Compared Of Coastline Extraction On Sentinel-2A Imagery and Aerial Photos : Case Study in Panggang Island, Kepulauan Seribu, Indonesia

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Abstract. Panggang Island is one of the inhabited islands in the Kepulauan Seribu and has a high population density. This high population density has led to widespread infrastructure development on the coast, both seaside settlements and piers as facilities and infrastructure for population mobility, thus affecting the position of the coastline. Coastlines can be determined by remote sensing using several sensors such as aerial photography and satellite imagery as technology used to capture phenomena on the earth's surface. This research aims to see differences in coastlines using two sensors with different spatial resolutions and see their accuracy. Sentinel-2A imagery uses the *Modified Normalized Difference Water Index* (MNDWI) method and aerial photography images use the *Digitation On-Screen* method. The research results show that there is a difference in the length of the coastline of 490 meters with a difference in shape that is not too significant. The level of accuracy using the kappa coefficient shows a figure of 0,69. So that in this study it can be concluded that the coastline formed is satisfactory in the process of comparing coastline formation with two different resolutions and is included in the satisfactory category (good).

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1. Introduction

The coastline is an imaginary line that can change because it adjusts to the tide or low tide at certain times. Coastal areas are where the sea and land meet to form a boundary which is commonly known as the coastline. There are 3 (three) types of coastlines, namely the lowest tide coastline (LAT), Mean sea level coastline (MSL), and the highest tide coastline (HAT)[1].

Panggang Island is one of the islands that is part of the Thousand Islands unit in northern Jakarta and has a high population density compared to the other islands in Kepulauan Seribu [2]. This high population density has led to widespread infrastructure development on the coast, both residences on the sea and piers as facilities and infrastructure for population mobility, thus affecting the position of the coastline

Changes in the position of the coastline can be monitored through the development of remote sensing technology which has greatly helped human work in area monitoring, mapping and modelling. The development of remote sensing sensors that provide data with wide area coverage will produce more varied information. Remote sensing data can be generated through various sensors, for example Sentinel-2A satellite imagery which has a spatial resolution of 10m/pixel[3]. The limitations of sensors that record the earth's surface remotely will be disturbed by atmospheric conditions such as cloud cover and water vapor, causing the resulting information to be slightly different from actual conditions and slightly inaccurate for area monitoring and mapping.

Several scientists continue to try to overcome this problem, so that in recent years an aerial photo sensor with higher accuracy has been developed as a solution for area monitoring and mapping. However, Indonesia's territory consists of many islands, meaning the available data is incomplete, so for some areas the data is not available. Apart from that, the use of aerial photography using an Unmaned Aerial Vehicle (UAV) which has a resolution of 5cm/pixel can be used for mapping small islands such as the current research location[4]

Compared of recordings with two different sensors will also get different coastline extraction results. Coastline extraction in Sentinel-2A satellite imagery uses the *Modified Normalized Difference Water Index* (MNDWI) algorithm utilizing the Green and SWIR bands to separate land and sea. Meanwhile, the aerial photo processing using agisoft metashape software produces orthophotos and then to obtain coastline extraction results using the *Digitization on screen* method.

Using data from two image with different resolutions can done with fast for know comparison results shoreline extraction use Sentinel-2A imagery and photos air use Unmaned Aerial Vehicle through accuracy tests. The resulting difference from second method extraction the can seen based on accuracy test uses kappa coefficient.

The purpose of carrying out this research is determine the differences in the results of the coastline extraction of Panggang Island from two remote sensing sensors with different spatial resolutions, namely the processing of Sentinel-2A Satellite Imagery and Aerial Photos by Unmanned Aerial Vehicle by the Geospatial Information Agency in the form of maps, as well as to determine the level of accuracy coastline results from high resolution images and medium resolution images.

2 Research methods

2.1 Time and Place

Study implemented from July to September 2023. Processed data obtained from processing of Sentinel-2A satellite imagery in 2021 and aerial photos in 2021 using an Unmaned Aerial Vehicle (UAV) by the Geospatial Information Agency. Data processing carried out at the Center for Marine and Coastal Environmental Mapping, Geospatial Information Agency. Research location used in this research is Panggang Island, Kepulauan Seribu in Figure 1.

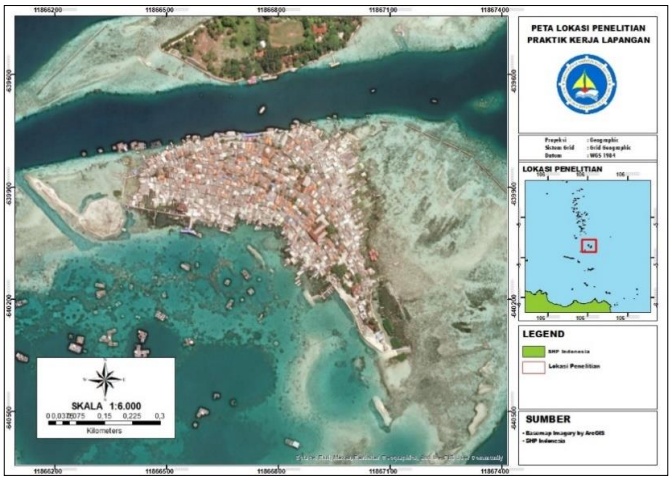

Fig 1. Map of research locations

2.2 Tools and Materials

Table 1. Data Types and Sources

No	Data Type	Source
1	Sentinel-2A Satellite Image	Copernicus scihub website
2	Recording Data Aerial Photo	Center for Marine and Coastal Environmental Mapping, Geospatial Information Agency
3	Elevation Data Advance Sea	Website Center for Geodetic and Geodynamic Control Nets
4	Map of Indonesian Coastline	Website of the Center for Marine and Coastal Environmental Mapping

Table 2. Types of software

No	Software	Utility
1	ENVI 5.3	Pre-processing of satellite image
2	ArcGIS 10.8	Extraction coastline analysis
3	Agisoft Metashape	Processing of Photogrammetry

2.3 Methods and Procedures

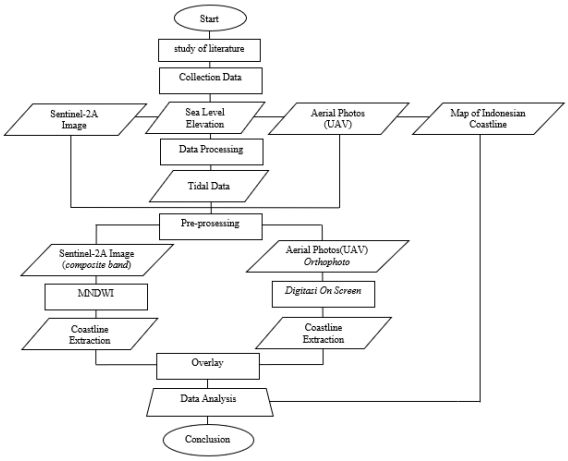

Figure 2. Flow Diagram

2.3.1 Data Collection

This research was conducted on Panggang Island, Kepulauan Seribu. Primary data in research this namely aerial photography image data from Geospatial Information Agency at the Center for Marine and Coastal Environmental Mapping unit with a recording date of August 30, 2021.

Next, data collected from several sources in this research :

a. Data sentinel-2A imagery is downloaded on the page Copernicus officially with acquisition on August 27, 2021.
b. Sea level elevation data from page of Indonesian Geospatial Reference System on the official website of the Geospatial Information Agency with time recording adapt image data recording Sentinel -2A and aerial photos on 27 & 30 August 2021.
c. Map of the Indonesian coastline at the research location provided by the Center for Marine and Coastal Environmental Mapping unit on the official website of the Geospatial Information Agency, namely https://tanahair.indonesia.go.id/ .

Data Processing

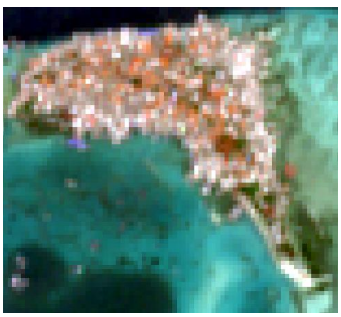

Fig 3. True Color

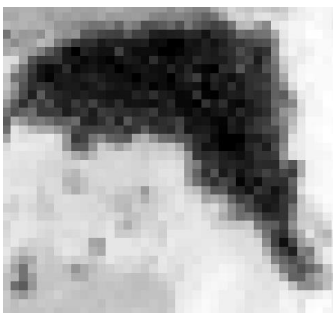

Fig 4. With Algorithm

Sea Level Elevation Data

Sea level elevation data available obtained through page of Indonesian Geospatial Reference System on the official website of the Geospatial Information Agency is then processed to obtain tidal data which is displayed in graphical form.

Satellite Image Data

Data image Sentinel -2A processed through pre-processing stages using software Envi 5.3. Then continue with do composite bands true calor and false calor utilizing the *Red, Green, Blue* and *SWIR* band*s* . Next, to focus the research area, it is necessary to form an Area of interest (AOI) via ArcGIS 10.8 software using *the extract by mask tools*[5].

In processing sentinel image that uses *Modified Normalized Difference Water Index* (MNDWI) method then will using the formula as following[6] ;[7]

$$\text{MNDWI} = \frac{(Green - SWIR)}{(Green + SWIR)} \quad (1)$$

On sensing far specifically for processing image , purposeful use of *Modified Normalized Difference Water Index* (MNDWI) for different between there is water and also land. Coastline extraction process as well as exists delineation waters become important thing when will evaluate the quality that exists in something waters. MNDWI algorithm has possible value calculated on each pixels.

After that, carry out extraction using an algorithm *Modified Normalized Difference Water Index* (MNDWI) in ArcGIS 10.8 software , the results of the raster data obtained are then separated by the digital number values between land and sea using conditional tools with the following algorithm Then the raster data must be converted into vector data to obtain coastline data.

$$con\ (MNDWI, 0 < 1 < 0) \quad (2)$$

Aerial Photos

Photo recording data air using Unmanned Aerial Vehicle processed using Agisoft software Metashape with stages The start is entering Photo recording that has been has the next reference aligned. The next stage is to create a *point cloud* and *build demo* as well as build ortho for get *orthophoto*. Then results *orthophoto* is exported for further processing in ArcGIS 10.8 software. The resulting *orthophoto* was then processed using ArcGIS 10.8 software to produce coastline extraction using the *Digitation On Screen* method.

1.3.1. Data Analysis

Resolution Shoreline Analysis Medium and High Against the BIG Coastline

Sentinel and imagery data Photo aerial UAV that has been through stage data processing so give results A map complete with the coastline with resolution middle and high. Next the coastline is formed from results processing the data will be analyzed to coastline reference from BIG (Badan Informasi Geospasial). Originally a coastline from BIG will shared into 4 segments , where every existing segments consists from 5 points connecting link segment one with other segments.

Accuracy Test Analysis Cohen's Kappa

Accuracy test analysis using Cohen's Kappa was used in field sensing Far with objective For determine is in One matrix error in a way significant different from others with formula calculations shown in equation below this[8]

$$K = \frac{Pr(a) - Pr(e)}{1 - Pr(e)} \quad (3)$$

Information :

Pr(a) = percentage of the number of measurements that are consistent between *raters*
Pr(e) = percentage amount change between *rater*
Then value that appears from results calculation will matched based on table category kappa coefficient below this.

Table 3. Kappa Coefficient Category

K < 0.40	Bad *(bad)*
K 0.40 - 0.60	Enough *(fair)*
K 0.60 – 0.75	Satisfying *(good)*
K > 0.75	Special *(excellent)*

2. Results and Discussion

2.1 Coastline Extraction in Resolution Imagery Medium and High Resolution Aerial Photographs

Coastline extraction results from Sentinel imagery using the MNDWI (*Modified Normalized Difference Water Index*) method, because MNDWI method itself more superior in matter extraction For different regional conditions big is body of water on land surrounding areas which are non- built and water areas which have concentration sediment low utilizes the Green band and SWIR band to separate land and sea [9]. The use of the MNDWI algorithm produces a line with length of 2,433 meters and the area is 174.31 km2, while the coastline extraction results from aerial photos use the *digitization on screen* method produces a line with length of 2,923 meters and the area is 147,45 km2 which will be presented in Figures 6 and 7.

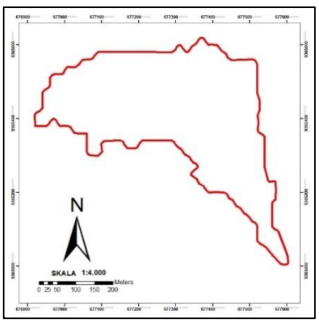

Figure 5. Sentinel-2A Coastline

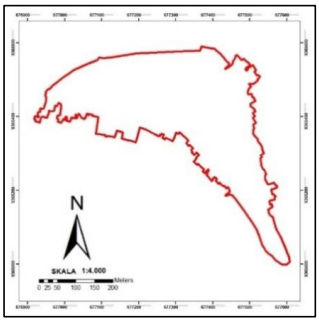

Figure 6. UAV Coastline

So, results shoreline extraction image Sentinel that uses MNDWI and imagery Photo UAVs use air digitization on-screen can displays comparison the length of the coastline overlay formed in the form of 490 meters and area 26,86 km^2. Besides that from the displayed coastline results extraction second image did not show a significant difference. Judging from the tidal condition of table 3, the recording was carried out when the sea water was high. So that the coastline formed is not influenced by the physical conditions of the waters.

Table 4. Tidal Conditions

Sensors	Date	Acquisition Time	Tidal Conditions	Depth(m)
Sentinel-2A Image	27/08/2021	10.00 WIB	highest tide	0,69
Aerial Photos	30/08/2021	13.00 WIB	highest tide	0,78

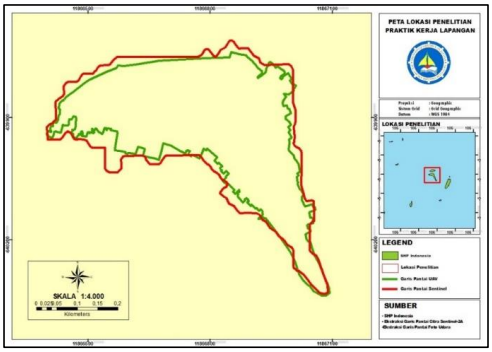

Figure 7. Overlay Coastline

The thing that differentiates namely the coastline results extraction aerial photos more details because has a resolution of 5cm/ pixel. Meanwhile, areas such as docks, anchored ships and floating buildings are classified as land by Sentinel imagery because they have a resolution of 10 meters/pixel as in Figures 8 and 9.

Figure 8. Differences in Classification of Satellite Images and Aerial Photos (1)

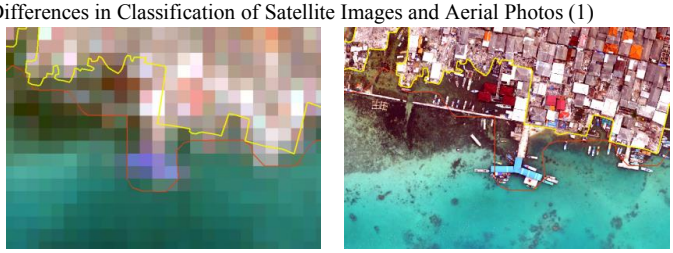

Figure 9. Differences in Classification of Satellite Images and Aerial Photos (2)

2.1 Accuracy Test

2.2.1. Extraction Shoreline Analysis Against the Coastlineby Geospasial Information Agency

Coastline extraction results obtained through Sentinel imagery and stages *digitization on screen* on orthophoto was successful show exists coastline differences with data on coastlines provided by Geospasial Information Agency. Differences emerge is in part different distance between the coastlines obtained through sentinel and orthophoto imagery with coastline data owned by Geospasial Information Agency coastline.

Difference distance the Then shared become a number of segment, where in One segment has five points samples used as comparison. As for the rules according to the Geospasial Information Agency coastline Basemap Assistance FAQ, in measure coastline distance from results extraction Sentinel and aerial photos imagery against written Geospasial Information Agency coastline data if the coastline is at above the Geospasial Information Agency coastline or more approach to land, then the distance in question will worth negative (-). Whereas for coastlines that are below the Geospasial Information Agency coastline or more approach to ocean so will worth positive (+).

Can seen in table 3 which shows results coastline distance aerial photos imagery and table 4 shows results distance to the Sentinel coastline. Where the value is formed from coastline distance between coastlines aerial photos imagery and Geospasial Information Agency coastline has average value of fourth segment amounting to 39,191 meters whereas for mark distance.

Coastline obtained between coastlines Sentinel imagery and Geospasial Information Agency coastline have average value of fourth segment amounting to 99,719 meters. The value of the coastline distance found from results extraction Sentinel imagery uses *Modiffied Normalized Different Water Index* (MNDWI) method with Geospasial Information Agency coastline has a higher average big because *Modiffied Normalized Different Water Index* (MNDWI) method still own weakness where its accuracy enough low [9]if compared to with results shoreline extraction aerial photos with *digitation on screen*. In other words, differences distance that appears in the results shoreline extraction aerial photos images and Sentinel images of the *Modiffied Normalized Different Water Index* (MNDWI) appear because exists difference method extraction, scale and difference resolution recording image good at resolution level medium and image resolution level high.

Table 5. Distance from Aerial Photo Coastline to Coastline by Geospasial Information Agency

	Aerial Photos				Total
	Segment 1	**Segment 2**	**Segment 3**	**Segment 4**	
1	-8,945	23,799	-1,171	-17,848	
2	-5,220	-36,458	-22,821	-17,726	
3	-3,741	24,225	15,568	-18,853	
4	-3,429	-11,598	6,175	-62,730	
5	-0.085	-6,111	-18,430	8,630	

Average	**-21,418**	**-6,142**	**-20,679**	**-108,526**	**- 39,191**

Table 6. Distance from Satellite Image Coastline Coastline by Geospasial Information Agency

	Sentinels				**Total**
	Segment 1	**Segment 2**	**Segment 3**	**Segment 4**	
1	-24,745	-36,686	-8,254	-26,755	
2	-9,190	-11,085	-13,122	-42,371	
3	-16,269	7,791	19,308	-44,447	
4	-19,556	-20,854	12,951	-63,531	
5	-9,243	-36,265	-26,876	-29,676	
Average	**-79,003**	**-97,099**	**-15,994**	**-206,780**	**- 99,719**

2.2.2. Consistency Test With Koefisien Kappa

Based on consistency test analysis comparison of coastlines that have been done , then give results kappa matrix presented in table 7. Required 2x2 table with objective For count results successful kappa value show amount agreement between *rater* (Auliya et al., 2017).Can seen acquisition results that's it as many as 15 pieces of data together own mark as type (-) and only 3 data have it mark as type (+). Whereas on the contrary happen disagreement to the 2 data assessed different from second method used.

Table 7. Kappa Matrix Results

		Aerial Photos		
SENTINEL		−	+	
	−	**15**	**2**	**17**
	+	**0**	**3**	**3**
		15	**5**	**20**

So that If entered to in equation :

$\Pr(a) = \frac{3+15}{20} = 0.9$

Measurement results (-):

$(\frac{15}{20})x\ (\frac{17}{20}) = 0.6375$

Measurement results (+) by:

$(\frac{5}{20})x\ (\frac{3}{20}) = 0.0375$

Pr (e)= Measurement (-) + (+)

$= 0.6375 + 0.0375 = 0.675$

Coefficient value Kappa :

$K = \frac{0.9-0.675}{1-0.675} = 0.69$

So that based on category existing kappa coefficient, can be seen that mark calculation of kappa obtained in the study this of 0.69 and entered to in category satisfactory (*good*). Can concluded that second methods used in research this in the form of aerial photos coastlines and Sentinel coastlines stated already enough for determine the coastline.

3 Conclusion

The aim of this research is to compared coastline extraction results using medium resolution imagery, namely Sentinel-2A satellite imagery with the coastline processing method using the *Modified Normalized Different Water Index* (MNDWI) algorithm and high resolution, namely aerial photography with the coastline processing method using the on screen digitization extraction method in the waters Panggang Island, Kepulauan Seribu, Indonesia. With the coastline length results from aerial photo extraction results being more specific than sentinel-2A extraction results. This is because the spatial resolution of aerial photography is higher, namely 5cm/pixel, so it is closer to perfect and matches the actual coastline on the earth's surface. Meanwhile, the extraction results from the sentinel-2A satellite are shorter because the sentinel satellite records the earth's surface from a long distance with a spatial resolution of 10m/pixel. Therefore, floating areas such as docks and ships that are anchored are read by land.

The result research have shown there is a difference in the results of the extraction of the coastline formed at 490 meters, where the results of the coastline extracted from aerial photos are 2,923 meters and the coastline extracted from the sentinel is 2,433 meters. The results of the accuracy level using the Cohen's Cappa theory show 0.69 so it is included in the satisfactory category (good). Therefore, it can be concluded in this research that the method used is satisfactory in determining the coastline on Panggang Island, Thousand Islands, Indonesia. So in the future, when determining coastlines,

you can use aerial photography or high resolution imagery to produce more accurate extractions, however, if there are obstacles such as limited high resolution image data, you can also use medium resolution imagery. Therefore, in the future, the determination of the coastline can be adjusted to the image that will be used. High resolution aerial photography is more recommended than medium resolution imagery for use in floating areas.

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