

Mangrove mapping and change detection in Sungai Asam Village, Indragiri Hilir Regency, Riau Province

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Abstract. Indonesia is an archipelago in the tropical climate that has the largest mangrove forest in the world. Based on data from the Ministry of Environment and Forestry, mangrove forest area is estimated about 9 million hectares in 2000. However, this amount is reduced drastically. Approximately, sixty percent of mangrove forest area in 2006, has been lost, damaged, and changed into ponds, plantation, agriculture area, and settlement. Indragiri Hilir is one of regency in Riau Province which has the high potential diversity of mangrove. Based on interpretation of Landsat 8 satellite imagery in June - July 2013, mangrove forest in Indragiri Hilir reached 100,211.23 hectares. The area of mangrove forest is estimated to decrease, due to land use and land cover change. Based on land cover change map, mangrove forest area in Sungai Asam Village has increased in 20 years.

1. Introduction

Like many other countries in Southeast Asia, the mangrove areas in Indonesia have decreased markedly. Indonesia is an archipelago in the tropical climate that has the largest mangrove forest in the world. Based on data from the Ministry of Forestry, mangrove forest area is estimated at about 9 million hectares in 2000. However, this number is reduced drastically. Around 60% of mangrove forest area in 2006, has been lost, damaged, changed into ponds, plantation, agricultural area, and settlement. It is estimated that mangrove forests in Indonesia is currently the only remaining 3.6 million hectares [1]

Mangrove forest are among the most important and productive of ecosystems and provide habitat for wildlife [2]. Mangrove ecosystems occur world-wide on tropical and sub-tropical coastline [3]. The mangrove is a unique and complex ecosystem. Moreover, mangrove ecosystems stabilize coastlines, clean water, protect land from erosion, and in many cases promote coastal accretion, and provide a natural barrier against storms, cyclones, tidal bores and other potentially damaging natural forces [4].

Mangrove ecosystems are reported to disappear worldwide by 1 to 2% per year, which is the same or even worse as compared to the nearby coral reefs or tropical rainforests. Mangroves are species-poor ecosystems and the number of mangroves has been reported to be directly correlated with forest size [5, 6]. So, further decline in mangrove area is likely to be followed by accelerated functional losses in the



future. The world-wide distribution of mangroves is a good thing, however, it remains uninvestigated how bad their decrease in functionality is.

For centuries, mangroves have contributed significantly to the socioeconomic lives of coastal dwellers as well as the people in Sungai Asam Village. Sungai Asam is one village in the Reteh District, Indragiri Hilir Regency, Riau Province. Since 2002, people in this village conducted community-based mangrove cultivation because of sea water intrusion in their coconut plantations that made their land unproductive. Mangrove reforestation is also conducted for the purpose of conservation and ecotourism development. Mangrove density in Sungai Asam expanding from year to year. In this village there are various types of mangrove species and wildlife that live inside.

Mangrove forest area changes in the last 20 years can be viewed using satellite imagery. Satellite remote sensing data can be used for large areas over time and thus represent an indispensable tool for mangrove forests monitoring. The objectives of this study are to map mangrove forests using LANDSAT imagery in Sungai Asam Village in 1996, 2006, and 2016.

2. Material and methods

2.1. Study area

Sungai Asam is a village located in the Reteh District, Indragiri Hilir, Riau Province. The village is situated in Indragiri River estuary. Indragiri river estuary waters have a number of alluvial inhabited and uninhabited islands (sediment originating from river mud). It has wet tropical climate with rainfall of 1300 mm throughout the year, the rains falling from October to March and the dry season lasts from November to February. The east coast of Indragiri Hilir delta is covered with massive mangroves forests. This forest is naturally plays into the ecological chain to keep the beaches from the waves and abrasion. Sungai Asam is surrounded by coconut plantation in the north and west, Asam River in the south, and Rawi Ditch in the east. Vegetation in the Reteh District dominated by mangrove species of *Rhizophora apiculata* and *Nypa fruticans*. Most of people in this village are working as a farmer in coconut plantation or rice field and the others are working as fishermen [7].

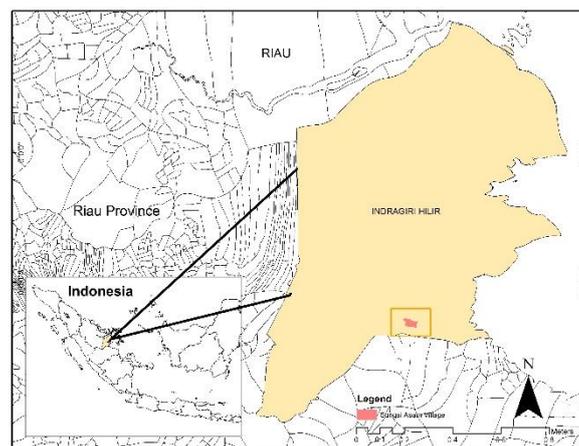


Figure 1. Study area

2.2. Satellite imagery

Multi-temporal medium resolution LANDSAT imagery was used to obtain comprehensive coverage and analysis of the current and historical mangrove conditions. The used imagery was acquired by several different satellite sensors including LANDSAT TM (March 8, 1996 and July 26, 2006) and LANDSAT 8 (June 3, 2016). The Landsat satellite data was georeferenced to UTM WGS 84 Zone 48 south. Spatial data were processed using ArcMap 10.3 software. Data processing using geographic information systems (GIS) consists of some steps such as data entry, data analysis, and data display.

Some important spatial data processing operations used in this research were the map digitation, map overlay, and area calculation (figure 2).

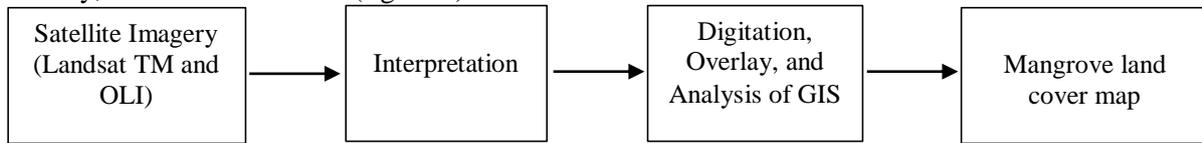


Figure 2. Flowchart of the image processing

2.3. Field survey data

The field data was collected during survey carried out during November 2015. The foundation for these field trips was the collection of land cover information in particular mangrove forests. Some points in Sungai Asam Village were visited and informations were collected ground-truth points using GPS (Global Positioning Systems) to create training data for supervised classification and generate accuracy assessment for the post classification of the land cover map in 2016.

3. Result and discussion

3.1. Mangrove forest land cover change from 1996-2016

Based on Landsat map obtained in 1996, 2006 and 2016, differences of mangrove forest land cover within 20 years can be seen. In 1996, the mangrove forest area was still dominated by swamp area (figure 3a). Before the mangrove reforestation in 2002, Sungai Asam Village was an unproductive coconut plantation due to sea water intrusion.

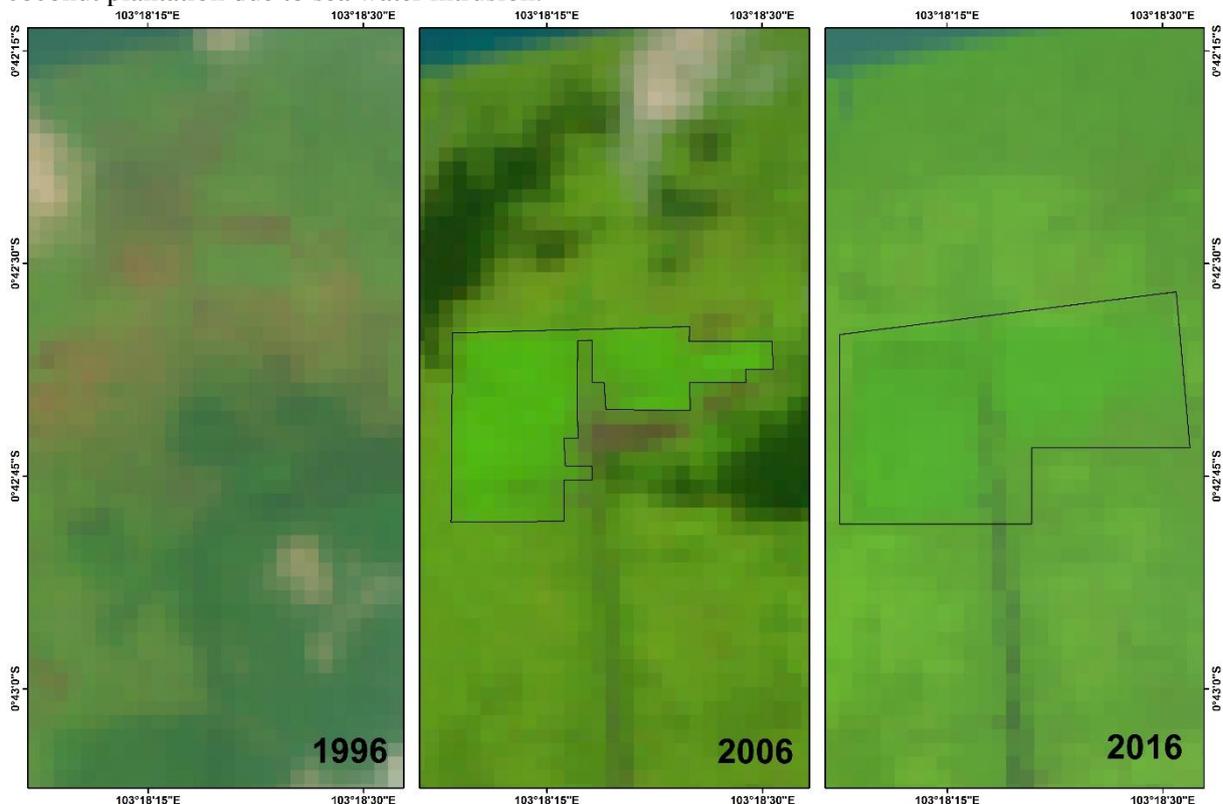


Figure 3. Land cover of mangrove forest in (a) 1996, (b) 2006, and (c) 2016

After the mangrove cultivation in 2002, swamp area was dominated by young *Rhizophora* sp. (figure 3b). In 2016, the mangrove forest area are expanded, denser, and dominated by mature stand of

Rhizophora sp. (figure 3c). Based on the results of extensive calculations, mangrove forest area from 2006 to 2016 increased significantly to about 25 times (table 1).

Table 1. Mangrove forest area in 2006 and 2016

Year	Total Area (hectare)
2006	1.37
2016	28.42

At first, the idea of mangrove reforestation (*Rhizophora apiculata*) comes from one of the village dweller after observing mangrove forests, especially in the Reteh District, those were decreasing and heading for extinction. Though mangrove forests have economical functions as a habitat for a variety of aquatic fauna (shrimp, crabs and fish), the idea was not initially supported by the other village dwellers, who mostly work as coconut farmers and fishermen, because they are less profitable.

After learning many positive impacts of mangrove planting, the community began to keen and interested in joining. In mid-2005, farmer groups formed "Forum for Sustainable Mangrove" with the aim of preserving the mangrove forests in the area of Sungai Asam. Now, the mangrove forest in Sungai Asam become green, a new sanctuary for many species of aquatic fauna and birds, and often used as a research location by universities [7].

3.2. Mangrove species

Based on survey results, seven mangrove species were found (table 2). The number is still less diverse thus the species enrichment is really needed.

Table 2. Plant species in mangrove forest

No.	Local name	Latin name	IUCN Red List Status
1	Api-api daun lebar	<i>Avicennia marina</i>	-
2	Bakau bandul	<i>Rhizophora mucronata</i>	Least Concern
3	Bakau kacang	<i>Rhizophora apiculata</i>	-
4	Pedada	<i>Sonneratia ovata</i>	-
5	Nipah	<i>Nypa fruticans</i>	Least Concern
6	Krakas	<i>Acrostichum aureum</i>	Least Concern
7	Drujon	<i>Acanthus ilicifolius</i>	Least Concern

Nypa fruticans is known to occur on soft, fine-grained substrata with a perennial (high) input of fresh water. *Rhizophora apiculata* grew at low to mid-tide level. *Sonneratia ovata* was usually planted in coastal areas to control erosion of tidal river banks. While, *Avicennia marina* and *Rhizophora mucronata* usually occur close to the sea, indicating their tolerance of high salinity [8-10]. Two shrubs species were found are *Acrostichum aureum* and *Acanthus ilicifolius*. Those species are growing along lakes, marshes, sea shores, and tolerant of raised salinity levels.

Table 2 shows that the majority of plant species in the mangrove forests is categorized as least concern and several other species aren't on the IUCN red list. Among all species encountered, *Rhizophora apiculata* is a species that dominates the mangrove forests. This species is cultivated by the community. Bakau kacang (*Rhizophora apiculata* Bl.) is the most economically important commercial species of mangrove trees, have been intensively exploited for their valuable wood for house construction [11]. The contribution this species towards the growth and primary production of mangrove ecosystem is remarkable. This is due to the fact that *R. apiculata* colonizes relatively faster; grows quicker and taller than other species [12, 3]. *R. apiculata* is the most dominant and productive species. It is also the most important species of commercial mangrove timber in the Asia-Pacific region.

4. Conclusion

Based on land cover map in 1996, 2006 and 2016, total area of mangrove forests in Sungai Asam Village has increased significantly. Village dwellers' awareness of the importance of mangrove functions for the environment make them conduct mangrove reforestation on abandoned land. Based on survey results, seven mangrove species were found. *Rhizophora apiculata* is a species that dominated mangrove forest. Most of species is categorized as least concern. The amount of species is still too few for a mangrove forest biodiversity. Therefore, species enrichment is really needed to increase the value of biodiversity.

Acknowledgment

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