Condition and mangrove density in Segara Anakan, Cilacap Regency, Central Java Province, Indonesia

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Abstract. Mangroves of Segara Anakan have high economic value and supports coastal fisheries. However, the condition of Segara Anakan mangrove is currently degraded due to various land uses which are more concerned with economic objectives than with mangrove conservation, thus causing a critical status of the mangrove land. Mangrove density is an indicator toward the critical level of a mangrove land. The objective of this research was to analyze the density level of mangrove cover of Segara Anakan. The method used was Normalized Difference Vegetation Index (NDVI) based on the interpretation of satellite image of Landsat 8 acquisition by 4 April 2016, and this is classified based on Guidelines of Inventory and Identification of Critical Land of Mangrove of Forestry Department in 2005. The result of data processing of Landsat 8 image shows that mangrove crown density of Segara Anakan based on NDVI is divided into dense class (4,792.11 ha), medium class (762,11 ha) and sparse class (571,95 ha) with a total area of mangroves of 6,126.28 ha.
Key Words: NDVI, Segara Anakan lagoon, mangrove conservation, critical status.

Introduction. Mangroves are intertidal ecosystems that live along tropical and subtropical beaches. Mangrove swamps provide a range of ecosystem services such as sediment traps where nutrients are absorbed and protect shorelines from erosion (Lugo & Snedaker 1974). Mangrove forests also provide various types of raw materials such as food, firewood, timber and tannins (FAO 1994; Hamilton & Snedaker 1984). Various species of fish, shrimp and crabs use the mangrove ecosystem as nursery ground and feeding ground (Field et al 1998; Lugo & Snedaker 1974). Globally, mangrove forests have decreased drastically (Field 2000). Since the observation from 1980, there has been occurred a 25% reduction in mangroves (FAO 2007). The main causes are land conversion to shrimp ponds, illegal logging, freshwater pollution and utilization (Barbier & Cox 2003).

Mangrove forests in Segara Anakan Logoon are part of the estuary ecosystem of Segara Anakan of Cilacap Regency and become the largest mangrove forest area in Java Island where in the past the width of the mangrove Segara Anakan area reached 21.500 ha (Sasaki & Sunarto 1994). Over time, several studies reported that the environmental pressures on the Segara Anakan mangrove forest still continue. However, the pressures were decreased the width of mangrove forest by 2013 with the remaining land area of 6,716 ha (Purwanto et al 2014). Increased development activities such as settlements, industries, rice fields, fishponds led to the conversion of this mangrove area which has exceeded the regenerative capability for mangrove life (Luqman et al 2013). If the pressure of human activities is continuous, it can cause an increase of land surface with critical status of mangrove. Thus, an assessment on the critical status of mangrove forests is needed. One indicator of the land criticality for mangrove is to assess the density of the mangrove by vegetation index. Calculation of the vegetation index can be conducted by utilizing the technology of remote sensing (Widyastuti 2000).

Vegetation index are very important because it can be used as an indicator in biomass estimation (Boone et al 2000), leaf index area estimation (Gong et al 2003) and primary productivity estimation (Ricotta et al 1999). The pattern of spectral characteristics of the leaves can distinguish radiation intensity of the reflected electromagnetic power (Arhatin 2007). The minimum reflection that appears in the visible (red) spectrum occurs about 0.67 μm, and this channel is very important for remote sensing, and violet/blue channels are approximately 0.36 μm and 0.40 μm (Leblon 2004).

This vegetation index algorithm or normalized different vegetation index (NDVI) is the most commonly used. The vegetation index is the reflection percentage of solar radiation by the leaf surface, and this is closely related to the concentration of chlorophyll (Arhatin 2007). The amount of chlorophyll concentration contained by a vegetation surface, especially the leaves indicates the greenness of the vegetation. The vegetation index is a mathematical combination between red and NIR bands (Near infrared) which have long been used to identify the presence and condition of vegetation. Mangroves have green leaf substances (chlorophyll), and mangroves grown on the coast. Therefore, in the present study, vegetation index algorithm or NDVI is calculated to analyze the current condition of mangrove of Segara Anakan.

Material and Method

Description of the study sites. The study began with a survey on the waters from the western side to the east side of the Segara Anakan lagoon. The research location was in Segara Anakan Lagoon of Cilacap Regency, Central Java Province. Segara Anakan (SA) mangrove ecosystem is located at 07°34’29.42”S – 07°47’32.39”S and 108°46’30.12”E – 109°03’21.02”E, being the largest lagoon at the southern coast of Java, comprised by the only large estuarine mangrove forest left in Central Java. This study site can be traveled by bus from Jakarta City (terminal bus of Kampung Rambutan) to Segara Anakan, Cilacap Regency, Central Java.

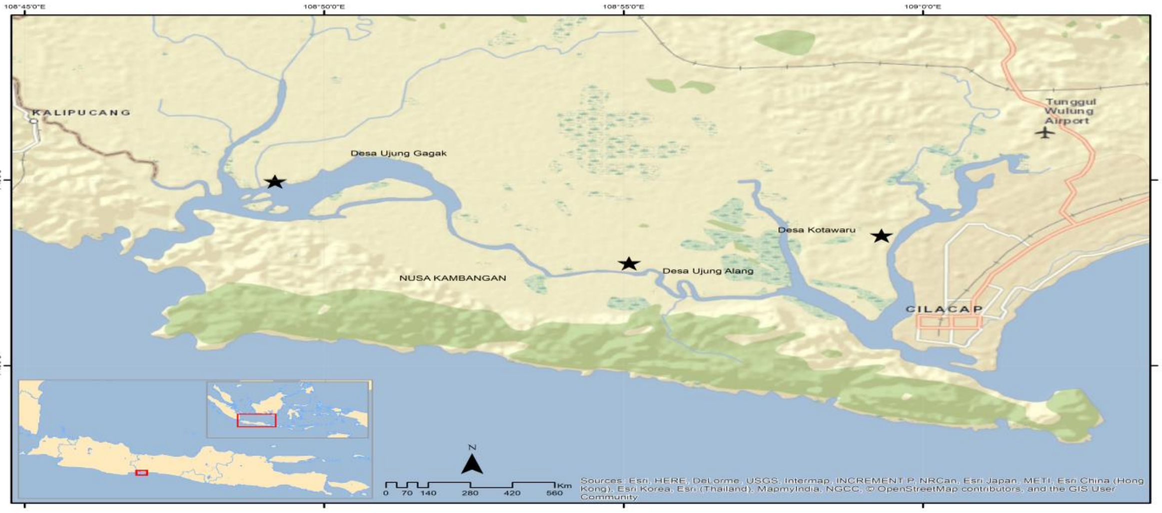

Figure 1. The research location of Segara Anakan, Cilacap, Indonesia.

The material used in this research was Landsat 8 satellite image path 121/row 065, recording dated April 4, 2016 which had been corrected geometrically and radiomatrically, and the image processing was carried out using Application ER Mapper 7.0.

The vegetation Index method based on NDVI value was used to determine the mangrove density level while the determination of mangrove density class referred to the Guidelines of Determination of Mangrove Land Critical Level of Ministry of Forestry Year

2005 (Dephut 2005) in which the density is classified into the densities of dense canopy, medium canopy, and sparse canopy (Table 1).

Table 1

Criteria of the mangrove density level (Dephut 2005)

Mangrove class	*NDVI value*
Sparse/Density	0 – 0.33
Medium Density	0.34 – 0.42
Dense Density	0.43 – 1.00

This NDVI method utilizes GIS technology and remote sensing. The process in determining mangrove density based on the satellite image can be conducted with the following procedures (Figure 2):

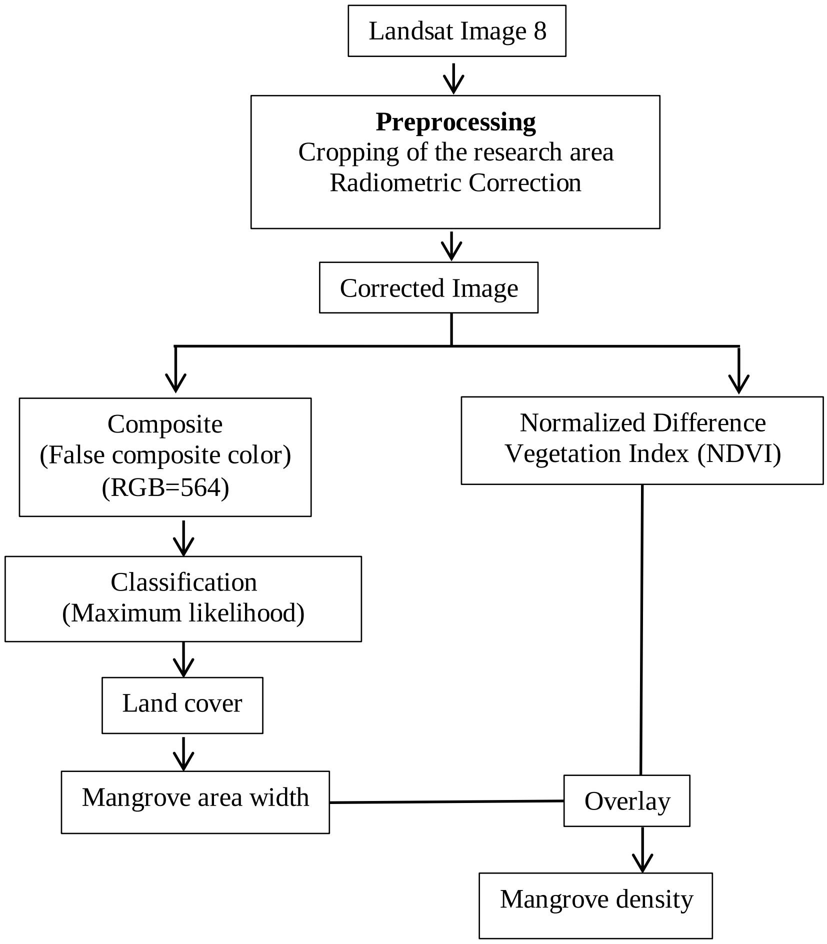

Figure 2. The flow chart of the classification process of the Segara Anakan mangrove distribution in Cilacap Regency of Central Java Province.

1. Landsat Image 8. The processing of Landsat Image data begins with image data transfer from the website http:/earthexplorer.usgs.gov/ to data storage. The data are then processed using ER Mapper 7.0 software.
2. Satellite Image Correction. Radiometric Correction in satellite image aims to improve an image of geometric distortion in order to obtain images with projection and coordinate systems such as those on the map. The distance, area, direction and shape of the uncorrected images toward the geometric distortion will vary along the images.
3. Image Sharpening. Image sharpening is conducted to facilitate the interpretation and understanding of an image. The advantage of digital image is that it allows itself to perform an image pixel assessment.

4. Overlay. Overlay is conducted using ER Mapper software. The overlay of a graphical data is to combine two or more new graphical data that have a mapping unit. In the overlay process, a new mapping unit will be obtained mangrove density.

The vegetation index is a mathematical combination between the NIR canal and long red channel which has been used to identify the presence and condition of vegetation (Lillesand & Kiefer 1997).

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{Red}}{\mathrm{NIR} + \mathrm{Red}} = \frac{\mathrm{canal\ 5} - \mathrm{canal\ 4}}{\mathrm{canal\ 5} + \mathrm{canal\ 4}}$$

NIR - the spectral reflectance value on the near infrared channel;
Red - the spectral reflectance value on the red channel.

Results

Descripstion of Segara Anakan Lagoon. Segara Anakan Lagoon is a National Strategic area according to the Indonesian Government Regulation no. 26/2008 (PP 2008). The total Segara Anakan lagoon and its environmental area is 24,968 ha (Ludwig 1984). The lagoon area has the coordinate limits of 7°37'22"-7°47'37" South latitude and 108°45'11"-109°2'54" East longitude. Segara Anakan Lagoon has 3 rivers that supplying its high sediment namely; Citanduy River, Cibeureum River, Cikonde River, which impacts in increasing thew expansion of the mangrove in Segara Anakan Lagoon and surrounding areas. This is in line with Setyawan (2010) who stated that geologically, the Segara Anakan lagoon area tends to decrease due to sedimentation and mangrove expansion.

The population of Cilacap Regency in 2015 was 1,780,533 individuals with the growth rate of 0.33 or the average growth rate of the population for the last 15 years has been 6,523 persons year^{-1}. This population growth encourages the opening rice fields by conversion of the mangroves from Segara Anakan area. The opening is also supported by a condition of the area which is suitable for rain fed agriculture. The development of rice field from the period of 1978-2014 (bracken time of 36 years) had an average opening of 315.841 ha year^{-1} (Table 2).

Table 2

The development of agricultural land and the change of Segara Anakan mangrove area

Area width (ha)	*Year*								
	1978	*1987*	*1991*	*1995*	*1998*	*2001*	*2004*	*2006*	*2014*
Mangrove	17,090	15,828	12,592	10,975	10,938	9,881.6	9,271.6	9,237.8	8,234.5
Paddy fields	0	1,861.7	5,959	8,069	8,133.3	9,479.1	10,011	9,972.7	13,232

Data source: secondary data (Nurfiarini 2014).

The opening of rice fields pushed the rate of mangrove area decrease in Segara Anakan. The openings have been going on for quite some time and are still being continued until now. Physically, this rice field condition is located above the highest tidal line. This condition became the basis of consideration by the community around Segara Anakan mangrove to change from the mangrove area to rice field. In addition, the illegal logging is still ongoing due to the market demand, wood products from mangrove logging can be used as firewood for cooking needs and house pole materials. However, unknowingly, the illegal mangrove logging has reduced the diversity of mangrove species (Yuwono et al 2007) although extension efforts on the importance of conserving mangrove ecosystems by the government and conservation activists is always done to inhibit the illegal logging. Land use change of Segara Anakan and decrease of mangrove area can be seen in Figure 3.

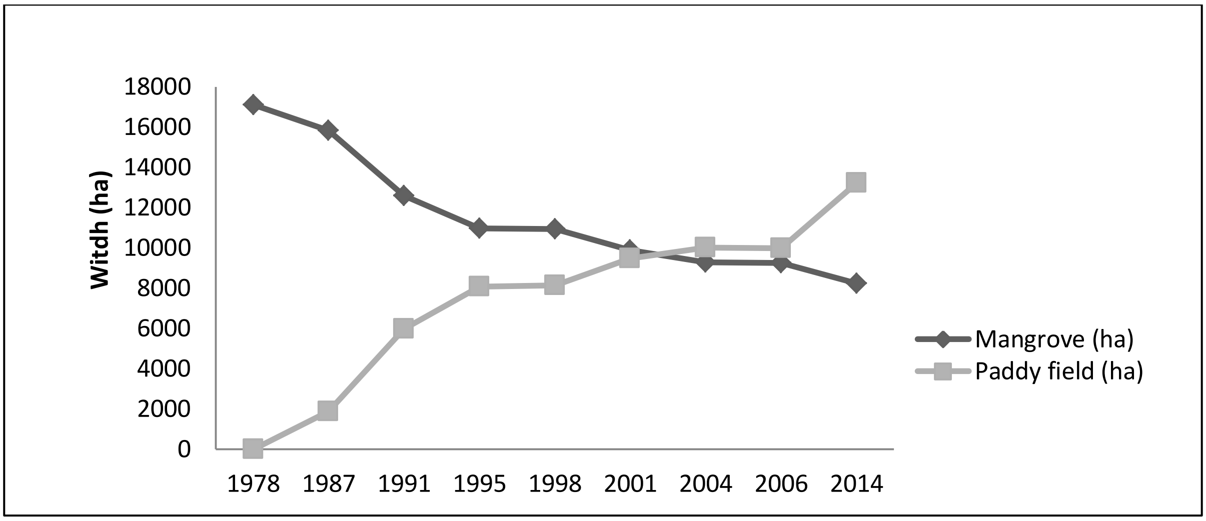

Figure 3. Changes in the area of Segara Anakan mangrove forest and paddy fields from 1978 to 2014.

In addition to the various potentials of important fish and non-fish species, Segara Anakan Lagoon also has the potential for diversity of mangrove species used for mangrove edu-tourism. There are currently 26 mangrove species. The interaction process of sedimentation, salinity and tides produces a suitable habitat for mangroves and forms a unique vegetation structure. This suitable condition causes mangrove plants to become invasive and increase the land area. The existence of this mangrove forest inhibits the silting of the lagoon Segara Anakan by sedimentation so that the volume of the lagoon waters remains stable and serves as a medium of traffic for ships and aquatic biota that live in this area. The biophysical, economic and social values of Estuary Segara Anakan make this area to grow rapidly and to promote better life.

Condition of the mangrove density of the Segara Anakan. Before determining the critical condition of Segara Anakan mangrove from the results of the image interpretation, the image processing of Landsat 8 acquisition by 4 April 2016 was carried out as follows: Landsat Image 8 (downloaded from the website of http; /earthexplorer.usgs.gov/ to data storage). The data were processed using the software of ER Mapper 7.0. Composite was conducted in this image processing stage known as False Composite Color (FCC), for the purpose of sharpening the mangrove object (Purwanto et al 2014); therefore, the result was the mangrove forest images which were sharper compared to those of the non-mangrove vegetation. For Landsat 8, the image composite was performed by a combination of RGB 564 (band) channel.

The next step is finding the value of vegetation index on mangrove. The vegetation index used was NDVI where an effective transformation was used to monitor mangrove density conditions. Bands used for finding NDVI values in Landsat 8 were band 4 (red) and channel 5 (near infrared). NDVI will produce values from -1 to 1. An NDVI value less than 0 indicates no water or land object whereas an NDVI value greater than 0 indicates high photosynthetic activity or agricultural activity. The value representing mangrove vegetation is in the range 0.1 to 0.7, so if an NDVI value above this value indicates the health level of better vegetation cover. The criteria of mangrove density level of the Ministry of Forestry are used for grading the density class values.

The result of Landsat 8 acquisition by 4 April 2016 shows that the classes of mangrove density include sparse class of 571.95 ha (red color), medium class of 762.21 ha (yellow color) and dense class 4,792.11 ha (green color). There have been increases in mangrove density today compared with those in the previous studies (Purwanto et al 2014) where the high density class was 27% while the result of the Landsat image of 8 April 2016 was 78.22%. Nevertheless, the increase is dominated by *Derris trifoliata* and *Acanthus ilicifolius* species, from bushes to heavily dense plants. The dominance occurs due to the tree-type stands that have been reduced so that sunlight reaches the surface of the soil causing these liana plants to flourish because they are exposed to considerable amount of sunlight. The existence of the dominance of these two species indicates the decrease in biodiversity of the mangrove forest. Both these liana plants are with these two species of *D. trifoliata* and *A. ilicifolius* species are seen as degradation of mangrove forest quality. *D. trifoliata* is an invasive plant and is a characteristic of succession of a mangrove forest. *Derris trifoliata* and *Acanthus* sp. dominate a particular area because they have a system of double breeding that is sexual and asexual.

Based on Figure 4, it is seen that the level of mangrove density of this sparse class (red color) is widely found in the northern part of Segara Anakan Lagoon that extends from west to east. The northern part of the Segara Anakan lagoon is characterized by many rice fields and densely populated settlements from various sub-districts. Both characteristics are thought to be the main factor causing the mangrove coverage of the sparse class because of the close proximity of the settlements making it easy to access by the community. Meanwhile, the southern part of Segara Anakan lagoon bordering Nusakambangan Island with thick wooded forest is only inhabited by two villages i.e. Ujung Alang and Klaces Villages. The distance of these two villages is quite far, and the villages have a low number of population. This southern area is also difficult to access because it borders directly with Nusakambangan Island which becomes a restricted area. In addition, the people living in the Northern part of Segara Anakan Lagoon are more dominated by the farmers than by the fishermen so that there is a need for agricultural land a means for survival, while the people living on the southern side of Segara Anakan Lagoon are still mostly fishermen who rely on the lagoon looking in looking for fish and still depend on the mangrove forest as a place to find fish, crabs and shrimps.

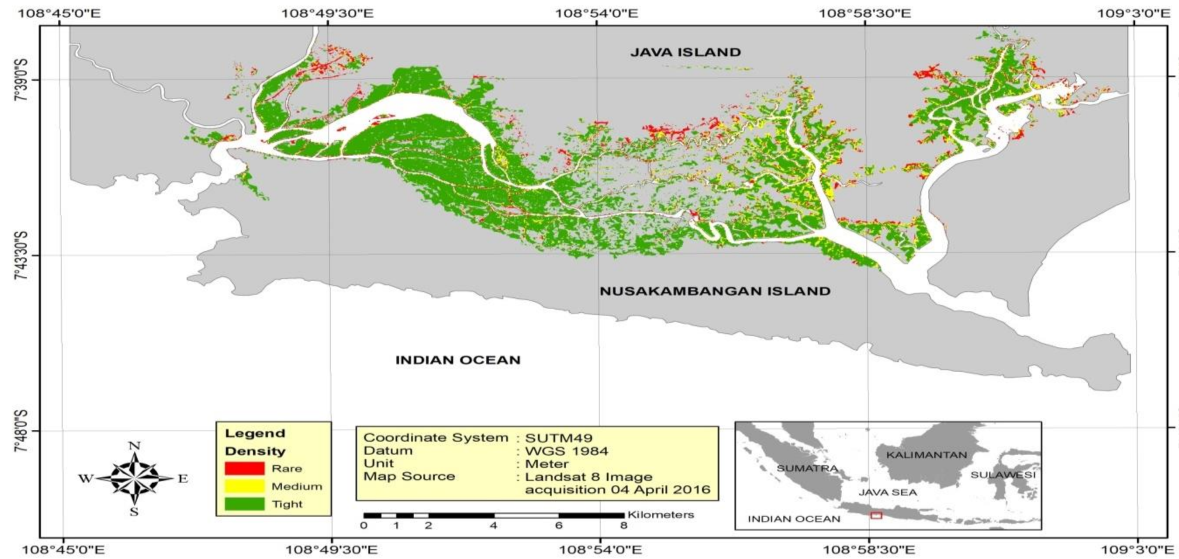

Figure 4. Mangrove density level of Segara Anakan based on Landsat 8 image recorded by April 4, 2016 using the software of ER Mapper 7.0.

Classification of mangrove land covers in Segara Anakan. Classification of land cover of Segara Anakan was obtained from the image of Landsat 8 on 4 April 2016 using the supervised classification method and maximum likelihood standard algorithm. The result of the land cover is divided into; 1) Non-mangrove vegetation of 33,067.62 ha consisting of paddy fields and forest area of Nusakambangan Island; 2) Mangrove vegetation of 6,126,28 ha; 3) Settlements of 1,568.25 ha, and 4) Waters of 19,858.28 ha.

From the above description, it can be seen that there is a decrease in the width of Segara Anakan mangrove area. Based on the interviews with some fishermen, the opening of mangrove area is still ongoing because there is an assumption from the fishermen that the mangrove forest of Segara Anakan will not disappear and continue to produce because of the emergence of soil (siltation) which is the results of sedimentations of the rivers especially the Citanduy River, carrying sediment particles and decomposed nutrients for mangrove establishment. This is in accordance with Wolanski et al (2006) stating that the siltation process in the estuary Segara Anakan area is a natural process, which is a combination of interrelated physical, chemical and biological processes and forms a food chain.

Based on Figure 5 the non-mangrove vegetation area has mostly been planted by rice. The area is no longer affected by the tidal activity because the area position is above the highest tidal boundary, and this non-mangrove land is arising land that is increasingly widespread and gets higher by the sedimentation process and by the work of the mangrove roots to form a new land which eventually reduces the width of Segara Anakan lagoon area.

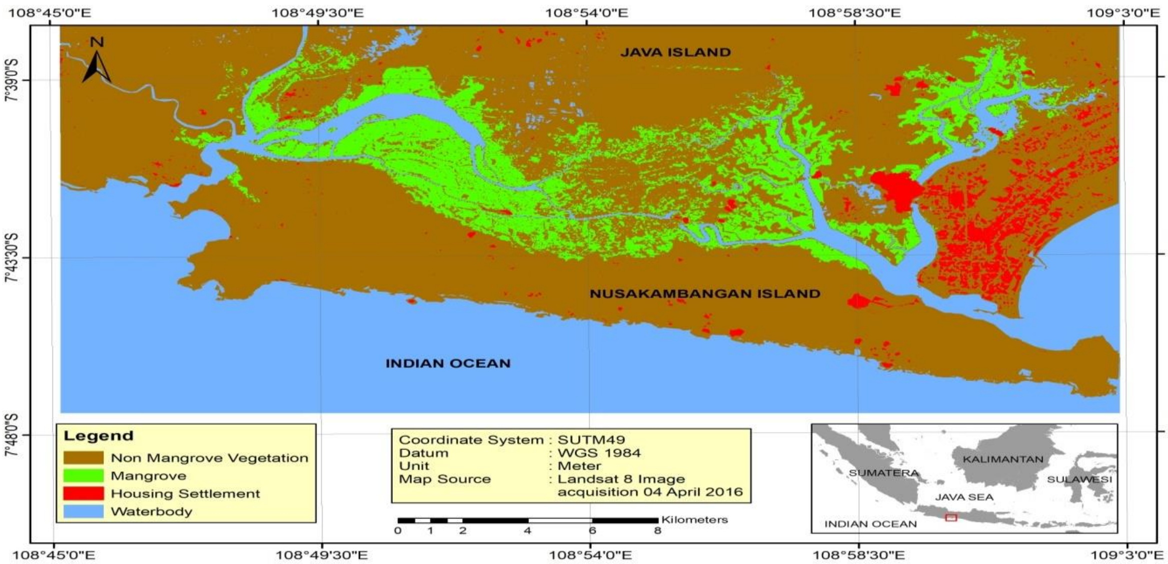

Figure 5. Classification of land cover of Segara Anakan based on the image of Landsat 8 recorded by April 4, 2016 using software ER Mapper 7.0.

For 38 years (1978-2016), there was a shrinkage of the lagoon area of 2703.7 ha or the rate of additional land area in the lagoon of 71.15 ha per year (Dewi at al 2016). The changes of mangrove area of Segara Anakan for the period of 1978-2016 can be seen in Table 3.

Table 3 shows changes in mangrove land cover increased by an average of 273.62 ha per year. During the period of this research, land clearing and illegal logging were still being conducted by the communities. This condition describes the continuity of the damage of mangrove forest in Segara Anakan.

Table 3

Changes in mangrove area from 1978 to 2016

Area width (ha)	*Year*									
	1978	*1987*	*1991*	*1995*	*1998*	*2001*	*2004*	*2006*	*2014*	*2016**
Mangrove	17,090.01	15,827.6	12,592.3	10,974.6	10,938.3	9,881.6	9,271.6	9,237.8	8,234.46	6,126.28

Description: *The processed image of landsat 8 acquisition by 4 April 2016.

Discussion. Various interests and needs and human activities have changed mangrove area to aquaculture area, rice fields, settlements, which leded to a decrease in the width of mangrove area of Segara Anakan. This is in line with Barbier & Cox (2003) who stating that 52% of the main cause of the decrease of mangrove forests in a global scale is the extension of aquaculture activities. The decrease of mangrove area almost occurs in all regions of Indonesia and in Southeast Asia. FAO (2007) stating that there has been a 25% decrease in the mangrove areas since 1980.

For example, in coastal Rembang Regency in Indonesia, shrimp, milkfish and salt ponds are commonly sights. In the rainy season, salt ponds that usually also become milkfish ponds, so this region becomes the largest supplier of milkfish in Central Java after Pati District. The coastal region of Rembang is also the largest salt producer in Central Java. Almost all of the sedimentary beaches form mud plains and have mangrove ecosystems converted into pond areas, and some pond areas far from the coastal lips are no longer productive due to changes in hydrological conditions, edafit (acid sulfuric acid), diseases and environmental pollution so that the ponds and their production facilities are left damaged and not taken care of. Mangrove forests are dominated by bushes and tree species (Setyawan & Winarno 2006). Meanwhile the mangrove forest from Sinjai Regency, South Sulawesi Province, Tongke-Tongke and Samataring Villages felt the impacts of mangrove ecosystem damage, such as the frequent occurrence of abrasion and the decrease of the number of local fishermen and mangrove catches which are now also the result of rehabilitation that positively impacts the fishery in these villages (Chadijah at al 2013). In addition in Tangerang Regency, conversion of mangrove land to aquaculture field is one of the biggest causes of mangrove degradation, as evidenced by low density (<50%) and low biodiversity where there are only 6 existing tree species, namely, *Avicennia alba*, *Avicennia officinalis*, *Rhizophora apiculata*, *Rhizophora stylosa*, *Rhizophora mucronata*, and *Nypa fruticans* with the highest Important Value Index (IVI) for *R. mucronata* (Aini 2015). In addition, the decrease of mangrove area is not only affected by opening of rice fields and aquaculture but is also affected by distance from settlement (Mulyanto & Jaya 2004).

Similarly, the opening of new rice fields is still on going. Soil arising from the sedimentation that is above the highest tide limit becomes the target of new rice fields. The increasing need of new rice fields is also caused by the immigration of the people from outside the region of Segara Anakan. The rise of new rice fields encourages most fishermen to become farmers. Farming system in the area used to be the mangrove land is rain-fed agriculture (irrigation of the rice fields depends on the length of the rainy season). The opening of new rice fields in Segara Anakan will continue to take place considering the Cilacap Regency as a buffer area for rice needs for Central Java Province. To date, the conversion of land has already reached 250 ha.

Illegal logging and paddy field openings will lead to increased sedimentation rates to the Segara Anakan lagoon, and this may increase the concentration of heavy metal pollution and harm the aquatic organisms and further endanger the Segara Anakan fisheries. Prabowo (2005) states that heavy metals accumulated by large animals such as fish and shrimp are sourced from food and particulates contained in water and sediment. The reduced mangrove forest means higher runoff flow from the mainland, causing high rates of soil surface erosion brought into river waters, and heavy metal content tends to be high in rainy season (Salah et al 2012). The above is evidenced by several studies including that of Prasetyo et al (2017) who stated that the Cu and Cd metals in mullet meat in the Donan River of Cilacap Regency showed values of 0.5009-2.6021 mg/kg and 0.0165-0.2307 mg/kg respectively. Kasari et al (2016) stated that the contents of several heavy metals (Pb, Hg, and Cd) of the Donan River estuary had exceeded the quality standard of seawater based on Ministry of Environment Act no 51, 2004 (KLH 2004). In this case, the value standard of heavy metal of Pb, Hg, and Cd are 0.008 mg/L, 0.001 mg/L, and 0.001 mg/ L respectivly. Fishes exposed to subletal contamination of different types of pesticides will show changes in physiological action, failure in breeding and other influences including growth rate (Brawn 1978). This may affect the level of fish production and the degree of gonad maturity which is inhibited by agricultural pesticides (Sulistiono et al 2001).

In addition to illegal logging and mangrove land clearing, various development activities around Segara Anakan also contribute to the level of heavy metal contamination in Segara Anakan waters. This development area becomes a waste disposal place from industrial and ship transportation activities so that it becomes main sources of heavy metal pollution in waters (Kumar et al 2012). The existence of illegal logging, land clearing and pollution will certainly threaten not only the diversity of mangrove which was reported in 2005 as 0.48-1.83 for eastern-Segara Anakan (Hilmi et al 2015), but also will lose the natural habitat of the estuaries that impact to decrease population and number of species of fishes, shrimp mainly for crabs living in the estuary of Segara Anakan. This is in line with Walton et al (2006) who stated that the abundance of crabs in the replanted mangrove is in increasing, which was studied in a replanted mangrove forest in Buswang, Aklan, Philippines.

The existence of mangrove forests and lagoon waters in Segara Anakan is a representation of the unique and widest estuary ecosystem in Java. Because the establishment of Segara Anakan area as a conservation area is an absolute act to do, and this is a real action to save the biodiversity and socio-cultural and economic structure of the communities of Segara Anakan lagoon area which is unique and has valuable aesthetics and advanced sciences, such as Kepulauan Seribu National Park with the uniqueness of small islands and coral reef ecosystems and environmental services available to the live of the people living there with a total economic value of 1,406,084.91 USD per year (Subekti et al 2013).

In Southeast Asia, mangrove crabs are a source of income for coastal communities, and 4 commercial species are found in the protected intertidal and subtidal sediment habitats (Arriola 1940). Decrease in the area of mangrove forest means reducing the amount of litter production that is the food for the detritus. This can change the characteristics of mangrove habitat so that it does not support optimal growth of mangroves (Mulya 2000). The destruction of mangrove habitat also causes the smaller body size of mangrove crabs caught by fishermen (Agusrinal 2015). For this reason, mangrove forests need to be preserved for the sustainability of the mangrove crab life cycle.

The main factor which causing the decrease of mangrove area is the illegal logging and this causes the change of habitat and food chain and affects the ecology of aquatic organism especially benthic organisms with significant economic values. Such changes may decrease the primary productivity of estuarine waters. However, mangrove damage affects the detritus food chain that characterizes the estuary food chain. Detritus forms a substrate for the growth of bacteria and algae, which are nutrients for suspension and detritus eating biota such as barnacles, shellfish, snails, worms, crabs (Brachyura) and crustaceans (Macrura). Food networks derived from such detritus; detritus is eaten by benthos, then benthos is eaten by benthopagous biota, and subsequently it is eaten by larger predators. Therefore it is clear that the role of mangrove forest as a provider of litter is very important to support food chain of detritus in an estuary ecosystem which in turn can lower the ability and capacity of waters in providing fishery resources.

Mangrove waters serves as a breeding ground for various types of aquatic organisms such as fishes, shrimps, shellfish, and various crabs all of which have high economic values. The most important contribution of the mangrove forest ecosystem in the waters is the litter, a source of organic material in the aquatic food chain (Kusmana 1997). The mangrove litter will be exploited by protozoa and bacteria which will then be described as organic materials and become a source of energy for the living biota in the water. Macrofauna and microorganisms are seen as important components in the decomposition process and are exported to the surrounding waters.

The mangrove ecosystem functions as shelter, foraging or self-rearing of various types of fishes. Mangrove forest habitat is the main habitat of mangrove crabs to grow and develop (nursery ground) because there are small organisms that become food for mangrove crabs. They love mud-based waters and a shallow protected layer of water (about 10-80 cm) as in the mangrove area. In such habitats, the mangrove crabs live and breed (KKP 2016). According to Moosa (1985), mangrove crabs prefer the characteristics of muddy and hollow habitats because they can hide under mangrove roots and mate in this conditions. Also, mangrove waters are medium for mangrove crabs to move freely in a wider area (Sulistiono et al 1994); therefore, the more extensive the mangrove waters, the more extensive the transfer of mangrove crabs to find foods and suitable places. According to Keenan et al (1998), Keenan (1999), LeVay (2001), mangrove crab is a type of crab living in mangrove habitat and mangrove crab populations are typically associated with mangrove forests that are still in good condition so that habitat degradation will have a serious impact on their presence. The declines of vegetation density and diversity are the quantity and quality of mangrove ecosystems.

The parent crabs and their young have the habit to return to the mangrove forested waters for shelter, foraging or raising (Moosa 1985). Adult mangrove crabs like to immerse themselves and mate in a mud habitat in the mangrove area while mangrove crab larvae can hide from predatory attacks due to the typical mangrove root structure. In addition, this mangrove root structure reduces the action of coastal waves so that sedimentary particles can be deposited, including organic matters for the needs of aquatic organisms. This shows that the mangrove root structure can form a natural trophic system and food chain.

The destruction of mangrove forest and its ecosystem in Segara Anakan must be stopped. Along with the growing human population and the increasing needs of the local community will be encouraged the utilization of mangrove ecosystem resources which will increase continuously beyond the carrying capacities of these ecosystems. The reasons for economic needs and poor understanding from the local community related to the carrying capacity of the natural ecosystem services and the ecological interactions are factors that are involved in the increase of the damage rate of this mangrove ecosystem.

Mangrove ecosystem is a natural habitat which has an important role in sustaining many aquatic species, to support sustainable fisheries. The mangrove in Segara Anakan area as the largest mangrove ecosystem in Java Island and has an economic and social value for developing the ecotourism area (Shaleh 2017) and an important ecological significance for advanced education and science, therefore, it is necessary to perform protection, preservation and to limit resources utilization, to ensure their existence and sustainability of the mangrove ecosystem. This is in line with the Government Regulation number 60 of 2007 (PP no. 60/2007), concerning the conservation of fish resources including the conservation of their ecosystem. Without conservation efforts, it is difficult to maintain the existence of this mangrove ecosystem, as various interests compete to gain economic values from the ecosystem services for the benefit of each party regardless of the carrying capacity of the ecosystem.

In addition, this conservation efforts need to get full support from the communities in Segara Anakan area in order to avoid conflicts and must involve the local wisdom as part of institutional empowerment, which is in line with regulation of ministry marine affair and fisheries no 30/2010 or PER.30/MEN/2010 Kementerian Kelautan Perikanan (in Bahasa). However, some communities disagree with protection and conservation programs because these programs limit their access to obtain economic values as much as possible from the available services of the Segara Anakan ecosystems.

In order to utilize the land and to make its development not overlap, zonation becomes a reference in the management of an area. For example, Karimunjawa National Park applied the zoning criteria divided into 4 zones, namely, core zone, sustainable fishery zone, utilization zone, and rehabilitation zone (Yusuf et al 2017) resulting in integration among the social, economic and ecological goals.

To support the conservation of Segara Anakan area, it is necessary for the communities to understand the limits and capabilities of the ecosystem services. This understanding is one of social capital that is important in controlling the utilization of mangrove ecosystem services so as not to affect the recovering power of the mangrove ecosystem. The roles of education and counseling become the driving force to increase this social capital.

Conclusions. The mangrove ecosystem in Segara Anakan is part of the Segara Anakan lagoon ecosystem. This ecosystem is an important area which has a high economic value for the surrounding communities for their daily basic needs. Due to the level of utilization that has exceeded the capacity of the ecosystem, the area width of the mangrove forest in Segara Anakan has decreased. The results of the image of Landsat 8 of 2016 show that the current area of Segara Anakan mangrove forest is 6,126.28 ha or decreased by 2,108.22 ha from the previous year of 2014 (8,234.5 ha). The distribution of mangrove density in Segara Anakan with the mangrove crown density level of each grade includes the sparse mangrove class of 571.95 ha (10%) and the medium mangrove class of

762.21 ha (12%). These two class areas are located the north of Segara Anakan Lagoon while the dense mangrove class area of 4,792.11 ha (78%) is located in the south of the Segara Anakan Lagoon. The results of the supervised classification and maximum likelihood standard algorithm obtained land covers divided into; 1) non- mangrove vegetation covering 33,067.62 ha; 2) mangrove vegetation covering 6,126.28 ha; 3) other objects or constructed land area covering 1,568.25 ha; and 4) waters covering an area of 19,858.28 ha.

Recommendations. The continuous decline in mangrove area may endanger the ecosystem balance of the Segara Anakan estuary area due to the reduction of the ecological function of mangrove forest as a barrier to the sedimentation, and various areas for the fishery biota will be lost, especially for the mangrove crabs which inhabit the mud in the mangrove. The decrease of mangrove forest area will also increase the run off threat which will produce high pollutant that will accumulate in the sediment and the water column which in the end will poison aquatic organisms (fishes, shrimps and crabs). As a result, one day these aquatic organisms become dangerous for human consumption because of their accumulated contaminants. Therefore, it is necessary to control pollution and determine the Segara Anakan ecosystem area as a watershed conservation area, and to optimize the existing land use and law enforcement. In addition, the strengthening of social capital in improving the understanding of the limits of capacity of mangrove ecosystems and estuary waters need to be improved through education and counseling on mangrove ecosystem and aquatic environment.

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