JOURNAL OF APPLIED GEOSPATIAL INFORMATION

Vol 1 No 2 2017

http://jurnal.polibatam.ac.id/index.php/JAGI
ISSN Online: 2579-3608

Mangrove Distribution in Riau Islands Using Remote Sensing Technology

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Received: May 26, 2017
Accepted: August 10, 2017
Published: August 11, 2017

Abstract
Mangrove mapping is done with remote sensing technology using high-resolution image data. Application and information are then presented in web form. This study aims to map the mangrove distribution in Riau Islands, Indonesia. Based on the analysis, from the research data obtained the total area of mangrove in Riau Islands in 2011 and 2017 amounted to 71,504.83 Ha and 64,218.90 Ha, decreased by 7,285, 93 Ha or decreased by 10.19%. Based on the regency, the largest mangrove area in 2017 is located in Batam City of 22,964.77 Ha, then Karimun Regency (13,659,58 Ha), Lingga Regency (11,881.61 Ha), Regency of Bintan (9,701.49) Ha, Natuna Regency (2,477.16 Ha), Tanjungpinang City (1,847.65 Ha), and Anambas Regency (1,686.61 Ha). The magnitude of the widespread change (widespread reduction) occurring over the years between 2011 and 2017 by district, Natuna Regency experienced the largest reduction of 1,949.69 Ha or around 41.39%, followed by Lingga Regency of 1,947.15 Ha (14.08%), Tanjungpinang Municipality of 284.13 Ha (13.33%), Karimun Regency 1,920.93 Ha (12.33%), Anambas Regency of 195.90 Ha (10.40%), Batam City 1,094.83 Ha (4.55%) and Bintan Regency with 93.29 Ha (0, 95%). Opportunities that the pixels classified on the mangrove image are truly mangrove on the facts in the field.

Keywords: Mangrove, Remote Sensing Technology, Riau Islands.

1. Introduction

The 32nd Provinces in Indonesia covering Tanjung Pinang City, Batam City, Bintan Regency, Karimun Regency, Natuna Regency, Lingga Regency, and Anambas Regency with an area of 252,601 km2, with about 96% being sea and only about 4% Land area (Kepri Dalam Angka, 2015). One of the natural resources of the Riau Islands region is the mangrove forest. Mangrove serves as a prevention of sea water intrusion, preventing coastal abrasion, as a place to live and food sources for several species of animals (Kathiresan & Bingham, 2001).

The mangrove condition in Kepri is currently damaged. Chairman of the NGO Air and Human Kepri, explained that the damage to mangrove forest or mangrove forest per year in Riau Islands, including Bintan and Tanjung pinang, reaches 40 percent. Generally, carried out by the government, employers and the public on the grounds of economic activity (Tanjung Pinang Pos, 2015). The distribution of mangroves in Riau Islands needs to be known first before prevention and mitigation efforts can be overcome. One way is to do the mapping of mangrove with remote sensing technology.

Remote sensing is the art and science to obtain information about the object, area or phenomenon through analysis of data obtained by using the tool without direct contact with the object, area, or phenomenon that is according in (Lillesand *et al.,* 2014; Sari & Lubis, 2017; Anurogo *et al.,* 2017; Aprilliyanti & Zainuddin; Lubis *et al.,* 2017; Farizki & Anurogo, 2017; Astutik *et al.,* 2017)

Remote Sensing Technology has been growing rapidly at this time. This technology can be used to determine the type of vegetation (Lefsky *et al.,* 2002; Anurogo *et al.,* 2015), vegetation monitoring using unmanned helicopters (Sugiura *et al.,* 2005), land use change (Rogan & Chen, 2004) Measuring and monitoring forest carbon stocks and changes (Goetz & Dubayah, 2011), monitoring lake water quality including supporting the implementation of the Kyoto Protocol on the environment (Rosenqvist *et al.,* 2003).

It is hoped that the Riau Islands mangrove forest map produced can help the government, community organizations (orkemas), and other parties related to policy making such as coastal development planning, ecotourism development, determination of fish breeding area, determination of abrasion free area, and determination of coastal settlement location beach.

Muhsoni (2009) conducted mangrove density mapping in Kangean Islands Using Normalized

Difference Vegetation Index (NDVI) algorithm. The method used by Word to obtain land cover is by using supervised classification.

The resulting mangrove density is divided into three parts, namely: Solid area of 83 Ha, Medium area of 991 Ha, Rare 2.333 Ha. Chevalda (2013) conducted mangrove mapping by detecting and calculating mangrove area using Image Fusion Citra Spot and Quickbid method at Los Tanjung Pinang Island.

Analysis of the distribution and density of mangroves using Landsat 8 image in Segara, West Java (Purwanto *et al.,* 2013).This research did separation of mangrove and non mangrove object by using unsupervised classification method and to analyze mangrove density by using NDVI formula. Martuti *et al.,* (2013) Conducted a study to study the creation of mangrove plant databases by identifying mangrove and mangrove vegetation density levels, so as to provide appropriate recommendations on targets. Primary data collection in this research covers measurement of mangrove vegetation distribution. Vegetation data were analyzed to obtain the Important Value Index (IVI) and Diversity Index (DI).

2. Research methods

Making the map of mangrove forest distribution using remote sensing data tool in this research using high-resolution image data that is the image of Riau Islands region covering Tanjung Pinang City, Batam City, Bintan Regency, Lingga Regency, Karimun Regency, Anambas Regency, Natuna Regency. The working principle of remote sensing method can be seen in **Figure 1**.

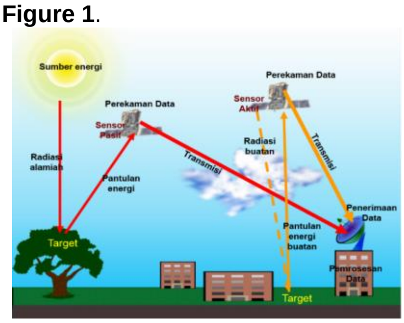

Figure 1. The working principle of remote sensing method (Buttler *et al.,*1988)

The research design is presented in **Figure 2**. In determining the limits of mangrove forests, also consider the elements or key interpretations that can help identify the appearance of objects to be interpreted. The result of the visual interpretation process obtained a tentative dissemination data about mangrove forest. This tentative data is data obtained based on the presumption of an interpreter. The data can be said to represent the validity of the object's appearance in fields validation test.

The tentative data of mangrove forest distribution is then used as a reference for the determination of samples to validate the field. Field validation test is intended to determine the level of truth of visual interpretation results. Testing the level of truth interpretation results using the error matrix with the basic reference of the interpretation that has been made.

The percentage of correctness of the interpretation can be stated that the data of the interpretation result can represent the original appearance in the field. The percentage limitation of the truth of the interpretation result must be greater or equal to 85%. This means that the extraction visual interpretation data from the remote sensing data represents 85% of all visibility in the field.

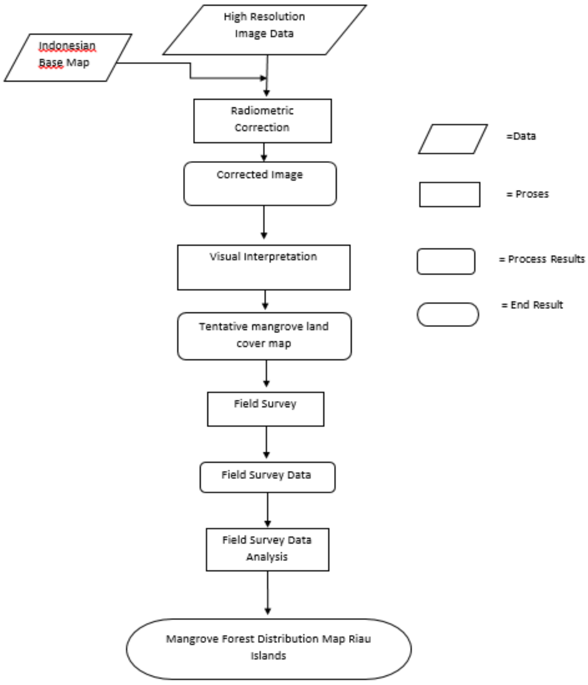

Figure 2. Research Design

The accuracy tests performed on this category data are generally the results of visual interpretation, digital classification, and groupings of spectral transformation values. The technique used is a contingency table that on the science of sensing is much better known as confusion matrix table name. Table the confusion matrix is a matrix table that links between classified pixels and ground truth data whose information can be retrieved from field data and verified maps. Information that can be taken from the confusion matrix is very much including the overall accuracy, accuracy producer, user accuracy, and kappa coefficient.

$$\textbf{Producer accuracy}\ (\%) = \frac{\text{The number of test samples accuracy of a class is correctly classified}}{\text{The number of test samples of accuracy in a class}} X\ 100$$

$$\textbf{User accuracy}\ (\%) = \frac{\text{The number of test samples accuracy of a class is correctly classified}}{\text{The number of test samples that are classified as accuracy class}} X\ 100$$

The value of the user and producer accuracy is calculated for each class that is in the classification. So is the case with omissions and commissions that are residuals of the producer and user accuracy. The overall accuracy score shows the number of pixels correctly classified in each class compared to the number of samples used for accuracy testing in all classes.

$$\text{Overall accuracy}\ (\%) = \frac{\text{The number of correctly classified pixels}}{\text{The number of test samples accuracy}} X\ 100$$

The kappa value shows the comparison between the classified results tested and the random classification results. In other words the kappa value indicates the consistency of the classification result. This kappa value will always be lower than the overall accuracy score.

$$\text{Kappa Coefficient} = \frac{(N\ x\ Xkk) - Xk\sum X\sum k)}{(N2 - \ Xk\sum X\sum k)}$$

Keterangan:

- N : Total sample for accuracy test
- Xkk : The number of correctly classified pixels
- Xk∑X∑k : The number of samples for an accuracy test for each class multiplied by the number of pixels classified in that class and added for all classes.

3. Result and Discussion

The mangrove distribution maps produced in 2011 and 2017 are shown in **Figures 3 and 4**.

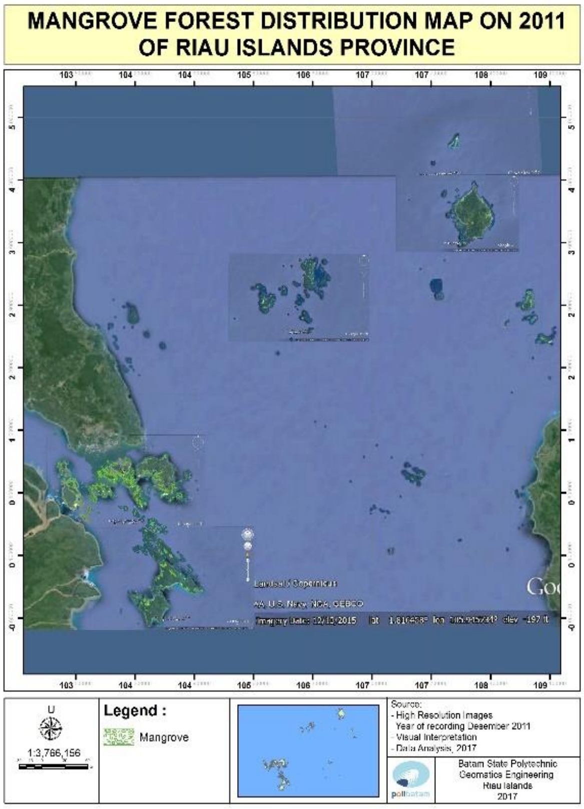

Figure 3. Mangrove forest distribution map on 2011 of Riau Islands

The Differences of Mangrove Area in 2011 and 2017 are presented in Table 2. Based on Table 2 it can be seen that in the current condition (2017), mangrove cities / regencies are Batam City (35.76%), followed by Karimun Regency (21.27%), Lingga Regency (18.50%), Bintan Regency (15.11%), Natuna Regency (3.86%), Tanjungpinang (2.88%), and Anambas Regency (2.63%).

Tabel 2. Luas Magrove di Kepulauan Riau Tahun 2011 dan 2017

No	City or District	Area (Ha)	
		2011	2017
1	Batam	24.059,60	22.964,77
2	Anambas	1.882,52	1.686,61
3	Karimun	15.580,51	13.659,58
4	Natuna	4.226,86	2.477,16
5	Tanjungpinang	2.131,79	1.847,65
6	Lingga	13.828,77	11.881,61
7	Bintan	9.794,78	9.701,49
	Total	**71.504,83**	**64.218,90**

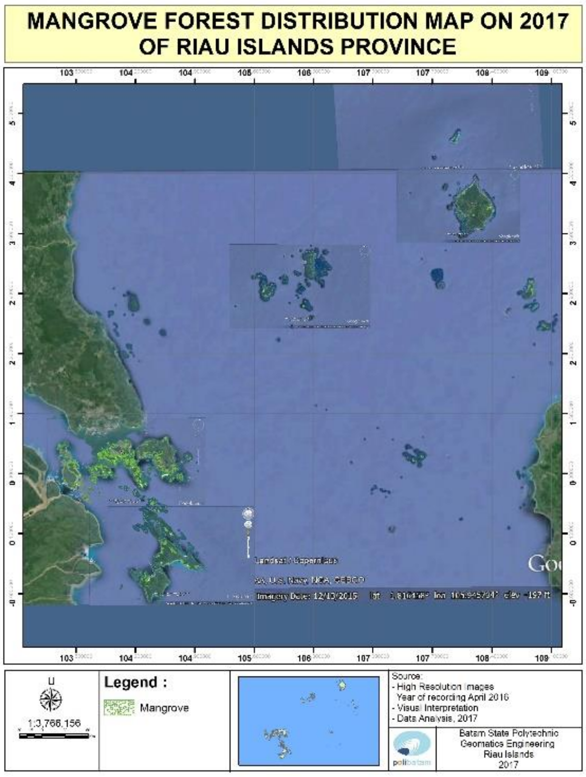

Figure 4. Mangrove forest distribution map on 2017 of Riau Islands

The magnitude of the widespread change (reduction in area) occurring in the year between 2011 and 2017 was 7,285, 93 Ha or decreased by 10.19% when compared to the total area of mangrove in 2011, meaning that within 5 years 10,19% of mangrove forest In the Riau Islands experienced a change of function both for reclamation activities or infrastructure development on the coast. If seen the change of area of regency, then Natuna Regency experienced the biggest wide reduction that is 1,949,69 Ha or about 41,39%, followed by Lingga Regency equal to 1,947,15 Ha (14,08%), Tanjungpinang City equal to 284,13 Ha (13, 33%), Karimun Regency 1,920.93 Ha (12.33%), Anambas Regency (195.90 Ha (10.40%), Batam City 1,094.83 Ha (4.55%) and Bintan Regency 93.29 Ha (0.95%).

Based on research conducted Syahputra (2014) in Riau Islands found 15 species of mangrove which is dominated by Avicena lanata, Lumnitzera littorea, and Xylocarpus granatum. The diversity of species in the Riau Islands is high. Validation results to the field show the same thing, the type of mangrove in Batam Island is also dominated by Avicena lanata and Lumnitzera littorea. Each district on the island of Batam has a wide range of different mangroves. Especially for the Batam Regency, mangrove area is divided into perkecematan as presented in Table 3.

Table 3. Mangrove Area in Batam City of 2011 and 2017

No	City or District	Area (Ha)	
		2011	**2017**
1	Batu Aji	371,484	292,357
2	Belakang Padang	3.004,967	3.002,072
3	Batam Kota	378,772	395,161
4	Bulang	5.525,365	5.377,398
5	Galang	9.108,580	8.996,774
6	Nongsa	1.219,364	1.134,086
7	Sagulung	1.561,204	1.561,204
8	Sekupang	738,871	738,871
9	Sungai Beduk	2.150,995	1.466,846
	Total	**24.059,60**	**22.964,769**

Based on Table 3 on the present condition (2017) seen specifically in Batam City, the sub district has the largest mangrove area located in Galang subdistrict, sub-district of Bulang subdistrict, Padang subdistrict, Sagulung sub-district, Sungai Beduk sub-district, Nongsa sub-district, Sekupang sub- Batam City Sub-district, and Batu Aji Sub-district.

According to research conducted by Irawan & Malau (2016), the mangrove area of Batam Island (without Galang District, Rempang, and Rear of Padang) is 18,805.71 Ha, if per district, Sagulung sub-district is 7,189.78 Ha, Batu Aji sub-district is 692 , 39 Ha, Sungai Beduk sub-district of 4,840, 67 Ha, Nongsa sub-district of 2,801.53 Ha, Sekupang sub-district of 1,431.78 Ha, Batu Ampar sub-district of 170.81 Ha, Batam Town sub-district of 1,032.25 Ha, Bengkong sub-646,49 Ha, and in Kecamatan Lubuk Baja there is no mangrove at all.

The difference in results is due to the different methods used. In this study using visual methods, while research Irawan & Malau (2016) using the method of Normalized Difference Vegetation Index (NDVI). Conditions in the field indicate the large number of human activities that are very harmful to the existence of mangrove forests, including: illegal logging, land use change, pollution and high sedimentation to form new land.

Therefore, the related parties are expected to further improve the supervision and socialization related to the importance of maintaining the sustainability of mangrove forests. Mangrove forest can actually be used as ecotourism. Mulyadi (2015) develop strategies and development of mangrove forests in Sungai Wain Balikpapan through the concept of ecosours are aware of 3 aspects, namely technical aspects, social aspects, and institutional aspects. Maulinna (2011) also stated that mangrove conservation efforts with community participation is the key to success in mangrove conservation. This concept can be applied in Batam Island mengigat Batam is the center of industry as well as tourism in the region of Singapore and Malaysia. Field validation results are presented in Table 4.

Image Interpretation	Field survey		Total	User	Error Commission
	Mangrove	Non Mangrove			
Mangrove	78	9	87	89,65 %	10.35%
Non Mangrove	5	38	43	88.37 %	11.63%
Jumlah	83	47	130		
Producer	93.98 %	80,85 %	Overall : 89.23%		
Error Omission	6.02%	19.15 %	Kappa: 0.837		

Table 4. Field Calculation Validation Results

The value of user accuracy in the mangrove class is 89.65%, which means 89.65% chance that the pixel classified in the mangrove image is really mangrove on the fact in the field. In other words, there is only 10.34% (error commission) it is likely that the pixel that is classified as mangrove is non mangrove in the field.

The value of user accuracy is more favored by the decision makers because the classification results are able to give estimation and description of the actual conditions in the field. The value of producer accuracy in the mangrove class is 93.97%, which means that 93.97% of the mangroves in the field in the research area are correctly classified, ie 19.14% (omission error) of mangrove in the field are not classified as mangrove. This accuracy producer value is generally more favored by the thematician because the accuracy is able to show the number of objects on the surface of the earth that is represented correctly on the map or the result of classification. The value of kappa coefficient in this study is 0.84 which means that the classification results can avoid 83.73% of errors that will appear in the random classification.

3. Conclusion

Based on the results of the research, it can be concluded that the mangrove distribution map produced shows that the total mangrove area in Riau Islands in 2011 and 2017 amounted to 71,504.83 Ha and 64,218.90 Ha, decreased by 7,285, 93 Ha or decreased by 10.19%. The value of user accuracy in the mangrove class classified on the mangrove image is really mangrove on the fact in the field. The accuracy of producer accuracy in mangrove class was 93.97%. The value of kappa coefficient in this study is 0.84 which means that the classification results can avoid 83.73% of errors that will appear in the random classification.

Acknowledgment

I express my sincere thanks to the referees for their valuable suggestions to improve the paper in present form. The authors are grateful to Ditjen Penguatan Riset dan Pengembangan Kementerian Riset, Teknologi, dan Pendidikan Tinggi & Politeknik Negeri Batam.

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