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Updating Small Working Area Statistics Mapping Using High-Resolution Image Data: A Case Study to facilitate population calculation in Batam Municipality, Indonesia

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A B S T R A C T

The identification of the administrative area maps is done using the data from boundary mapping conducted by field workers. This mapping was carried out with a process of field survey and renewal of the position of the boundaries of the area. These regional boundaries will be processed by supporting applications (QGIS). This research aims to update the statistical data map used to calculate the population in the research area. The regional apparatuses serve as a starting point for mapping processing and as information on the smoothness of the 2020 population census. The processing produces administrative boundary data that have been updated from the previous map in the form of gender and infrastructure, the number of residents per district, the area per district and the location of astronomical lines in the region. Based on the mapping identification results, there are several boundaries of the area whose position has been shifted due to two factors, namely changes by natural factors and changes by human activities as well as a discrepancy between Digital Maps and Analog Maps. It is then necessary to map administrative areas that are in accordance with the application of satellite imagery (SW Maps) which are represented in vector format.

A R T I C L E   I N F O

1. INTRODUCTION

Issues on population are one of the problems faced in almost all regions of Indonesia, which over time will greatly affect population growth affecting various aspects of life in the form of population density, number of sexes, and the number of facilities and infrastructure (Gustiawan, 2018; Inayah, et al., 2018; Nanggung, etal., 2020; Robial, 2015).

For this reason, mapping is needed in each region which will contain some information consisting of past and present information obtained from the results of data collection in accordance with field conditions (Mossoux, et al., 2018; Robial, 2015).

This mapping takes population data in an area based on sex ratio, number of facilities and infrastructure (social, economic, and education), and population density. These data are in the form of a digital map and analog map (Kusumaningrat, et al,. 2017; Porter, et al., 2019). Throughout Batam city, there are no underlined areas of mapping activities carried out by the Batam Central Statistics Agency in May and its processing from May-September 2019. However, there are several areas identified as having inaccurate information quality in the form of administrative boundaries, landmarks, infrastructure, and content. That's why Ground check was re-done to ensure the truth of field conditions with Digital Maps and Analog Maps (Chandler, et al., 2018; Mossoux, et al., 2018; Silvan-Cardenas, et al., 2010).

Information regarding mapping and identification of population in Tembesi, Batu Besar, Sambau and Tanjung Piayu, is processed manually and automatically using Quantum GIS (QGIS) software and SW Maps. Presentation in the form of a map will help the process of observing population identification patterns and RT / RW boundaries more easily (Kwan, et al,. 2015; Robial, 2015).

The importance of this ground check phase is expected to be able to facilitate the delivery of information about the route to be passed by the 2020 Population Census officer, so as to minimize the occurrence of faults on the route to be passed (Napieralski, et al,. 2007; Rehman, et al., 2017; Setiadi, et al., 2015). Based on the aforementioned background, in the mapping the author takes the title "Updating Small Working Area Statistics Mapping Using High Resolution Image Data: A Case Study to Facilitate Population Estimation In Batam Municipality (Tembesi, Tanjung Piayu, Duriangkang, Sambau and Batu Besar)".

2. RESEARCH LOCATION

This research is located on some areas in Batam city, the Location is at Sungai Beduk sub-district and Tanjung Piayu sub-district. The research area is located in coordinates 01˚ 02' 19,464'' LU and 103˚ 59' 44,34'' BT, 01˚ 01' 7,176'' LU and 104˚ 4'16,968'' BT, 01˚ 10' 9.804'' LU and 104˚ 4'52.032'' BT.

3. METHODS

The data used in this mapping are secondary data and primary data, where the location map reference data are obtained not directly from the direct collection process in the field, but rather obtained from the Central Bureau of Statistics Agency which had previously carried out the mapping. These secondary data are used to conduct an error-indicated ground check so that inaccurate data are obtained. The second data in this study are primary data, where the data used are obtained directly through the results of the ground check field using the SW Maps application and Analog maps. The data generated from the

ground check ground are the data in the form of coordinates with the following procedure (Li and Lu, 2016; Nasution, 2018; Salim, et al,. 2018).

- Preparing the tools and materials needed in the research process;
- Identifying administrative maps using the QGIS application; the identification process includes the name of the district and also the suitability of its identity;
- Splitting the Parent Map data (Batam Municipality Map) which is used to make Analog and Digital maps that are needed to help the process of making coordinates;
- Overlaying between digital maps and maps that have been provided by the Batam Central Statistics Agency. In this overlay process, it uses the facilities provided by QGIS in the form of plugins. Overlays are used to determine the suitability of administrative boundaries with Google Satellite in several regions;
- Creating a project in the SW Maps application to design the coordinates of Groundcheck results;
- Creating a layer in SW Maps by selecting Geo-packaging and entering the results of the split main data that is useful for displaying the digital map needed to carry out the ground check process and make the labeling process at each study location; and
- Conducting a field ground check, this is done if the area is indicated by administrative boundaries, merging and inaccurate field officers when making previous maps.

To ensure the administrative boundaries of the village, the first thing to do is to confirm the village, local RT/ RW (Kwan, Hariyanto and Setyawan, 2015; Rehman, et al., 2017) if information related to the administrative boundaries is sufficient, then the coordinate photo will be taken as a marker to carry out the digitization process using the SW application Maps (Ramadhani, Bennett and Nex, 2018). Processing of ground check data from the field by taking photos of coordinates in the administrative boundaries and also photo infrastructure is done by shapefile data export from the SW Maps application. Then the shapefile will be overlaid on digital maps in the form of Google satellite, and will be compared between digital maps with maps of Ground check results from the field. If damage is identified on the previous map, it will be done to repair the suitability by digitizing using the Quantum GIS (QGIS) application (Smith, Rose and Booth, 2006; Porter, et al., 2019; Ahmad and Kim, 2020). Geometric correction needs to correct recording errors geometrically so that the resulting image has a same coordinate and scale system (Markiewicz, et al., 2019), as a field control point (reference coordinates) for geometric corrections a map of the earth scale of 1: 25,000 was used. Field control points are determined by comparing the appearance of objects on the map and satellite imagery (Gonzalez-Partida, et al., 2008).

The next step is to create polygon administrative boundaries following the updating of analog and digital maps. After the digitization repair process is complete, the next step is to merge digital maps of the administrative area and perform cleaning that serves to tidy up the gaps between polygons and clean up when polygons occur in line with one another using the Quantum GIS (QGIS) application. The results of a digital map that has been carried out by the cleaning process is then done by making a layout using a template in accordance with the previous map template. The work areas for census and survey activities carried out by the Central Statistics Agency include administrative, governmental, including units, settlements, transmigration, communities, isolated tribes and enumeration areas. The statistical work area consists of provinces, districts/ cities, villages/ villages, and SLS and Non-SLS Regions.

Administrative boundaries and infrastructural facilities using geospatial techniques are presented in the form of thematic maps, which include the number of family cards, sex, sub-

facility facilities, so that the map can be used by population census field officers in 2020. The research flow diagram is shown in **Figure 1.**

Figure 1. The research flow diagram

4. RESULTS AND DISCUSSION

In this chapter, we will discuss the results of the mapping that have been carried out, namely the justification of boundaries, the provision of information such as: gender (Gender), Area, Astronomical Lines, and Data on the Number of Population per Village in one District. After the data is grouped and proceed with data processing, both the data from the previous field results with the real data that has been checked again. Then the results of this data processing and mapping are useful for the local community, local structures and especially the "2020 Population Census" officers later.

4.1. GEOMETRIC CORECTION

Geometric correction is an effort to correct recording errors geometrically so that the resulting image has a uniform coordinate and scale system, and is done by means of translation, rotation, or scale shifting. As a field control point (reference coordinates) for geometric corrections a map of the earth scale of 1: 25,000 was used. Field control points are determined by comparing the appearance of objects on the map and satellite imagery. The number of field control points used for geometric correction is 10 points, which are spread in the study area. Coordinate transformation technique used is affine order 1, while resampling is done using the nearest neighbor technique. The results will be described in **Table 1, Table 2, Table 3** and **Table 4.**

Table 1. Gender

Subdistrict	District	Gender	
		Male	**Female**
Sagulung	Tembesi	19.492	18.574
	Sungai Binti	12.992	11.813
	Sungai Lekop	10.296	9.586
	Sagulung Kota	14.618	13.412
	Sungai Langkai	23.309	21.869
	Sungai Pelunggut	14.009	13.189
Sungai Beduk	Tanjung Piayu	9.551	9.02
	Muka Kuning	3.781	3.3784
	Duriangkang	9.807	9.36
	Mangsang	19.721	19.475
Nongsa	Ngenang	745	674
	Kabil	15.526	14.025
	Batu Besar	14.455	13.424
	Sambau	5.264	4.905

Tabel 2. Total Area

Subdistrict	District	Area (km2)
Sagulung	Tembesi	38.12
	Sungai Binti	5.759
	Sungai Lekop	4.071
	Sagulung Kota	1.933
	Sungai Langkai	3.983
	Sungai Pelunggut	9.994
Sungai Beduk	Tanjung Piayu	42.093
	Muka Kuning	12.001
	Duriangkang	9.999
	Mangsang	56.581
Nongsa	Ngenang	81.47
	Kabil	48.11
	Batu Besar	96.68
	Sambau	64.09

Table 3. Total population

Subdistrict	District	Total Population
Sagulung	Tembesi	38.006
	Sungai Binti	24.807
	Sungai Lekop	19.882
	Sagulung Kota	28.03
	Sungai Langkai	45.178
	Sungai Pelunggut	27.198
Sungai Beduk	Tanjung Piayu	18.571
	Muka Kuning	7.565
	Duriangkang	19.167
	Mangsang	39.196
Nongsa	Ngenang	1.419
	Kabil	29.551
	Batu Besar	27.879
	Sambau	10.169

Table 4. Atronomis position

Subdistrict	District	Astronomis Position	
		Latitude (LU)	Longitude (BT)
Sagulung	Tembesi	1.03874	103.99565
	Sungai Binti	1.03425	103.93885
	Sungai Lekop	1.03596	103.95589
	Sagulung Kota	1.04275	103.95194
	Sungai Langkai	1.03694	103.96578
	Sungai Pelunggut	1.02871	103.95887
Sungai Beduk	Tanjung Piayu	1.02629	104.0656
	Muka Kuning	1.06739	104.01865
	Duriangkang	1.01866	104.07138
	Mangsang	1.03877	104.05583
Nongsa	Ngenang	1.0494	104.1267
	Kabil	1.04473	104.03399
	Batu Besar	1.13187	104.08744
	Sambau	1.16939	104.08112

4.2. DESCRIPTION OF BOUNDARY MAPPING

In this mapping we can get the truth of the position of the boundaries of RT / RW in each region. This mapping will be the fina result of this thesis. Information on population data will be loaded on maps of the 2020 population census statistical work areas. Data that can present map supporting data and more real information as a means of supporting regional progress.

1. Map of Work Areas for the 2020 Population Census Statistics of the Sagulung District of Batam. The result is shown in **Figure 2** and **Figure 3.**
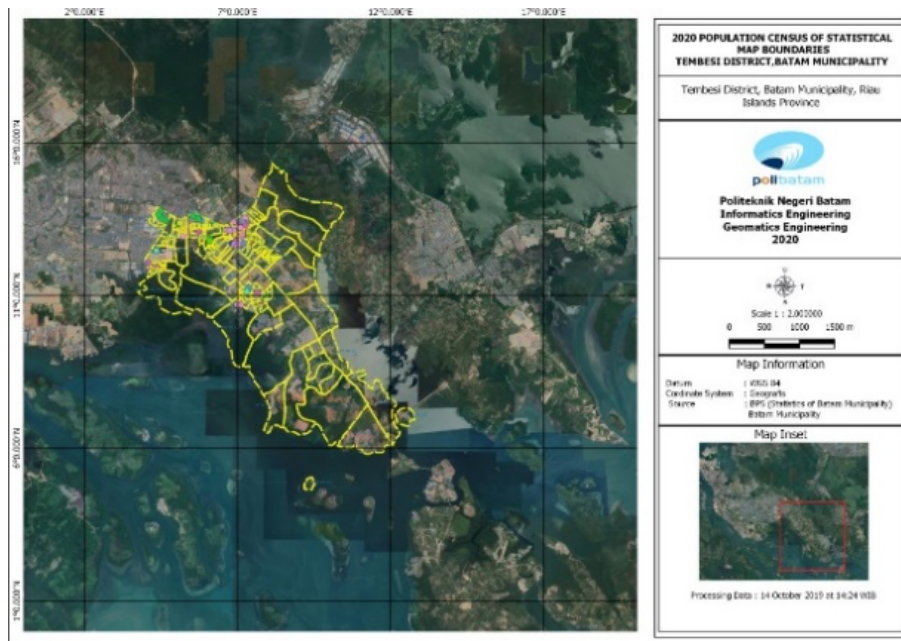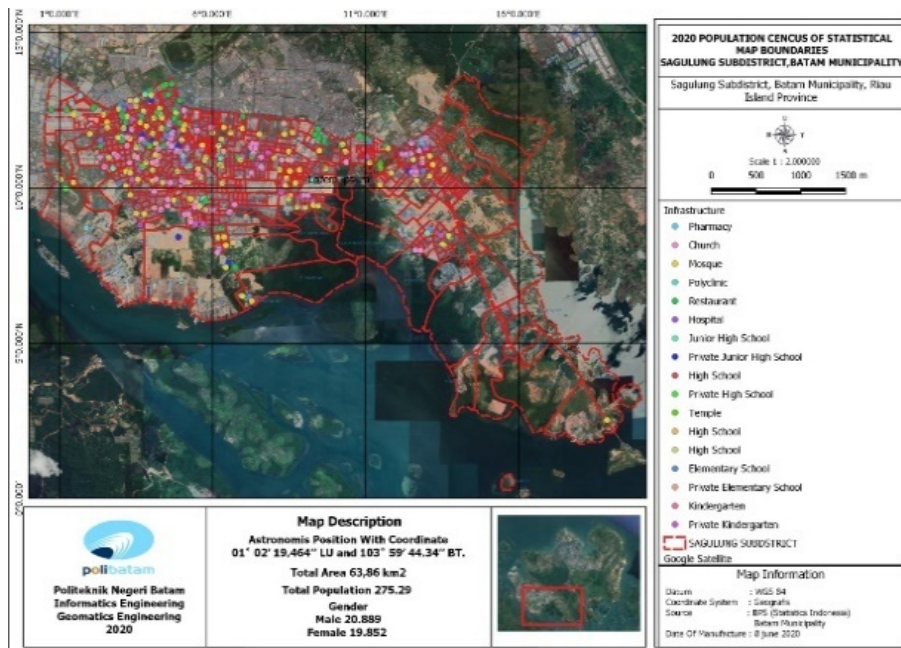
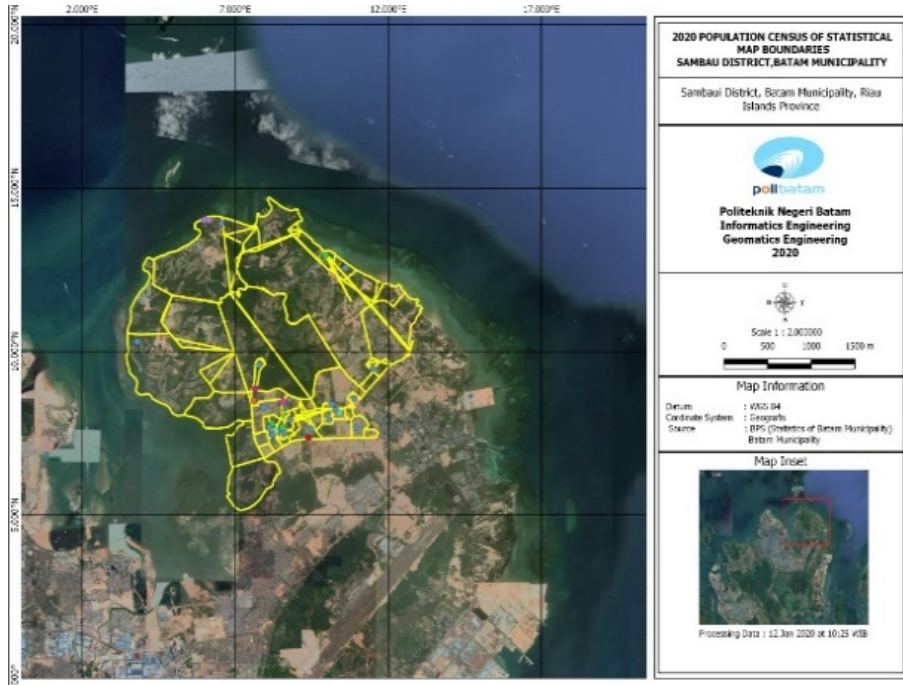**Figure 2.** Mapping location of Tembesi District

Source: BPS-Statistic of Batam Municipality, Interview of Regional Study Area
Figure 3. Mapping location of Sagulung District

The results of the research through the map data above show the boundary of the Sagulung District and the Tembesi Village area map. It can be seen that Sagulung District has various kinds of facilities and infrastructure in the form of education, health, economy, and places of worship. The boundary line of the Sagulung Subdistrict experienced a division, this was due to a dispute between the local administrative agency and the increasing population occupying the Sagulung District. Sagulung District has an area of 63.86 Km² with the number of Residential Census Buildings in Tembesi Village (14,531), Sungai-Binti (7,458), Sungai-Lekop (6,185), Sagulung Kota (7,841), Sungai-Langkai (11,886), Sungai -Pelunggut (9,836), and the number of non-residential census buildings in Tembesi Village (1,497), Sungai Binti (687), Sungai-Lekop (133), Sagulung-Kota (1,595), Sungai-Langkai (809), Sungai-Pelunggut (1,080)

and the number of empty residential census buildings in Tembesi Village (1,939), Sungai Binti (949), Sungai-Lekop (644), Sagulung-Kota (656), Sungai-Langkai (1,020) and Sungai-Pelunggut (1,158).

2. Map of Work Areas for the 2020 Population Census Statistics of the Nongsa District of Batam. The result is shown in **Figure 4** and **Figure 5.**

Before

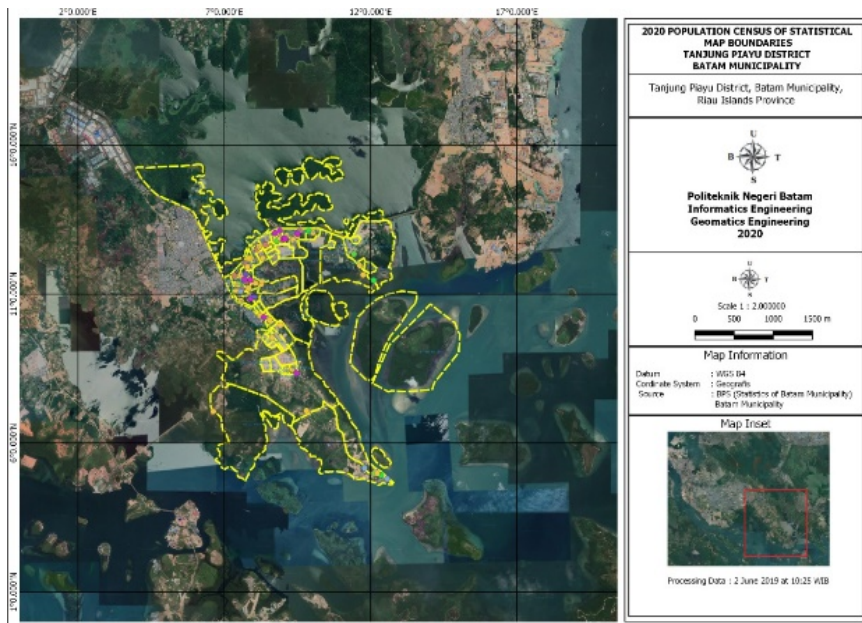**Figure 4.** Mapping location of Nongsa District (Before)
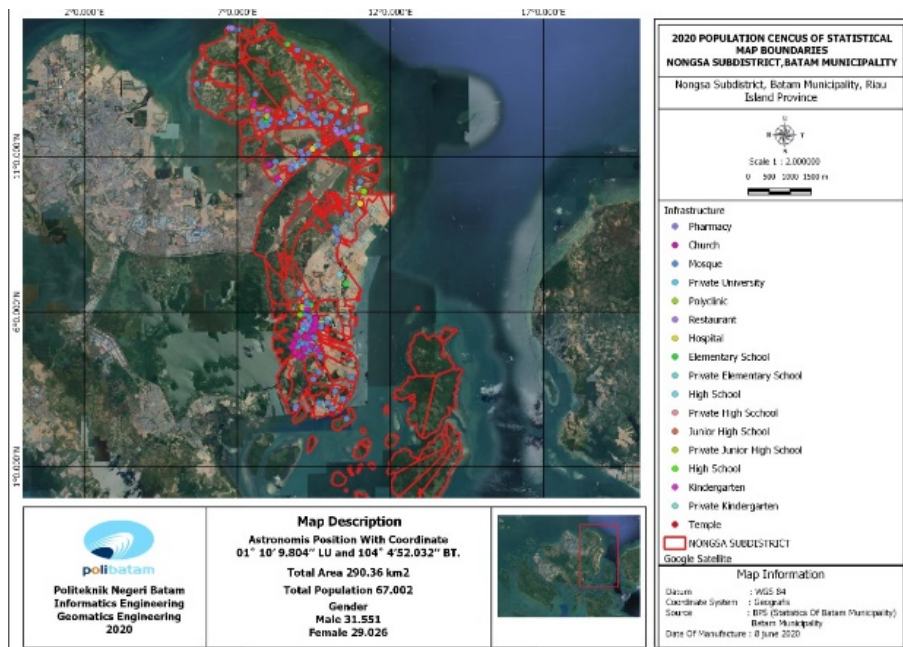
After

Source: BPS-Statistic of Batam Municipality, Interview of Regional Study Area

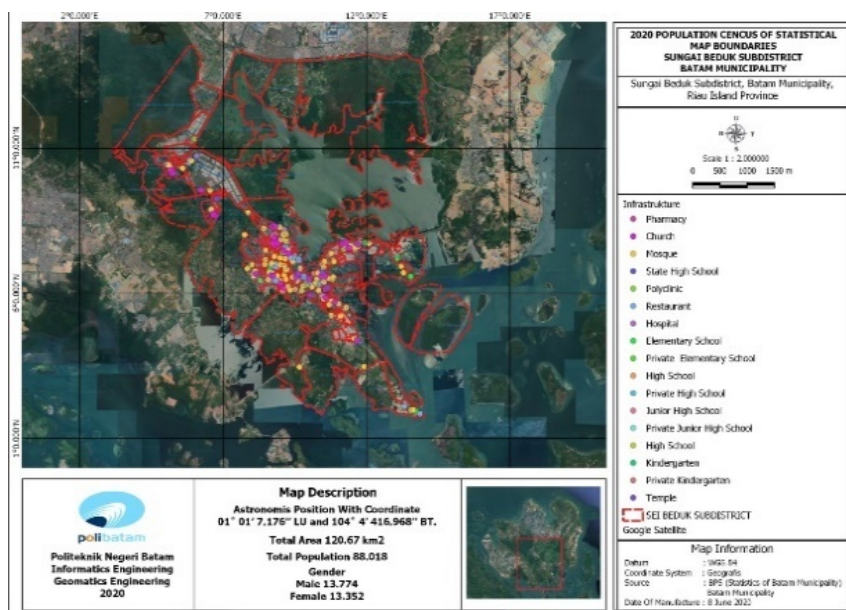**Figure 5.** Mapping location of Nongsa District (After)

The results of the research through the map data above shows the boundaries of the Nongsa Sub-District and the map of the boundaries of the Sambau Village. It can be seen that Nongsa Sub-District has various kinds of facilities and infrastructure in the form of education, health, economy, and places of worship. The boundary line of the Sagulung District experienced expansion, this was due to a dispute between the local administrative agencies. Nongsa District has an area of 290.36 Km² with the number of Residential Census Buildings in Ngenang (328), Kabil (9.448), Batu Besar (9.803), Sambau (2.882) Census Buildings, and the number of Non-Residential Census Buildings in Ngenang Village (22), Kabil (652), Batu Besar (249), Sambau (59), and the number of empty census buildings in Ngenang (26), Kabil (712), Batu Besar (1,300), Sambau (171).

3. Map of Work Areas for the 2020 Population Census Statistics of the Sungai Beduk District of Batam. The result is shown in **Figure 6** and **Figure 7.**

Before
Figure 6. Mapping location of Tanjung Piayu District (Before)

After
Source: BPS-Statistic of Batam Municipality, Interview of Regional Study Area
Figure 7. Mapping location of Tanjung Piayu District (After)

The results of the research through the map data above shows the boundaries of the Sungai-Beduk area. It can be seen that Sungai-Beduk Sub-District has various kinds of facilities and infrastructure in the form of education, health, economy, and places of worship. Tembesi Village has an area of 120.67 Km² with a total male population of 31,551 people with the number of Residential Census Buildings in Tanjung Piayu Village (6,706), Muka Kuning (4,230), Duriangkang (5,425), Mangsang (11,661), and the number of Census Buildings. Non-Residential in Tanjung Piayu (307), Muka Kuning (789), Duriangkang (442), Mangsang (588), and the number of Empty Residential Census Buildings in Tanjung Piayu (990), Muka Kuning (3.039), Duriangkang (876), Mangsang (778).

5. CONCLUSION

Updating small working area statistics map to facilitate population calculation based on all the results of the mapping in the field that has been done is important to know the state of the administrative area more accurately at the same time can find out the conditions and error points of the boundaries of the region. From the mapping results, we can find the geographical location and coordinate points as justification points for the boundaries. The results of the mapping can also be a source of accurate information for map users. From the three districts that have been concluded by the author, that the population data obtained is the real data. This data is carried out with an interview system by the mappers and several district structures that manage the study areas conducted by the mappers. Gender and infrastructure data which is made as information on the map can also provide information on population development in that year about how the area is developing.

6. RECOMMENDATION

Updating the statistical work area needs to be carried out on an ongoing basis so that it can be used as an accurate basis so as to get statistical data that is in accordance with the targets to be achieved.

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