

The Role of Geospatial Information for Accelerating the Delineation of Village Boundaries in Indonesia using Cartometric Method

Tri Patma Sari

Training Division of Geospatial Information Agency, Indonesia

Abstract— The number of villages in Indonesia currently is 83,436 villages, which will continue to increase each year. For instance, 49 years ago in 1969/1970, the number of villages was 44,478. The administrative boundaries of a village are very important to affirm and to stipulate legal aspects in the management of resources. Considering the large number of villages, it is necessary to accelerate the affirmation of village boundaries [Riyadi, 2018].

The study was conducted using a qualitative descriptive approach, by analyzing the contribution of geospatial information in supporting the delineation acceleration of village boundaries carried out by Geospatial Information Agency (BIG) during the period from 2013 to 2019 throughout Indonesia. High resolution orthorectified satellite imagery was used by implementing the cartometric method as mandated in the Minister of Home Affairs Regulation (Permendagri) No. 45 of 2016 concerning Determination and Affirmation of Village Boundaries. This method has been proven to accelerate the processes of establishing village boundaries. It is estimated that the number of villages in the period 2013-2019 will reach 76,196 villages or approximately 91,26 % of a total 83,436 villages. Settlement of village boundaries is part of the work plan of One Map policy contained in Presidential Regulation No. 9 of 2016 which is a catalyst for speeding up administrative boundaries including village boundaries.

Keywords— Cartometric method, Delineation and Village Boundaries.

I. INTRODUCTION

The era of political decentralization in Indonesia, which began in 1999 is often referred to as the beginning of the era of regional autonomy, Law Number 22 of 1999, which was later revised with Law Number 23 of 2014 concerning Regional Government providing opportunities for regions to regulate their own domestic affairs. Regional expansion has been carried out by the government to strengthen the principle of decentralization [Sumaryo, 2014]. This principle allows provincial, regency/city and village governments to regulate their own regions based on the principles of regional autonomy and co-administration tasks. The implementation of regional autonomy has been running for 20 years. During this time many emerging New Autonomous Regions or designated *Daerah Otonomi Baru* (DOB) were established. Until now there are 34 provinces, 416 regencies, 98 cities and 83,436 villages [Permendagri, 2017]. The establishment of the DOB is stated in the law on the formation of regions which contain chapters on regional delimitation. In Law No. 23 of 2014 it

is clearly stated that regional boundaries become one of the territorial basic requirements that must be delineated by coordinate points on the base map. The map becomes an inseparable attachment to the law. Administrative boundaries are included in the basic geospatial dataset of national topographic maps (*Peta Rupabumi Indonesia*), and is one of the important data to support development planning in Indonesia. This kind of geospatial information has an impact on the management of internal affairs such as natural resource management, spatial planning, taxes, land administration, expansion of new autonomous regions, census of statistical data, and others.

With the existence of the Law number 6 of 2014 concerning Villages, the position of the village government became stronger as the executor of regional autonomy. This law has implications for the importance of determining boundaries between regions and even between villages, and the need for village maps on a large scale map that will support many matters that are mandated by this Law. Village maps are increasingly needed to

implement the Indonesian government's policy to assist village development by providing village allocation funds. One of the parameter indicators for allocating the amount of village funds is the size of the village. To obtain the village area and size, a clear and firm village boundary map is needed thus enabling the area of the village to be calculated more accurately. In terms of spatial aspects, there are still 83,436 villages that do not yet have village maps in accordance with the rules of mapping, and thus has an impact on not-yet-defined areas. For the villages which already have maps, most of them did not obey the cartographic rule, for instance the delineation of the village boundary is given only in sketch form, not a map. The obstacle faced in making a map of the main village is the unavailability of large-scale national basemaps [Ambarwulan, 2014].

Determinations of village boundaries must be done considering the villages in Indonesia continue to grow over time and the number increases along with regional autonomy implemented by the central government. The expansion of the villages always increases every year, in 1969/1970, the number of villages was 44,478, and in 1978/79 the villages increased by around 15,000 in total to 60,645. In 1983/84, when there was a new village arrangement based on Law No. 5 in 1979, the number of villages increased to 66,437. And now based on Permendagri Number 137 of 2017 concerning the Administrative Region Code and Data, the number of villages has reached 83,436 [Riyadi, 2018]. The formation of new villages resulted in changes in the boundaries of the village administration so that it needed the determination and affirmation of village boundaries.

However, the rate of expansion which has increased from year to year is almost entirely not preceded nor followed by the affirmation of the village which has resulted in unclear division of village assets, resulting in conflicts between villages and even between regencies/cities if village boundaries, as well as regional boundaries, are not yet stipulated and affirmed. Considering the large number of villages, it is necessary to accelerate the affirmation of village boundaries. In such regulation, it is mentioned that the determination and affirmation of village boundaries aims to create good governance, providing clarity and legal certainty of the village that meets the technical and juridical aspect.

The authority for definite determination of regional (province and city/regency) boundaries is made by the Ministry of Home Affairs, and the Regional Government for sub-district/village boundaries. The administrative boundary on topographical maps is an indicative boundary. In order to change the indicative boundary into a definitive,

a determination and affirmation process is needed. For delimitation/delineation, it can be done in a cartometric manner on topographic maps or images. The stipulation of the cartometric method as one method in tracking regional boundaries was followed by the addition of realization of affirmation of regional boundaries.

Acceleration of boundary affirmation between adjacent areas is very necessary as an important effort to accelerate the implementation of One Map Policy as stated in Presidential Regulation No. 9/2016 on One Map Policy, which is targeted to be completed by the end of 2019. It shows the positive action in reducing the spatial conflict problems. The target of that policy was to reintegrate all map themes in Indonesia into one map (single reference, single standard, single databases and single Geoportal). Administrative boundary dataset was one of 85 thematic maps. The One Map Policy is a catalyst for speeding up administrative boundaries including province, regency/city and village boundaries [Patmasari, 2017].

As reported by the Ministry of Home Affairs based on data from 2016 - 2017, the number of definitive segments increased significantly by 45.45%, out of a total of 977 inter-regional segment boundaries 453 segments were completed [Riyadi, 2018]. The cartometric method can be said to accelerate the realization of boundary affirmation. In addition, indirectly, the One Map Policy is also indicated to be one that contributes in accelerating the realization of boundary affirmation. Even the Ministry of Home Affairs has targeted that at the end 2019 the problem of regional boundaries in all regions can be resolved, and the acceleration of the settlement of this boundary is also to reduce conflicts between adjacent areas. The eastern region of Indonesia is the main focus of completion of the boundary segment, particularly the boundary segments between the provinces of Papua and West Papua. For both regions since the formation of several autonomous regions in 1998, there is no segment that has been resolved by the adjacent regency or city (Permendagri, 2018)

According to the Law No. 4 of 2011 on Geospatial Information, the Geospatial Information Agency or *Badan Informasi Geospasial* (BIG) is an institution authorized to carry out geospatial information in Indonesia, especially Basic Geospatial Information. Officially, the Indonesian base map called *Rupa Bumi Indonesia* (RBI) is one manifestation of basic geospatial information that contains the following elements: coastline, hypsography, waters area, geographical names, boundary lines, transportation and utilities, building and public facilities, and also land cover. The village boundary

which is the subject of this study is part of the boundary element that is included in the Indonesian Basemap.

BIG as the National Mapping Agency is responsible for providing the basemap in various scales, i.e.: 1:1,000,000, 1:500,000, 1:250,000, 1:100,000, 1:50,000, 1:25,000, including large scale basemaps 1:10,000, 1:5,000, 1:2,500 and 1:1,000. However until the end of 2018, the availability of large-scale RBI maps was still very limited. For the scale 1: 10,000 only 1.17% were available of the territory of Indonesia (BIG, 2018). To overcome the problem of the availability of village boundary in producing the RBI map with a scale of 1:25,000 or larger, BIG has introduced the cartometric method using high resolution orthorectified satellite imagery with a spatial resolution of approximately 0,50 m, which can be used for identifying the village boundary line instead of investing in time consuming and expensive field surveys. For this purpose some satellite imageries as Pleiade, Geo-eye, and WorldView that have spatial resolution equivalent to the level of accuracy of the base map scale 1:5,000 can be used to prepare village boundaries with sufficient accuracy.

In order to accelerate the affirmation of village boundaries in the territory of Indonesia, during the period 2013 to 2019, BIG has carried out delineation of village boundaries using a cartometric method. Starting in 2013 a trial of cartometric delineation was carried out for 47 villages. Each year the acceleration of delineation is increased in line with the government One Map policy which is stated in the President Regulation No, 9 of 2016. Using the available data of high-resolution satellite images, up until 2018 a total of 43,486 villages have been delineated (BIG, 2018). And in 2019 the village delineation activities are still being carried out to complete the delineation of village boundaries in the remaining areas, approximately around 32,840 villages.

The aim of the study is to obtain a comprehensive understanding of the role of geospatial information for accelerating the determination and affirmation of village boundaries in Indonesia and an inventory of challenges and solutions.

II. MATERIAL AND METHOD

The territory of Indonesia consists of provinces, regencies/city, district and villages. Geographically, Indonesia is located at 6°N - 11°S to 85°E -141° E, with a map of the location of study shown in Figure 1. The Indonesian territory consists of 34 provinces, 416 regencies, 98 cities, and 83,486 villages with the distribution of the number of villages in each region and a varied village area shown in Figure 2. In general, the problems in determining boundaries in areas other than in Java, are that the area of the villages are very wide, difficult to reach, limited human resources and the lack of data availability with sufficient accuracy. Therefore, to solve this problem it requires the best method for time efficiency and funding saving. The cartometric method is relevant to this need because of the fact that the village boundaries are virtual lines that only exist on the map.

Taking into account the importance of village boundary maps and the limited number of village boundaries agreed upon, in this study, it will be described how the geospatial aspects play an important role in acceleration of village boundary delineation in Indonesia. The cartometric method is the search of boundary lines on the work map and the measurement of the position of points, lines, distances and area coverage by using basic maps and other additional geospatial data and information (article 1, number 11). According to Malling (2013), the cartometric method is a method of measuring and calculating the numerical value of a map. This method is applied for delineation of village boundaries following certain procedures to measure and determine a set of points, line and area (polygon) on work maps that are supported by adequate geospatial information.

This research used three general steps. First, was the analysis of various policies and legislation which emphasize the government's commitment in implementing village boundaries. Secondly, an evaluation of the delineation mechanism including the type of image used and result of delineation was carried out by BIG during period 2013-2019 throughout Indonesia. Thirdly, conclusions were made on the basis of the results of the discussion and various problems and constraints discovered that will be resolved.

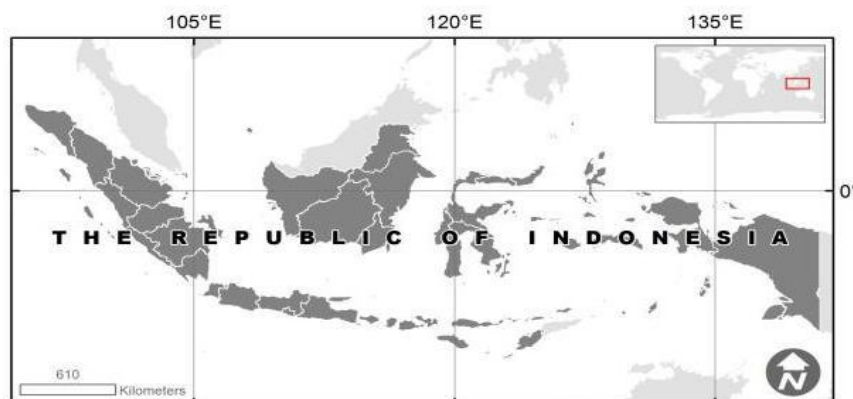


Fig.1: Map of study location

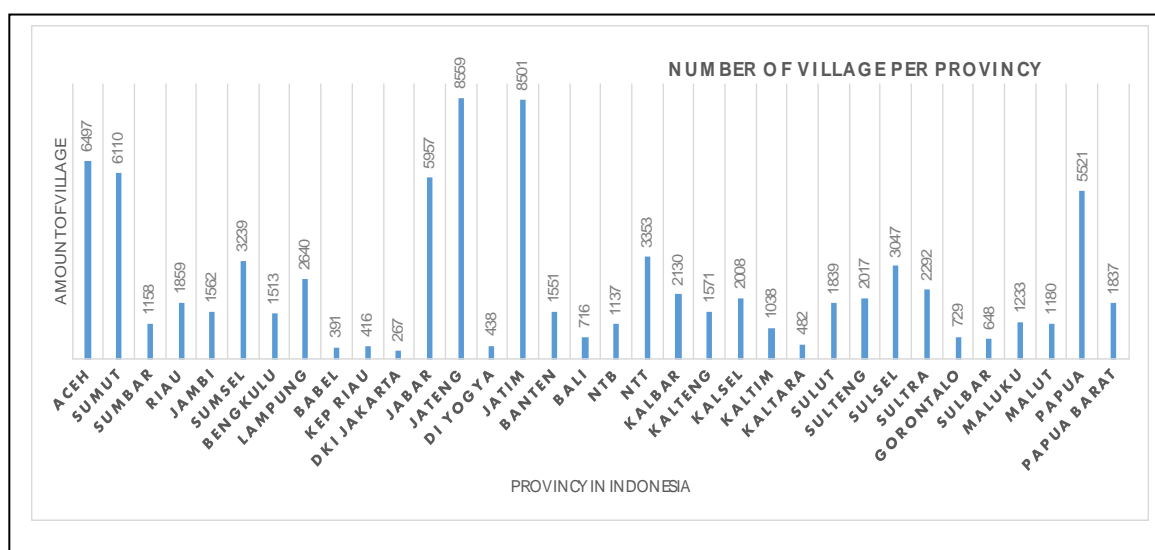


Fig.2: Distribution of number of village in each province (Pemendagri,2017)

III. LITERATURE REVIEW

Administrative boundary mapping has legal and technical aspects that should be considered by decision makers during work using maps to delineate boundaries. Both related aspects have been correctly prepared and implemented to produce the good legal boundary. These technical aspects consist of determination, measurement, and mapping. The legal aspect is related to the prevailing laws and regulations. The dynamics of legal regulations strongly affect the governance of administrative boundary mapping.

1. Village boundary and village map

According to Law No. 6 of 2014 concerning the village, a village is defined as the unity of the legal community that has boundaries and the authority to regulate and manage government affairs, the interests of local communities based on Community initiatives, the right of origin, and recognizes and respects traditional rights in the government system of Republic of Indonesia. In the case of village formations, it is required to attach a map of the

village boundary area approved by the relevant technical institution.

Village boundary map is one type of thematic maps that is made referring to the National basemap with a scale of 1:5,000 or larger. In the event that the needed basemap is not available, then high resolution orthorectified satellite imagery can be used instead. Village boundaries are the boundaries of the administrative area of inter-village governance with administrative areas that are the authority of other village governments.

The village boundaries indicate the existence of the village which, according to prevailing laws and regulations, must have an area boundary map. Village boundary delineation is done by cartometry on an agreed basemap or an agreed substitution basemap. In Permendagri No. 45 of 2016 the village boundary is a boundary between the administrative areas of villages that are a series of coordinate points located on the surface of the earth which can be natural signs such as a watershed, median of rivers and/or elements of artificial objects (for instance roads, railroads,

irrigation channels, and boundary pillars) in the field which are outlined in map form.

2. Legal and Policy Basis in the village boundaries.

a. Law No. 23 of 2014 concerning Regional Government in Transitional Provisions article 401 paragraph 2 states "Confirmation of boundaries including area coverage and broad determination as referred to is carried out based on technical calculations made by institutions in charge of Geospatial Information". The institution authorized to handle geospatial information is the Geospatial Information Agency, based on Law No.4 of 2011 concerning Geospatial Information.

b. Law No. 6 of 2014 concerning Villages

Law No.6 of 2014 concerning Villages, states in Article 8 paragraph 3f that the boundaries of the Village Area which are stated in the form of Village Maps are regulated in Regulations of the Regent / Mayor. It is further related to article 17 paragraph 2 which states that regional regulation including the formation, deletion, merger, change of status, and determination of the village, are enclosed with maps of village boundaries. It was stated that the village formation meant here was the establishment of a new village. Determination is made through the relevant Regent/City Regulations. One of the conditions that must be fulfilled is that there are village boundaries in the form of village maps. Therefore a village that will be expanded must first have clear and firm boundaries, and village maps must be available.

c. Presidential Regulation No. 9 of 2016 concerning Acceleration of the Implementation of the One Map Policy (OMP) at the Level of accuracy of Maps Scale 1:50.000. The target of the policy is to reintegrate all map themes in Indonesia into one map (single reference, single standard, single database, and single geoportal). The One Map Policy Program shows positive actions in reducing the problem of spatial conflict. Administrative boundary maps are one of 85 thematic types to be integrated and synchronized. The target of the One Map Policy must be completed by 2019.

d. Law No. 4 of 2011 concerning Geospatial Information. According to this law, BIG is the institution authorized to manage and realize geospatial information covering whole Indonesia. So far, BIG has completed Mapping at scale 1:25,000 in certain areas (Java, Bali, Nusa Tenggara and Sulawesi). And scale 1:50.000 has covered Sumatra, Kalimantan, Maluku and Papua. To support the mapping of village areas, large scale maps are needed starting from a scale of 1: 10,000 to scale 1: 1,000. Until the end of 2018, the availability of large-scale RBI maps was still very small. For the scale 1: 10,000, only 1.17% of the territory of Indonesia was available (BIG, 2018). Village boundary

map is one type of thematic maps, which must be made in reference to the basemap. A scale of 1: 5,000 or larger or using the best available data such as high resolution satellite imagery that has been orthorectified is needed to fulfill sufficient accuracy. In cases where very high resolution imagery is not yet available then an orthorectified high resolution image with the spatial resolution of 4 meters can be used.

e. Permendagri No. 45 of 2016 concerning Guidelines of Determination and Affirmation of Village Boundaries, This Permendagri contains regulations on the procedures for village boundary delineation and demarcation, the executing organization, the result validation process and the dispute settlement. The attachments detail the principles and the process for village boundary delineation and demarcation which is very relevant to the Geodesy aspect and requires geospatial information data. The village boundaries indicate the existence of the village which, according to prevailing laws and regulations, must have an area boundary map. Determination and affirmation of village boundaries aims to create orderly government administration, providing clarity and legal certainty towards the boundaries of a village that meets technical and juridical aspects. Determination means determining the boundary on a map, which is referred to as cartometric determination on an agreed base map. The boundary determination only applies to villages that were formed after this regulation took effect. Boundary demarcation includes the installation of boundaries on the ground based on prior delineation results.

f. Regulation of the Head of the Geospatial Information Agency No. 3 of 2014 concerning Specifications for presenting village maps. Making village maps refers to the specifications of village map presentations and with certain layout templates. Matters that follow in developing village maps must refer to the geospatial aspects which are related to the datum and the map projection system, map scale, boundary lines and the map accuracy rules. The status and type of boundary lines are important issues that must be arranged in the village map. The village map will be in the form of a definitive boundary line after it has been stipulated in the regent/mayor's regulation regarding affirmation of village boundaries.

3. The Role of Geospatial Information in Boundary Making

a. The role of map in the delimitation/delineation Stage. Theoretically and empirically, two important stages of boundary making are the delimitation/delineation and demarcation of boundaries, which in the process require Geospatial Information as an infrastructure for identifying, selecting and defining the boundaries (Jones, 1945). In the

delineation stage, a map has an important role as a technical tool for choosing the location and defining boundary lines, as a negotiating tool to reach boundary line agreements, as a media to display the results of agreement in the delimitation that will be attached to the minutes of the agreement or will later be used as a guideline in the demarcation stage, and to describe and present the boundary lines that have been made at the stage of delimitation and demarcation. Therefore the scale and quality of the map become very important. The delineation is an accurate, detailed, legally phrased definition, to avoid any future dispute over its practical interpretation (FIG, 2013).

b. The roles of maps in the demarcation stage

The results of the delimitation/delineation stage, which include narrative in the articles of agreement and boundary maps attached in annex of agreement, will be transferred to the ground through the installation of the demarcation pillars. Demarcation is to determine the position of a point and the true boundary line on the ground which is done bilaterally. Boundary points that have been agreed in the delimitation process are transformed into the field and physically marked by a construction of a monument or boundary pillars, guard post or other facilities (Jones, 1945). This demarcation is done to determine the coordinates of boundary points through measurement, survey and mapping activities using appropriate technology, equipment and methods and up to date technologies, including commonly used geodetic equipment such as GPS and common worldwide geodetic reference systems, e.g. WGS 84. In village boundary mapping in Indonesia, the Indonesia Geospatial reference System referred to as *Sistem Referensi Geospasial Indonesia* (SRGI) must be used as the mapping reference. It is possible to define the boundary very precisely by coordinates at the centimeter level. The results of the demarcation activities will be described in the demarcation of the boundary map. This map contains coordinates of the boundary points as a result of the field measurement which will be used in the administration and boundary line management phase. Therefore large-scale maps such as 1:10.000 or greater would be very helpful. The existence of these pillars is very important in some boundary segment conditions. For this reason, the boundary pillars can be prioritized in certain boundary segments, among others, in conflict-prone boundaries, in areas that are difficult to

interpret in the field. For areas with access to reach limits that are difficult to reach, for example on hills, in remote areas, etc., it can be done in a cartometric manner.

c. Geodetic aspects in Village boundary making

The determination and affirmation of village boundaries are carried out through the principle of geodesy and processed in a cartometric manner on an agreed basemap. Referring to the attachment of Permendagri 45 of 2016, several technical matters that follow in developing village maps must refer to the geospatial aspects which are related to the datum and map projection systems, map scale, and boundary lines.

The maps used in the formation of the village must use the datum and reference system that applies nationally (SRGI 2013). This was done to facilitate the process of integrating village boundary data. The projection system is used to calculate the area of the village. Different projection systems can result in broad values that are also different. Calculation of village area throughout Indonesia must be carried out using the same projection system (Lailissaum, 2017).

d. Availability of Geospatial Information in Indonesia for village boundary mapping

The basic map used to create the village map is the map RBI scale 1:5,000. As mentioned in Permendagri No. 45 of 2016, in cases where it is not available then it may use an upright high resolution image with the lowest spatial resolution of 4 meters. (Please give actual information) Unfortunately until the end of 2015, the availability of large-scale RBI maps covers only approximately 1,17% of the territory of Indonesia, thus the village boundary delineation activities in Indonesia during period 2013-2019, use high resolution image data. High resolution images can be used to recognize objects in the field and facilitate easy identification of boundary objects that are used as a reference for setting boundaries, such as riverbanks, road edges, and other objects as illustrated in Figure 3. To interpret or examine the objects seen in the image, the image is interpreted. Image interpretation can be defined as the process of intensively interpreting an image carried out thoroughly to identify and conclude the appearance of the elements in the image, which are then used to present the necessary information about the interpreted area (Sumaryo, 2002).



Fig.3: Boundary segment between Medan - Deli Serdang

To meet the needs of high-resolution image, the Presidential Instruction Number 6 of 2012 assigns BIG and LAPAN to provide, process and disseminate upright high resolution image to be used for development purposes, including village boundary mapping. The following is the coverage of Satellite Imagery that has been provided by BIG and LAPAN consisting of Satellite Imagery: Airbus (Pleiades), Digital Globe (Quickbird, Geoeye, Worldview-2, Worldview-3), with the acquisition year 2013 - 2015, and spatial resolution of 0.5m. Image coverage is 1.043.252 km² (almost 55,2%) of Indonesia as illustrated in Figure 4. The high resolution image still needs to be perfected with geometric corrections and topographical correction with the orthorectification process, so that the image becomes an upright image with correct orthogonal projection for better mapping accuracy, and include coordinates in the reference system that applies nationally. (BIG, 2012). The implementation of Satellite Image Orthorectification has been carried out by BIG using Pixel factory Software. In

general, the first step of the correction procedure is an implementation of geometric correction, with Digital Elevation Model (DEM) and Ground Control Point (GCP) as input data. Unfortunately, these ortho images as mentioned above covered only 50% of Indonesia, while the remaining area was supplied by SPOT 5 and SPOT 7 imagery. The SPOT 7 Ortho satellite imagery are provided by the vendor in the form of data that has been PANSHARP/fusion with a resolution of 1.5 m using systematic orthorectification processes.

Furthermore, in the implementation of delineation of village boundaries, there are complications since satellite images in some areas were covered by clouds in excess of the permissible percentage (due to weather conditions), especially in areas in Kalimantan, Sumatera and Papua known as eternal clouds. For this reason, and also for areas that are not yet available, high resolution satellite imagery was substituted using Bing Map which is georeferenced to primary data and ESRI image basemap.

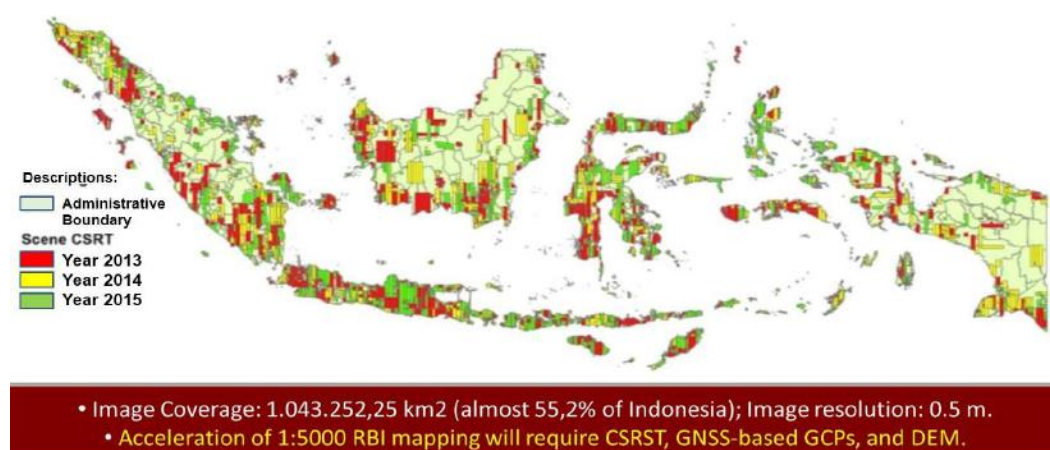


Fig.4: Coverage of High Resolution Satellite Imagery

e. Village boundary delineation using cartometric method
 Village boundary delineation is a part of the village boundary affirmation stage referring to Permendagri no 45 of 2016. Tracing the village boundary lines above the draft work map follows the shape of a river, mountain ridge or any other natural features to delineate village boundary. Other than that, the delineation of village boundary may follow an artificial feature, such as roads, railways, irrigation waterways, etc. With the availability of technology geospatial information along with appropriate images, the delineation can be carried out easily and accurately. Of course, human resources are needed that possess the ability to use GIS software. Delineation process must involve stakeholders in the area, such as village officials and village community leaders who understand the boundaries of their territory. If all segments of the boundary line have been agreed upon, a cartometric boundary line can be drawn on the agreed map/ortho image. With this method, village boundaries are determined on maps, both hardcopy and digital, while activities in the field are only carried out if needed. The resulting data is in the form of village boundary maps and coordinate listings of boundaries points in a cartometric manner (in certain regions). Delineation of village boundaries to meet the basic needs of geospatial information on village administrative boundaries, with the aim of producing indicative administrative boundary data, include results of a village boundary map for each village. The general stages on delineation village boundaries are carried out in villages that are adjacent to each sub-district. The stages of village boundary delineation are carried out as follows:

- ✓ Tracing the village boundary above the draft work map follows the shape of a river or mountain which is a natural boundary or follows a non-natural boundary
- ✓ Verifying the indicative limits in the draft work map, by carrying out the interpretation above the draft work map with background of high resolution upright images
- ✓ Tracing village boundaries based on data and information from boundary instructions submitted by the two village heads on a cartometric basis on the draft work map (hardcopy) according to the agreement.
- ✓ Updating village boundary data digitally with GIS software displayed on a large screen using a projector, in order to see in more detail the appearance of the various types of elements identified above.

- ✓ The selection of cartometric points on easily recognizable objects. For example, on a river or a straight road points are only made at the ends of segments (intersections or turns of roads or rivers). Cartometric point coordinate extraction is done using GIS software
- ✓ Signing the minutes of the boundary agreement that contains information on the results of the boundary description and the delineation process and lists the coordinates of the village boundary cartometric points.

IV. RESULT AND DISCUSSION

1. Strategy in Accelerating Delineation of Village Boundaries in Indonesia period 2013– 2019

As clearly stated in the Village Law, that BIG is responsible for the validity of the Village Map. In order to support the government's current vision and mission, as mentioned in Law No. 23 of 2014, Law Number 6 of 2014, Presidential Regulation No. 9 of 2016, the Center for Boundary Mapping of BIG is obliged to provide regional boundary information, including village boundaries. In connection with the number of villages, the implementation of delineation activities conducted by BIG partners in this case private consultant engaged in survey and mapping with supervision by BIG personnel. In the process of delineating village boundaries in the regions, BIG has involved local government officials and village officials. The following is the implementation of delineation of village boundaries in Indonesia carried out by BIG.

- a. Starting in 2013, a prototype of cartometric delineation with agreements between adjacent village officials was carried out in 47 villages. The delineation of the village boundary as a pilot project was done in several areas in Java, namely Bantul, Semarang, Bogor and Surabaya. In determining village boundaries, the stages are carried out through document research, determination of work maps and delineation on work maps and village boundary map making. In these cases, the images used are the best available image data, (such as image from Bing map) with a note that it will be recreated with a high resolution orthorectified satellite image provided by BIG. In 2014, the delineation was continued in Java for 201 villages in several regencies, namely West Bandung, Tasikmalaya and Pekalongan. After successful implementation of the cartometric method, furthermore in 2015, this method was widely applied for 1392 villages bringing the total of completely delineated villages to 1640, approximately 2% of the

total number of villages in Indonesia. The result of delineation consists of, among others, village working maps with a scale 1:10.000, verbal description of the boundary delineation, minutes of agreement and disagreement. During the process of making cartometric village boundary maps, disputes or differences of opinion may occur between community members in a village or with adjoining village members. Differences in perceptions, opinions or disagreements regarding village boundaries are a logical consequence of Village Boundary delineation. In the case of disagreement over boundaries, dispute resolution has been regulated in Permendagri 45 of 2016 (article 18, to be resolved through deliberation and facilitated by the Regent/Mayor and stated in the minutes). In fact, the cartometric method is more efficient than delineation with the field survey method that requires a high level of man power, money and time.

- b. With respect to government policies and availability of high-resolution orthorectified satellite imagery, in the fiscal year 2016 – 2017 BIG accelerated the village boundary delineation with agreements between adjacent village officials, using high resolution ortho image, namely Pleiades and Worldview 3, provided by BIG with the acquisition year of 2013 - 2015. Using these images with spatial resolution of about 0.5m, the boundary element objects visualized in the satellite image are very clear, hence village officials can easily identify and verify village boundaries. To facilitate the implementation of delineation, the activities to trace the village boundary above the draft work map were carried out following natural and artificial features using digital or hard copy image. Village boundary data was also updated digitally with GIS software displayed on a large screen using a projector in order to see in more detail the appearance of the various types of elements identified above. In cases where the natural and artificial features are not apparent to delineate the boundary, the delineation may follow a line which is agreed upon by the stakeholders. In 2016, **BIG** conducted delineation in 2510 villages spread across 19 regencies/cities. Continued in 2017 BIG has further completed delineation in 8009 villages spread across 38 regencies/cities in various provinces in Java, Bali and the Nusa Tenggara regions. Up to 2017, BIG completed an accumulated amount of 12,159 villages or 14,57 % of the total number of villages in Indonesia (BIG, 2017). During this period, the delineation also produced a set of cartometric points.

Thus the results during this delineation process, besides producing a map of delineation work include a descriptive part data of list coordinates of entire boundaries in a common geodetic datum system. Extraction of coordinates of boundary points with a certain distance was conducted only in the agreed boundary segment. The selection of cartometric points was conducted on easily recognizable objects, e.g. on a river or a straight road where the points were only determined at the end of segments (intersections or turns of roads or rivers). Cartometric point coordinate extraction is done using GIS software.

- c. Taking into account that the target of One Map Policy must be completed at the end of 2019 and BIG's commitment as the provider of administrative boundary data as part of the national data set, in period 2018 -2019 there will be a change in strategy and policy. With consideration of the reasons mentioned above and the large number of remaining villages, more than 60,000 villages, the strategy for delineation mechanism is carried out without agreements between neighboring villages. With this strategy delineation without agreement/without minutes of agreement. delineation will speed up . In 2018 delineation has been carried out with a volume of 31,147 villages (in 227 districts/cities, 18 provinces) especially in most regions of Sumatra, Kalimantan, Maluku, and Papua regions (BIG,2018). With this volume, and in consideration of the quality of the image data used, namely SPOT-5 and SPOT-7 with spatial resolution ≤ 2.5 meters, then delineation of village boundaries is carried out without minutes of agreement. Based on experience using SPOT 5 and SPOT 7, the boundary elements in the image are difficult to identify, so village officials have difficulty interpreting the image to understand the village boundaries. And no point coordinate extraction is carried out. For delineation in the Papua region, taken into account are the difficulties of geography (because the area is very large so it is not possible with limited time to reach each village or gather village officials). Delineation is carried out in the district/city and without agreement. A similar approach was used for the Maluku region. As for delineation in the Kalimantan and Sumatra regions, the implementation of delineation was carried out in the sub district and without agreement. However, the results for all regions are still presented in each village, a work map of resulted delineation. The achievement of village boundary acceleration

activities during the period 2013-2018 was 43,486 villages or 51.39% of the number of villages in Indonesia, a very significant progress (BIG, 2018).

Distribution village delineation is as illustrated in Figure 5.

2013		2014		2015		2016		2017		2018	
City/Regency	Total Village	City/Regency	Total Village	City/Regency	Total Village	City/Regency	Total Village	City/Regency	Total Village	Province	Total Village
Kab. Bogor	12	Kab. Bandung Barat	165	Kab. Karawang	278	Kab. Magelang	372	Kab. Tegal, Kota Salatiga, Kab. Rembang	466	Aceh	839
Kab. Bantul	8	Kab. Tasikmalaya	8	Kota Surakarta	51	Kab. Belu	81	Kab. Wonorejo, Kab. Sukoharjo	461	Sumatera Utara	4905
Kota Semarang	19	Kab. Gunungkidul	9	Kab. Sragen	199	Kab. Malaka	127	Kab. Kebumen, Kab. Grobogan	477	Sumatera Barat	938
Kota Surabaya	8	Kab. Gresik	11	Kab. Blitar	31	Kab. Timor Tengah Selatan	278	Kab. Sukabumi	386	Jambi	1425
		Kota Pekalongan	8	Kota Blitar	21	Kab. Jember	51	Kab. Garut	442	Kepulauan Riau	372
				Kota Batu	24	Kab. Gianyar	70	Kab. Kediri	344	Bengkulu	1513
				Kab. Malang	39	Kab. Tabanan	133	Kab. Gorontalo, Kab. Boalemo, Kota Gorontalo	337	Lampung	553
				Kab. Tulungagung	59	Kab. Badung	62	Kab. Humbang Hasundutan, Kab. Toba Samosir, Kota Medan	348	Sumatera Selatan	3239
				Kab. Boyolali	67	Kota Denpasar	43	Kab. Bojonegara, Kab. Ngawi, Kab. Magetan, Kota Madiun	475	Riau	1859
				Kab. Temanggung	222	Kab. Klungkung	59	Kab. Karanganyar, Boyolali	377	Kalimantan Barat	2130
				Kab. Klaten	401	Kab. Bangli	72	Kab. Pati	406	Kalimantan Tengah	1240
						Kab. Karangasem	78	Kab. Demak, Kab. Semarang	484	Kalimantan Selatan	1676
						Kab. Buleleng	148	Kab. Lamongan	474	Kalimantan Timur	1022
						Kab. Lombok Barat	122	Kab. Jepara, Kudus	327	Kalimantan Utara	462
						Kab. Lombok Tengah	139	Kab. Blora	295		
						Kab. Lombok Timur	254	Kab. Purworejo, Kendal	470	Province	Total Village
						Kota Kupang	51	Kab. Ponorogo, Kab. Pacitan, Kota Kediri	362	Maluku Utara	1180
						Kab. Timor Tengah Utara	193	Kab. Bogor, Kota Bogor	502	Maluku	1033
								Kab. Sumba Timur	156	Papua	4924
								Kab. Nganjuk, Kab. Malang, Kab. Tulungagung, Kab. Bojonegara	207	Papua Barat	1837

**Total
43,486 village**

Fig.5: Distribution of the location of village delineation carried out during the period 2013-2018 (BIG, 2018)

- d. As mentioned previously, one of the One Map Policy targets is to complete the village boundary for the entirety of Indonesia by the end of 2019. Currently in 2019, the cartometrics delineation without agreement is being carried out for approx. 32,840 villages, 194 cities/regencies, 18 provinces, in areas that RBI map scale 1:25.000 are available, especially the whole region of Sulawesi, Sumatra, Java, Nusa tenggara and Papua in areas that not have been delineated yet in previous years [Artanto, 2019]. The images used are SPOT-5 and SPOT-7 with spatial resolution ≤ 2.5 meters. The strategy for delineation mechanism is carried out without agreements between neighboring villages. The stages of delineation of village boundaries carried

out in 2019 are the same as in the previous year 2018, and the results for all regions are presented with a delineation work map for each village. Basically, the areas of delineation in 2019 have RBI map scale 1:25,000. Thus the results obtained also are simultaneously updating village boundaries at a resolution of 1: 10,000. At the time of writing this paper the implementation of delineation is still ongoing until November 2019. It is estimated that the number of villages in the period 2013-2019 will reach 76,196 villages or around 91.26%. The realization of Village boundaries delineation period 2013 – 2019 by BIG, is as illustrated in figure 6. All efforts made to describe village boundaries throughout Indonesia will be completed until the end of 2019.

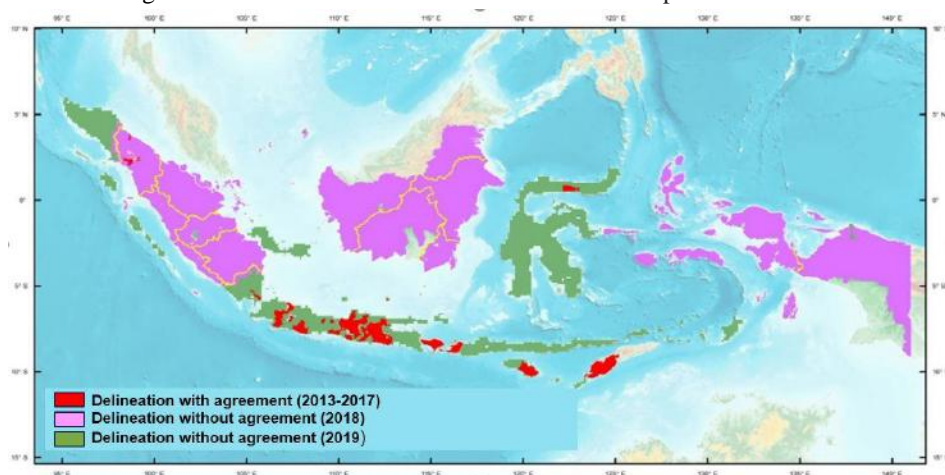


Fig.6: Distribution of Delineation village boundary in Indonesia period 2013-2019 (BIG, 2018)

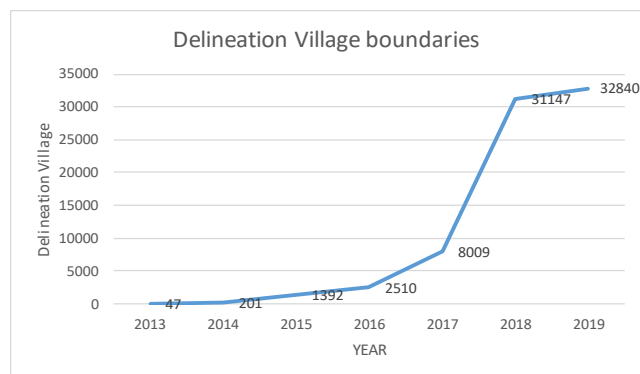


Fig.7: The Acceleration graphics for the realization of Village boundaries delineation Period 2013 – 2019 by BIG

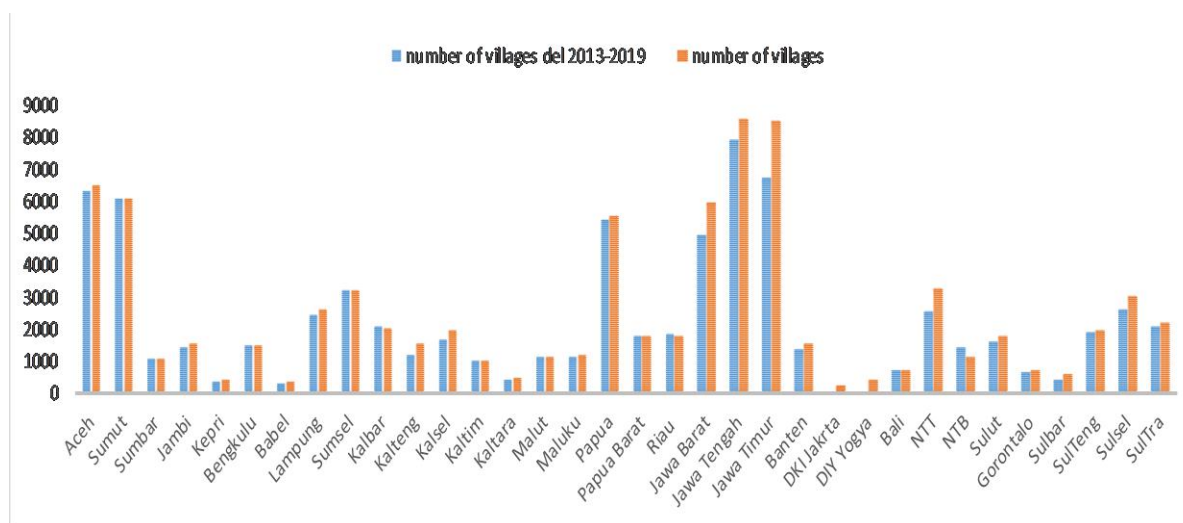


Fig.8: The Acceleration of number of village and number of delineation period 2013 – 2019 in each province

2. Achievements and Challenges

a. It is estimated that the number of villages in the period 2013-2019 will reach 76,196 villages. The results showed that village boundary mapping using high resolution orthorectified satellite imagery had produced accurate village maps according to cartographic and geometric rules. The cartometric method can be concluded successfully accelerating the realization of boundary delineation. In addition, indirectly the One Map Policy is also indicated to be one of the government's policies that encourages accelerating the realization of boundary village delineation as shown in figure 7 and figure 8, which accelerated during the period of 2018-2019 in line with the one map policy target by the end of 2019. Significant increase in realization of boundary delineation was in 2018 towards 2019, from 12,159 villages (year 2017) to 76,196 villages. The trend of realization of boundary delineation in each province during the period 2013-2019 has fluctuated according to Figure 8.

b. It could be noted that the accelerating of boundary delineation without agreement between stakeholders may lead to conflicts or problems in the future. It can be anticipated to use new and more accurate data in the future.

c. By using the cartometric method in carrying out delineation of village boundaries, it provides village boundaries without the need to conduct field surveys in examining village boundaries. Delineation and mapping of village boundaries may be executed faster and inexpensively, especially for Indonesia with a large number of villages. Of course, the accuracy of the village boundaries obtained will depend on the quality of the images used. With Pleiades and WorldView 3 images with a resolution of 0.5 meters, it will produce a geometric horizontal accuracy that is much better than using SPOT 5 and SPOT 7. But the boundary images on satellite images are also very dependent on the interpretation of images carried out together with village/district officials. The role of geospatial information fully

supports the acceleration of village boundaries in the territory of Indonesia.

- d. The results of the village boundary delineation by cartometric that has been carried out by BIG during 2013-2019 will be used as a reference for administrative boundary data on the topographic map at resolutions 1:10,000. In addition, it is also recommended to be used for updating village boundary data on Spatial Maps to support the One Map Policy. In addition, it is very easy to integrate all the results of the village boundary data in the Indonesian territory into a boundary for each district/city, province (in the form of seamless) because it is already within one national reference.
- e. Delineation produces a number of documents, such as a work map village boundary, list of cartometric coordinate data, minutes of agreement (for certain regions), etc. The importance of certain documentation was recognized as a technical report of the delineation and is important for preventing loss of data, which may be valuable for future demarcation and future surveying and geodetic work. According to our experience, the value of the documents above are very useful to support any technician in reconstructing the boundary line. The positional and geodetic data that fully document the location of the boundary are essential descriptive data, and the type and shape of the pillars is only complimentary.
- f. The result of village boundary delineation consists of work maps. The data will be used and followed up for the next stage in the affirmation process. The regional government requires the final product in the form of village maps that have been agreed by village officials, and the ratification of regent/mayor regulations (legalization efforts in legal aspects) with village maps and coordinates of village boundaries as attachments.
- g. The development of mapping technology and spatial data requires geospatial data and information in a digital format that can facilitate data analysis, etc. With the rapid development of mapping technology, and in following up on the delineation of village boundaries that are filled with geodesy aspect and the use of geospatial data information, reliable human resources are needed in the field of geospatial information. This special expertise can be obtained through education and training related to the field of geospatial information, such as understanding aspects

of village boundary mapping, the use of GNSS for positioning, remote sensing, and the use of GIS software etc. So far there is a lack of human resources in local governments in the geospatial sector or mapping. Training of a combination of conventional methods (face to face) and elearning systems should be considered. By implementing the E-learning system, it is expected to be more optimal.

V. CONCLUSIONS AND SUGGESTIONS

1. The large volume of villages in Indonesia and the urgency of the availability of village maps require a mechanism to accelerate the provision of village maps. Cartometric method has been successfully applied as an alternative model in accelerating the determination of village boundaries
2. Upright high resolution satellite images (ortho image) such as Pleiades , World View 2 , SPOT 5 and SPOT 7 are very useful to use in mapping village boundaries, especially in areas where topographic maps on a scale of 1:5,0000 are not available. Technical studies are needed regarding the assessment of geometric accuracy of coordinates related to horizontal accuracy, mainly when coordinates are extracted by cartometrics from ortho images
3. It is expected that the availability of village boundary spatial data in the form of work maps resulting from delineation of village boundaries produced by BIG in the 2013-2019 period, can be immediately followed up by the regional government in supporting the acceleration of legalization in the legal aspects, especially in areas with agreed boundaries. Simple procedures need to be formulated by BIG as technical guidelines.
4. It is necessary to increase coordination between the level of regional and central government in accelerating the implementation of village boundaries, so that they can be implemented efficiently, transparently and accountably in order to intensify the implementation of Permendagri no. 46 of 2016 concerning Determination and Affirmation of Village Boundaries
5. There is a need to improve the synergy between the Ministry of Home Affairs, BIG, Local Governments, and Universities to improve adequate human resource capacity in the aspects of planning, village boundary mapping through education/training, technical guidance, and border research primarily related to spatial information, both hardware and software.

6. It is necessary to conduct human resource development in enhancing the competence of the geospatial information specifically for the purpose of establishing and affirming village boundaries
7. It is necessary to accelerate the complete coverage and updating of basic Geospatial information throughout the NKRI region and necessary to procure large-scale maps to support various development programs in Indonesia

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