Implementation Provisions of Government Regulation Number 24 of 1997 concerning Land Registration[3]. The implications of fulfilling the technical specifications are the results of participatory mapping can be used for land registration activities.

Participatory mapping activities carried out with training and mapping simulations need to be gradually and sustainably improved as the concept of a fit approach for purpose land administration is low cost, fast and good output.

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