Regional mapping and community development to conserve mangrove forests on the southern coast of Sumenep Madura

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Abstract. The extent of Indonesia's mangrove conditions both qualitatively and quantitatively continues to decline from year to year. The increase in the number of industries and settlements requires the opening of new lands. To be able to meet these needs, the area of mangrove forests on the coast often experience land conversion. In order to protect further damage to mangrove forests, conservation and rehabilitation efforts are needed that involve the community actively. This study aims to identify changes in the area of mangrove forest on the southern coast of Sumenep Madura Regency. Then the research was continued with community service activities through planting seeds and training on the use of mangrove fruits. The satellite image used in this study was 2002 Landsat 7 and Landsat 8 imagery in 2017. The analysis was carried out with image composites followed by the supervised classification method. The results showed that there was a decrease in the mangrove forest area of 95.75 ha in the period 2002-2017. Furthermore, the activity continued with community service through the planting of 3000 mangrove seedlings and training on the use of mangrove resources.

Keywords: mangrove forest, satellite images, Landsat, community services

1 Introduction

Mangrove forest ecosystems are typical ecosystems of coastal areas that play a role in maintaining fisheries resources and for the survival of other ecosystems [1]. Indonesia is one of the countries that have the largest mangrove forest in the world. The area of mangrove ecosystems in Indonesia reaches 75% of the total mangrove in Southeast Asia or about 27% of the total mangrove area in the world. The distinctiveness of Indonesia's mangrove ecosystem is to have the highest diversity of species in the world. Mangrove Indonesia is distributed especially in the coastal areas of northern Java, Sumatra, Kalimantan, and Papua. However, the condition of Indonesia's mangroves both qualitatively and quantitatively continues to decline from year to year.

Data from the State Ministry of Environment released in 2012 explained that the potential area of Indonesian mangrove forests is around 9.204.840,32 Ha. The area can be classified into several classes based on their condition, which is a good condition (2.548.209,42 Ha), moderate condition (4.510.456,61 Ha) and damaged condition (2.146.174, 29 Ha). Another data was provided by the Geospatial Information Centre by analyzing over 190 scenes of

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Landsat satellite imagery data acquired from 2006-2009. The results showed that the area of mangrove forests in Indonesia was 3.244.018,46 Ha with a damage rate of nearly 70%.

The increase[2] in the number of industries and settlements requires the opening of new lands. In order to meet these needs, the area of mangrove forests is vulnerable to be converted into residential and industrial areas. This area conversion can directly give a negative impact and threaten the sustainability of the coastal environment. Previous studies have discussed the possible effect of the loss of mangrove forests and its impact on the coastal area. The destruction of mangrove forests can physically eliminate the function of mangrove forests in preventing coastal abrasion [3], meanwhile, it was reported that in the southern coastal region of Bangkalan Regency, the destruction of mangrove forests resulted in abrasion and caused intrusion of seawater into community wells [4].

Urban spatial planning and the designation of coastal areas that are not obeyed directly can also be potential threats to the mangrove ecosystem [5]. In addition, the illegal logging of mangrove trees by residents to be used as firewood is still often found in mangrove forests. The low concern of the local government towards the protection of mangrove forests is reflected in the absence of clear rules and law enforcement to prevent and reduce illegal logging activities by the community. In fact, several local governments in East Java have eliminated the obligation to reforest mangrove forests in several coastal sub-districts. Of course, this makes the existence of mangrove forest ecosystems increasingly threatened [6].

Efforts to conserve and rehabilitate mangrove areas[7][8] should be done with the support of accurate and reliable scientific data, so that rehabilitation programs are conducted in accordance with environmental characteristics. As a reference for implementing rehabilitation programs, remote sensing images with various advantages offered the relevant data sources. Through the utilization of satellite images, the extent and level of density of mangroves in a location can be observed in detail[9]. Furthermore, through survey activities, environmental information can also be collected and will be very useful in determining the critical level of mangrove land and the form of environmental protection and improvement efforts.

Active participation of coastal communities is very much needed in efforts to conserve and rehabilitate mangrove forests. Intensive and continuous information delivery[10][11] about the importance of maintaining the sustainability of mangrove forests is one way to increase public awareness. In addition, the introduction of the economic benefits of mangrove forests and the direct involvement of the community in land rehabilitation activities can also be a strategy to increased community participation in protecting coastal areas[12]. This study aims to identify changes in the area of mangrove forest on the southern coast of Sumenep Madura Regency[1]. Then the research was continued with community service activities through planting seeds and training on the use of mangrove fruits.

2 Methods

This research was conducted from June to September 2018. The location was southern coast of Sumenep Regency. In general, this research was divided into 2 main activities, namely the identification of changes in the area of mangrove forests and community service to carry out land rehabilitation and the introduction of mangrove processing through training activities.

2.1 Satellite Image Analysis

Identification of changes in the mangrove forest area[7][8] at the location of the study was conducted by analyzing Landsat 7 satellite images acquired from 2002 and Landsat 8 acquired 2017. Image processing was carried out using ENVI 4.5 software and ArcGIS 10.2. The main output produced of this process was a map that showed the distribution of mangrove forests and their density (seen from the NDVI index value). The flow of satellite image processing to determine the distribution and extent of mangrove forests is explained in the following diagram.

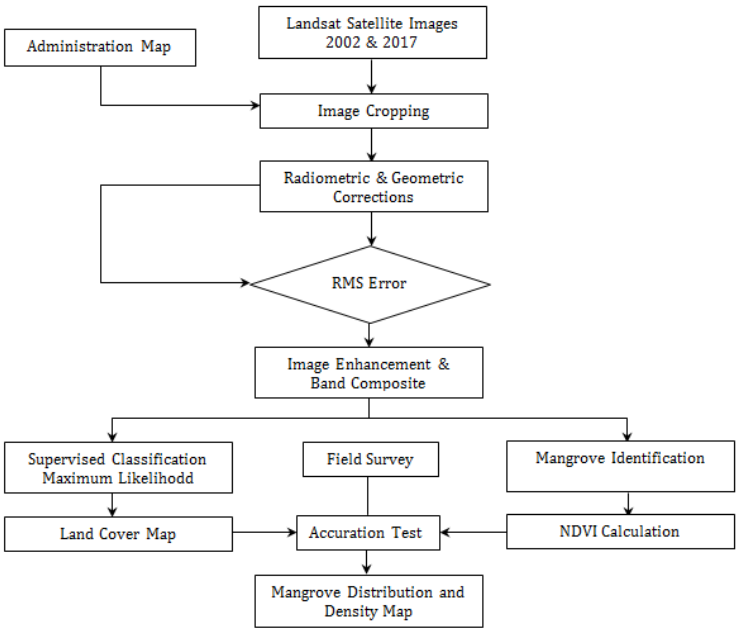

Fig. 1. Satellite Data Analysis Flow Chart

2.2 Mangrove's Area Rehabilitation

The results of satellite image processing to determine the changes in a mangrove forest area on the southern coast of Sumenep Regency were then used to determine the location of mangrove's area rehabilitation. Rehabilitation of mangrove's area was carried out by planting 5000 mangrove seedlings. The planting involved several parties, namely the community at the location, KKN students of Trunojoyo University of Madura and local government/village officials. Before planting, the community was given socialization about the importance of preserving mangrove forests. At the stage of the implementation, the research team, students, and village officials carried out empowerment efforts in the form of counseling and training regarding the rehabilitation of mangrove forests. One indicator of the success of the community empowerment program is the involvement of community members in the implementation of the program. Therefore, an intensive approach is needed so that the community is willing to be invited to work together in carrying out the rehabilitation program.

2.3 Training on Mangrove Fruit Utilization

Technically, the training was carried out by the research team assisted by students from the Community Service Program. Specifically for the material utilization of mangrove fruit was conducted by inviting practitioners who have business in mangrove resources processing. The types of skills taught to the community include:

a. Food made from mangroves (chips, cakes/snacks, gelatine, and candied fruit).
b. Beverages made from mangroves (syrup).
c. Introduction of nutrition and content of food ingredients made from mangroves.

3 Results and Discussion

3.1 Mangrove's Area Mapping

The satellite image is one of the main data sources in identifying and analyzing the distribution patterns of mangrove forests in the coastal areas. The processing capability of satellite image data that is able to separate vegetation from other types of land cover has been widely used by many researchers [5][7]. This makes the calculation of forest area/vegetation cover can be done more quickly, accurately and cheaply when compared to conventional measurements.

One easy way to recognize or differentiate objects of vegetation with other objects is to utilize the capabilities of image processing software in conducting composites or merging channels. In Landsat imagery used in this study, a combination of red channels (Band 543) can provide a clear appearance for vegetation. Furthermore, by carrying out further analysis by considering the theoretical pattern of mangrove distribution, it can also be distinguished between mangrove vegetation and other vegetation which are both located in coastal areas [8]. Based on the pattern of growth and distribution, mangrove vegetation can be easily found in coastal waters with muddy substrates or a mixture of sand and mud. In general, this type of beach is located near a river mouth or protected waters (Figure 2).

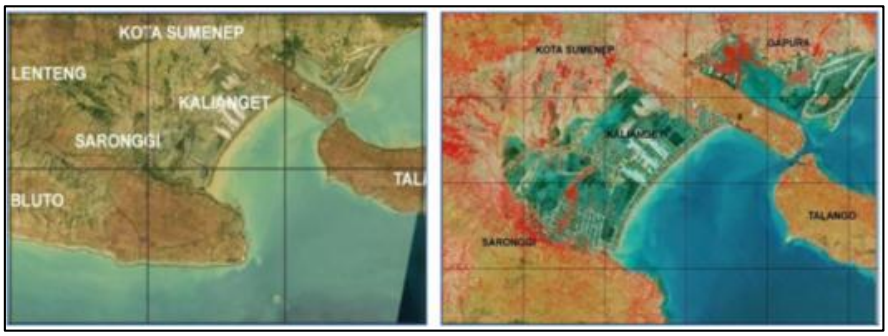

Fig. 2. The difference in Display of Landsat 8 Satellite Image with Natural Composite Band (RGB 321) and Red Composite Band (RGB 543); Bright Red Near the Coastal is Mangrove Forest

Table 1. The Change of Mangrove's Area in 2002-2017

Sub District	Area 2002 (Ha)	Area 2017 (Ha)	Change (Ha)	Dominant Change Types
Gapura	267,84	215,38	-52,46	Shrubs
Kalianget	169,94	135,89	-34,05	Salt Field
Pragaan	97,6	80,28	-17,32	Shrubs
Saronggi	73,84	81,92	+8,08	

The results of analysis of Landsat 7 satellite imagery in 2002 showed that the mangrove forests in the southern coast of Sumenep Regency were spread in 4 sub-districts, namely Pragaan, Saronggi, Kalianget, and Gapura. The total area of mangrove forest detected was 609,22 Ha. Furthermore, the results of analysis of Landsat 8 satellite images in 2017 indicated that there was a decrease in the area of mangrove forests. Detection's results of Landsat 8 satellite images showed that the area of mangrove forest in the location was approximately 513,47 Ha, meaning that there has been a decrease in the mangrove forest area around of 95,75 Ha in the period 2002-2017.

As a natural coastal ecosystem and has important ecological functions, mangrove forest ecosystems are also vulnerable to damage due to human activities. Various human activities such as clearing new land, harvesting wood and so on contribute greatly to the destruction of mangrove forests. The damaged of mangrove forests will then shift their functions to other forms of land use or even be abandoned into vacant land. Based on table 1, it can be explained that the area of mangrove forests has decreased significantly. This change is thought to be due to human activity. As a result of this extensive reduction, there is also a change in the type of mangrove land use. The land which is in 2002 was a mangrove forest, in 2017 was damaged or switched its function into salt field and shrubs.

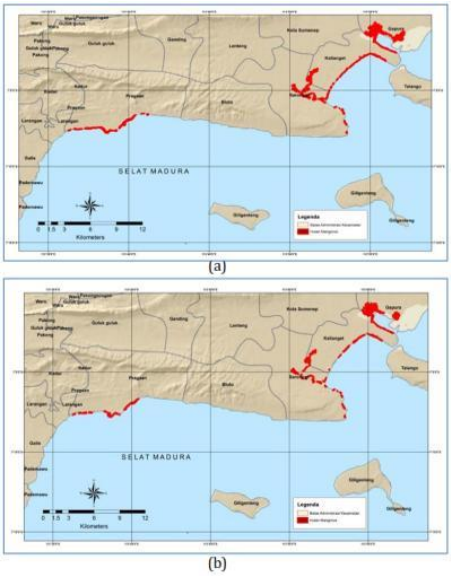

Fig. 3. (a) Results of Analysis of Landsat 7 Image 2002 and (b) Landsat 8 Image 2017 for Identification of Mangrove Forests in Southern Coast of Sumenep Madura

3.2 Mangrove's Area Rehabilitation

Based on the results of the analysis of satellite imagery (Table 1), it was detected that the area which experienced the largest reduction in mangrove forest area was Gapura Sub-district. Therefore, rehabilitation activities were carried out in that location. In conducting the rehabilitation of mangrove 's area at the location, community members, village officials, and 30 KKN students were fully involved. The number of seeds planted around 5.000 seedlings which are equipped with "ajir" (supports made of bamboo). In order to keep the newly planted seedlings from wave interference, a number of wave resistance structure made of concrete were also installed. Most types of seedlings planted were *Avicennia* and *Sonneratia* species which were specially imported from nurseries in the Kenjeran region of Surabaya.

Support from village officials and the community was also a consideration in choosing the location of mangrove's area rehabilitation. Since 2015 a community group has been formed, their focus on maintaining the sustainability of mangrove forests and protecting mangrove forests from illegal logging, while at the same time trying to utilize fisheries resources that can be found in mangrove forests. Prior to planting mangroves, preliminary activities were carried out, namely socialization to the community about the importance of mangrove forest rehabilitation. The speakers were from practitioners who had experience in planting mangroves in East Java. The goal to be achieved was for community members and students to understand the correct way of planting mangroves so that the possibility of success in planting was high.

The mangrove planting was carried out in the coastal area of Gapura Sub-district on August 1, 2018. In this activity, the students were assisted by residents and community members to prepare the seedlings first. Preparations made including transportation to the location by boat. This was done because the planting area was located quite far from the place where the seedlings were dropped. Furthermore, supports made from bamboo were prepared to keep the seeds upright. Another tool used was the plastic rope that has been equipped with markers to adjust the spacing.

Fig. 4. Preparation of Mangrove's Seedling

Fig. 5. Mangrove's Planting Conducted by Students and Community Members on August 1, 2018

Fig. 6. Area Condition After Mangrove's Planting (August 2018)

Fig. 7. Area Condition Three Months After Mangrove's Planting (November 2018)

3.3 Training on Mangrove's Fruit Utilization

To increase public awareness in acting and preserving the mangrove ecosystem, the community needs to understand as well as get direct benefits from mangrove resources. Training on mangrove fruit processing was carried out by KKN students. Community members who were invited as trainees came from groups of fishermen, housewives and

Karang Taruna. In this activity, students were specifically given skills about the types of mangroves that can be processed into several types of food ingredients and beverages such as flour, substitute for rice, chips, and syrup.

Before the training, laboratory tests were conducted to determine the content of several types of mangrove fruits. The analysis was conducted at the Food Technology Laboratory of the Faculty of Agriculture, Trunojoyo University of Madura. The analysis results showed that the fruits of *Sonneratia* species have high ascorbic acid or vitamin C, which reached approximately 70.4% in every 10 grams of ingredients. On the contrary, this type of fruit is low in the percentage of fat, protein, and carbohydrates. The test for other species, namely *Brugueira*, showed completely different results. This species of mangrove's fruit turns out to be high in carbohydrate content, which reaches 82.1% in every 25 grams of ingredients. These differences in results can be used as a basis for further utilization or processing. According to the content, the species of *Sonneratia* can be used as the main ingredient in making beverages, such as syrup. While the *Brugueira* species can be recommended as a substitute for rice.

Fig. 7. Mangrove's Fruits of Brugueira and Sonneratia Species

Fig. 8. Examples of Mangrove's Fruits Processing (Syrup and Fluor)

There is not much information regarding the potential and benefits of mangrove as a food source. The research conducted in the community of Rayori village Biak Numfor district of Papua provided information that the local communities have been consumed mangrove fruit especially *Bruguiera gymnorrhiza* [9]. Residents living in the coastal areas or around mangrove forests, such as in Muara Angke Jakarta and Balikpapan Bay in traditional ways, apparently have consumed several types of mangroves as vegetables, such as *Rhizophora*

mucronata, *Acrosticum aureum*, and *Sesbania grandiflora*. *Bruguiera gymnorrhiza* or commonly called "lindur" is consumed by mixing it with rice, while *Avicennia alba* (api-api) fruit can be processed into chips. *Sonneratia alba* (pedada) fruit is processed into syrup and candy by the local community in Wonorejo Surabaya [10]. Likewise in parts of West Timor, Flores, Sumba, Sabu and Alor, these communities utilize mangrove fruits as a substitute for rice and corn during drought seasons [11]. Communities in Lembata district, East Nusa Tenggara, have become accustomed to consuming mangrove peanuts as local food at certain times. The fruit of *Bruguiera gymnorrhiza* which traditionally processed into cakes, mixed with rice or eaten directly with coconut spices contains high carbohydrates, even surpassing various types of carbohydrate sources commonly consumed by the public, such as rice, cassava corn or sagu. Furthermore, the research conducted by IPB in collaboration with the Food Security Agency of East Nusa Tenggara explained that the energy content of *Bruguiera gymnorrhiza* fruit was 371 calories per 100 grams, higher than rice (360 calories per 100 grams), and corn (307 calories per 100 grams). The carbohydrate content of this species was 85.1 grams per 100 grams, higher than rice (78.9 grams per 100 grams) and corn (63.6 grams per 100 grams) [11,12].

4 Conclusion

Based on the analysis of satellite images for mapping mangrove forests on the southern coast of Sumenep Madura, the results showed that the total area of mangrove forests detected in 2002 was 609,22 Ha. Meanwhile, the results of image analysis for 2017 show that the area of mangrove forest in the location reached 513,47 Ha, meaning that there has been a decrease in the area of mangrove forest by 95,75 ha in the period 2002-2017. The reduction in the area of mangrove forest was caused by changes and conversion in land use. To prevent more damages, community participation in protecting the mangroves forest was needed. In this activity, a community service program was conducted for the rehabilitation of mangrove's area through planting 5000 mangrove seedlings in Gapura District, Sumenep Regency. Mangrove fruit processing training was also conducted to show the direct benefits that can be obtained by the community from the existence of sustainable mangrove forests.

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