GISUP2014(International),No.16,pp.3-13, February 19-21, 2014

Long-term Monitoring of Mangroves Conversion Along the Nothern Coast of West Java Province, Indonesia Using Multi-temporal Landsat satellite images

Sam Wouthuyzen[1)], Melati Ferianita[2)], Boy Fachrul[2)], Rustam Hakim[2)], Femmy D. Hukom[1)], and Helmi Purnama[3)]

1). Recearch Center for Oceanography, LIPI swouthuyzen@yahoo.com
2). LEMLIT - Trisakti University, melatif99@yahoo.com
3). PT PHE ONWJ, situgede@gmail.com

ABSTRACT: In this study, we monitor the land use conversion of mangroves to the fish pound or in Indonesian call "Tambak" along four districts situated in the north coast of West Java Province every 2 decades using multi-temporal Landsat Satellite images. A total of 17,028 ha mangroves areas in those districs recorded in 1972/73 that drastically decreased to 9,063 ha in 1993/94 and then drop to 6.003 ha in 2012/13. Mangroves were heavily converted to tambak between 1972/73 and 1993/94 with decreasing rate of 398 ha/year, but rather slower as 153 ha/year between 1993/94 to 2012/13. In the same periods, the tambak areas increased from 17,064 ha to 27.721 ha and to 42.610 ha, respectively, with the increasing rate of 533 ha/year (1972/73 - 1993/94) and 775/ha/year (1993/94-2012/13). The loss of the dense mangrove cause severe beach erosion in all districts with rate of 1-10 km/year and the intursion of seawater up to 17 km. Beach erosion damaged many tambaks and houses of the coastal comunities. Efforts to restore the damaged mangrove have been made by various parties. A small fraction of the effort is successful, but most of the others failed, because of the improper in replanting mangroves.

1. INTRODUCTION

Indonesia is the largest archipelago country in the world with the second longest coast lines after Canada (81,000 km) and have more than 17,000 big and small Islands. Therefore, the cosatal zones are very huge. Situated in tropical areas, the coastal zone of Indonesia generally has 3 important ecosystems, namely mangrove, seagrass and coral reef. These ecosystems serve as shelter, spawning, nursery and feeding grounds for many marine faunas, including protected faunas such as turtles and dugongs **[1]**.

Indonesia also has the world's largest mangrove, ie 27% of the world's total mangrove, or 75% of the mangroves in Southeast Asia **[2]**. The Geospatisal Information Agency of Indonesia estimated a total area of 3.244 million ha based on 199 satellite images of Landsat-7 ETM+ **[3]**. The Biodiversity of mangroves in Indonesia are very varies. There are 75 species representing 24 family and 41 genera are found **[2]**. Other records at least 202 species that consists of 43 species true mangrove and the rest are associated mangrove **[4]**, while update data mention that there are 92 species of true mangrove **[5]**.

Ecosystem of mangrove, as well as seagrass and coral reefs are also known to have high productivity, exceeded the productivity of tropical rain forests **[6]**. Therefore, it is not be surprised that those ecosystems can make the coastal zones of Indonesia are very rich in marine resources. This leads Indonesia to become known as "mega marine biodiversity center in the world".

Economic valuation of mangrove ecosystems based on the benefits and functions such as production, ecological, and socio-economic functions show that mangroves provide high economic benefits to coastal communities. The average total economic value of mangrove ecosystems from various regions in Indonesia is about USD 3,750/ha/year [7, 8]. Nevertheless, the mangrove areas have been decreased drastically; due to high population pressure that causes the increase of many activities, such as deforestation and mangrove conversions to other land uses (reclamation for agiculture, industry, urban areas), as well as environmental pollution [9].

In a large-scale, mangrove area has been converted into brackish water fish ponds (in Indonesian called "Tambak"). The loss due to this conversion is estimated at 1.6 million ha. Conversion of mangrove areas in 1980s was 155,081 ha, mostly taking place in Java, Sumatra and Sulawesi and increased to 285,500 ha in the 1990s [2]. Actually, tambak has a long history in the northern coast of Java, where initialy milkfish (*Chanos Chanos*) has been cultivated since 15th century. However, in 1970 method of intensive shrimp farming in tambak was found, which coincided with high market demand and high prices of shrimp at that time caused large conversion of mangroves[9].

Changes in the function of mangrove to tambak have major impact on the eco-bio-physical processes, such as rapid erosion, loss of green belts, which serves as a natural buffer to protect the soil from large waves, water quality degradation, reduced marine biodiversity, loss of spawning, nursery and foraging habitats for fish, shrimp and other marine life. In this paper, we conducted study on the conversion of mangroves into fishponds (tambak) and its impact as well as conservation efforts along the northern coast of West Java Province.

2. Methods

This study was conducted along the northern coast of West Java Provinve. There are 16 districts and 7 municipals in this provinve. Among of them 4 districts are situated along the northern coast of West Java Province, namely: 1. Karawang, 2. Subang, 3. Indramayu and 4. Cirebon Districts that faced to Java Sea (Figure 1).

To map and to monitor mangroves and their changes due to conversion of mangrove into fish pond (tambak), we used effective and efficient methods by using remote sensing techniques utilizing multi-temporal Landsat images. Two-decadal (1972/73, 1993/1994 and 2012/2013) of 8 Landsat satellites images are used (Tablel-1).

Before the images analysis is done, first, all images were corrected for the atmospheric influences using a simple method known as Dark Object Subtraction (DOS) [10]. Map of habitats in 5 districts of study sites were made using cluster analysis module in the

Figure1. Map of study sites that conducted in 4 districts (Bekasi, Karawang, Subang, Indramatu and Cirebon) along the northern cost of West Java Province.

image processing packages (IDRISI ANDES soft-ware). Cluster analysis classified the study sites into 9 classes habitat (Sea, Mangrove-1, Mangrove-2, Tambak-1, Tamabak-2, Vegetation-1, Vegetation-2, Vegetation-3, Urban areas). After careful validation using field observation in 4 districts, the habitat were regroup again into 4 classes, namely Sea, Mangrove, Tambak and others (all other vegetation than mangrove + urban areas). Based on these maps the dynamics of mangroves and tambak can be observed, while the areas of both can be calculated.

Tablel-1. Two decadal of multi-temporal various Landsat satellite images use in this study.

Satellites	Path/Row	Date	Observed Districts			
			Kerawang	Subang	Indramayu	Cirebon
1. Landsat-1 MSS	131 /064	Oct. 1972	+	-	-	-
2. Landsat-1 MSS	130 / 064	Nov. 1972	-	+	+	-
3. Landsat-1 MSS	129 / 065	Aug. 1972	-	-	-	+
4. Landsat-5 TM	122 / 064	Dec. 1993	+	+	+	-
5. Landsat-5 TM	121 / 065	Aug, 1994	-	-	-	+
6. Landsat-8 OLI	122 / 064	Aug. 2013	+	+	-	-
7. Landsat-8 OLI	122 / 064	Sep. 2013	-	-	+	-
8. Landsat-8 OLI	121 / 065	Sep. 2013	-	-	-	+

3. Results and Discussions

Mangrove, as already mentioned provide products and environment services that are beneficial to the coastal communities. Large-scale mangrove conversion into tambak is the major causes of mangrove destruction along the northern coast of Java Island including the study sites that can be seen as follow:

Karawang Districts

This district consists of 30 sub-districts (kecamatan), 9 are located in coastal areas, but the observations only made in one sub-districts (Cimalaya District), in 4 vilages (Cemara jaya, Sungai Buntu and Sedari Villages) with the total cost line of 73.7 km. In general, mangrove has no longer formed forest, but only a few stands of trees that are grown in the dike, in the middle of the pond, in the left / right side of the river or the road and dry land (Figure-2) There were 14 species of true mangroves and 15 species of associated mangroves with *Rhizopora murconata, R. stylosa*, *Soneratia caeseolaris* dan *Avicennia officinalis* as dominant species.

Figure 2. Mangrove stands that no longer formed forest in some places of Karawang districts

Multi-temporal analysis of Landsat satellite images show a fairly dense mangroves found in 1972 (2,699 ha), but decreased in 1993 (1,159 ha) and dramatically decreased in 2013 (234 ha) (Figure 3). Conversion of mangroves to agricultural areas and fish pond (tambak) degraded the mangroves. This can be seen by the increase of tambak areas from 9,625 ha (1972) to 10,089 ha (1993) and became

wider to 11,411 ha (2013) (Figure 3). Degradation of mangrove caused coastal erosion that damaging many tambaks and residents (Figure. 4). The rate of erosion along the shoreline of this district reaches about 5 to 10 meters per year. As a result, sea water eroded the land to reach about 50-500 m.

Replanting hundred thousands of mangroves as an effort to rehabilitate mangroves have often attempted by many organizations, but some of them failed, because they used incorrect method or procedures, such as to plant a certain species of mangrove in the wrong habitat (substrate), some other just only plant the mangrove and left them without a properly maintained and monitor [11].

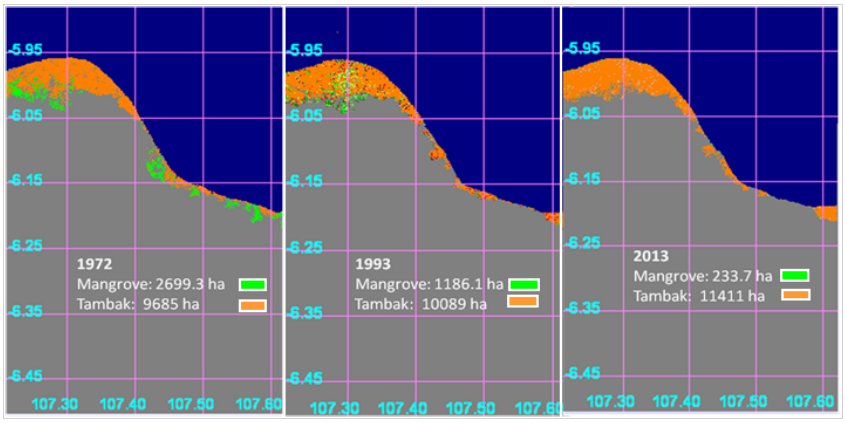


Figure 3. Long-term monitoring of mangrove and tambak dynamics using Landsat images in the Karawang District,

Subang Districts

This district cosisted of 30 sub-districts, and 4 among them are situated in coastal zone with the coastal line of 68 km. Field observation was conducted in sub-district of Blanakan in 3 villages. There are 10 species of true mangroves and 9 of associated mangroves. The dominant species for tree category is *Sonneratia caseolaris*, while for seed are *R. mucronata* and *A. marina*. High number of those seeds indicated that the study site could be served as a source of mangrove seeds.

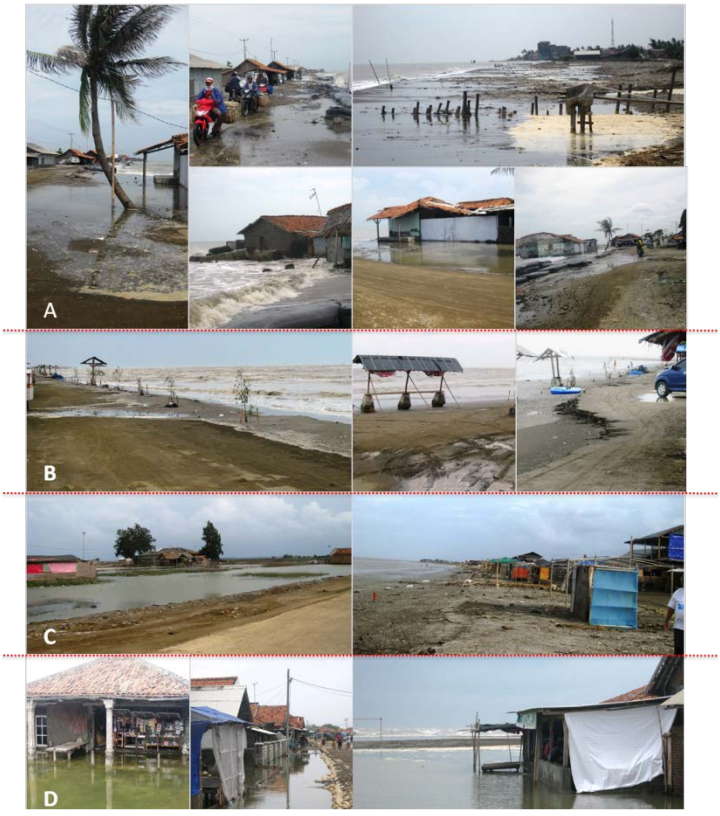


Figure 4. Coastal erosion in the some villages (A. Cemara Jaya, B. Samudra Jaya, C. Ciparage, D. Sedari) of Karawang District.

Multi-temporal analysis of Landsat satellite imageries showed relatively dense mangrove found in 1972 (3,100 ha). In 1993, the areas of mangrove increased (4,455 ha), but decreased in 2013 (3,873 ha) (Fig. 5). However, the areas were still bigger than those in 1972. Increase of mangrove areas in this districts demonstrated a success effort in mangrove replanting program both in the green belt areas, as well as in the tambak (Silva fishery

program), which was fostered by local Forestry Management Authority (Perum Perhutani). Such kind of conservation efforts need to be continued and spread to other districts.

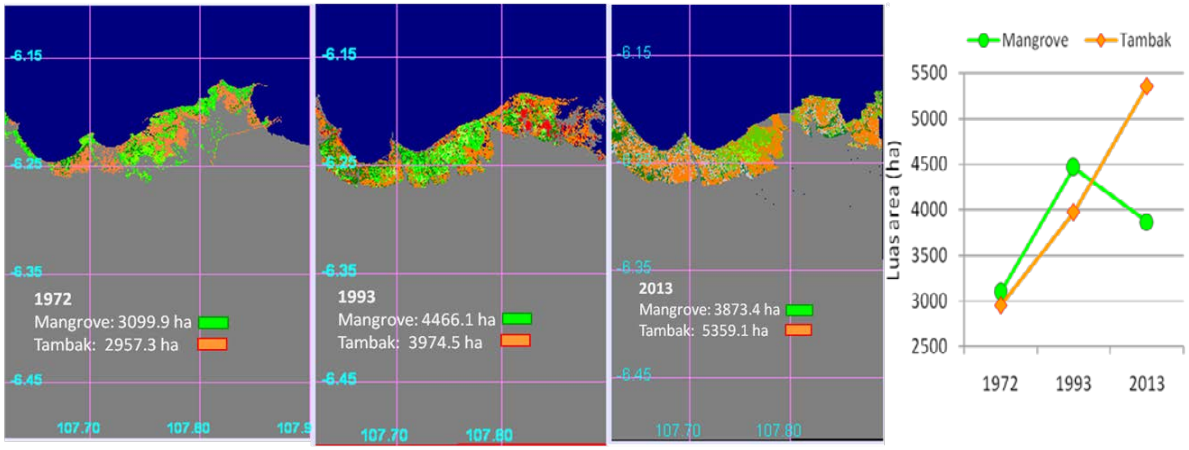


Figure 5. Long-term monitoring of mangrove and tambak dynamics using Landsat images in the Subang District,

At the same monitoring period, the areas of tambak increased from 2,957 ha to 3,875 ha and again to 5,359 ha (Figure 5). Although the areas of tambak in Subang were ½ of those in the Karawang, but the average of decline rate was similiar (69 ha/year). In this district, the coastal erosion relatively less then the other districts (karawang, Indramayu and Cirebon), because dense mangrove still grow in the coast line (figure 6). Thus, mangrove serves as a natural fortress that protects the coast from big waves, especially during west monsoon. Futhermore, fishermen in this sub-district, which are mostly focused on catching blue crabs (*Portunus pelagicus*) got the advantage of better catches due to mangrove services (Figure 7).

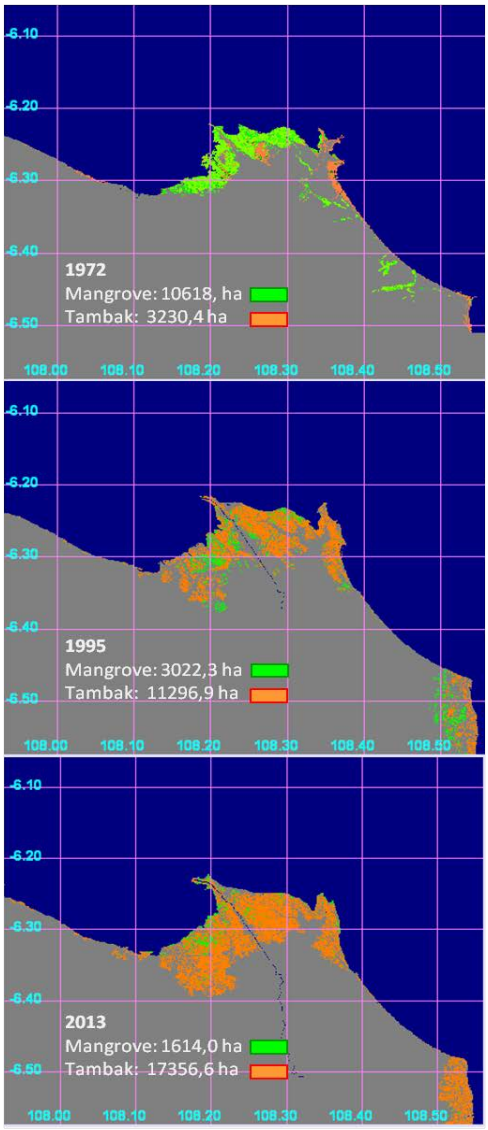
Figure 6. .Mangrove in the coast line of Subang District act as natrural fortress in protecting the beach from erosion (Top).

Figure 7. Crab fishermen got adventages of better catches due to mangrove services (Left).

Indramayu District

The district of Indramayu has 31 sub-districts among them, 11 sub-districts are in the coastal zone with the coast line length of 141.1 km. Observation conducted only in Sub-district of Kandanghaur (Eretan Wetan and Kulon villages). There were 14 species of true mangrove and 6 species of associated mangrove with the dominant species of *R. mucronata, R. stylosa* and *A. marina*. Mangrove distribution is very limited around the tambak and the river edge (Figure 9)

Figure 9. Distribution of limited mangorve in Indramayu District.



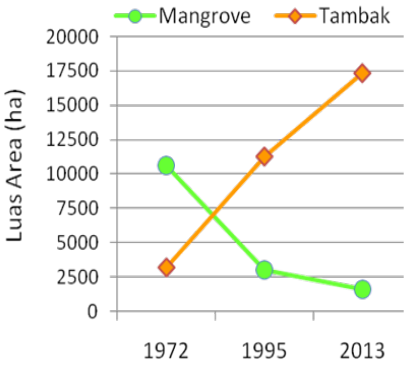


Figure 10. Long-term monitoring of mangrove and tambak dynamics using Landsat images in the Indramayu District,

Multi-temporal analysis of Landsat satellite imageries showed that initially, mangroves in this district were very dense, ie 10,618 ha (1972), but dropped dramatically to 3,222 ha (1995) and recently only 1,614 ha (2013) (Figure 10). The average of declining rate of mangrove was approximately 345 ha/year due to mangroves conversion to tambak. On the contary, a very sharp increase of tambak were shown from 3,230 ha (1972) to 11,297 ha (1995) and recently increased to 17,357 ha with a rate of 337 ha/year (Figure 10).

The impact of the damage mangroves along the coast of this district has resulted very broad erosion, and damaging many coastal structures (Figure 11). Coastal erosion occurs in many places within this district reaching 1-10 m/year and seawater intursion up to 17 km. To solve erosion problems, coastal structures such as dikes, sea wall, groyne or breaker waves are required, but this needs high costs as shown in Figure 12).

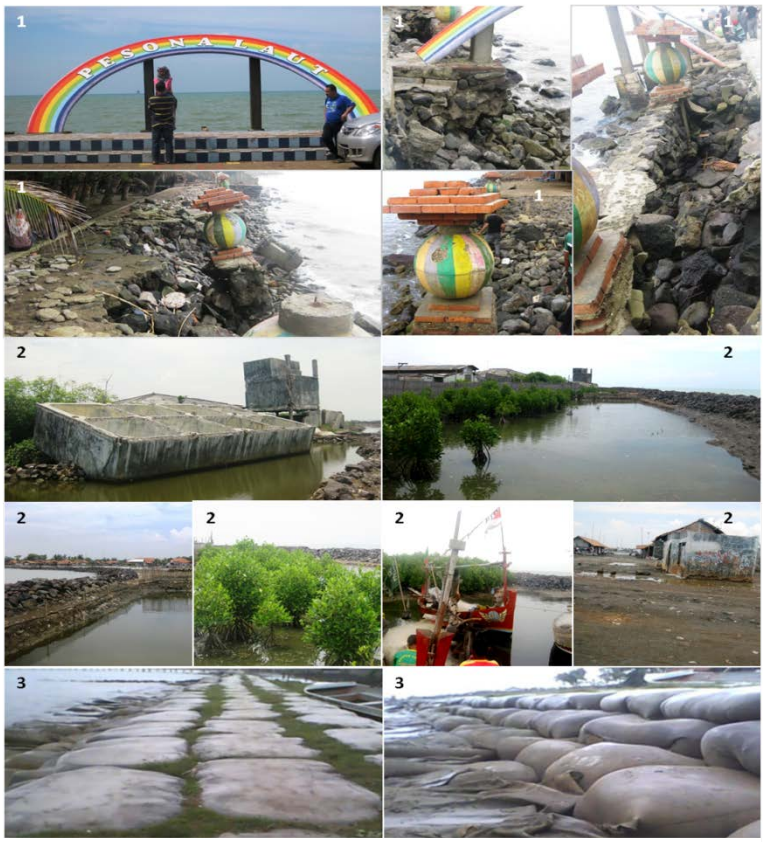


Figure 11. Coastal erosion in the some places of Indramayu District.

However, based on Fig. 10, the decreasing rate of mangrove significantly reduced in the period 1995-2013 compared to the period 1972-1995. These are due to:

- The Launch of mangrove rehabilitation movement by the Office of Forestry, Indramayu District since 2004 with a plan to plant 1.4 million mangrove trees in areas that mangrove condition was critical. Effort of coastal reforestation will continue until the damage condition of mangrove recovery.
- Increase in public awareness of the local communities about the importance of the role, functions and benefits of mangrove, so many communities begin to participate on mangrove planting and rehabilitation activities, although the participation is still low.
- There are many private companies, NGOs, universities, and other professional organizations also participated in mangrove conservation, such as the Indonesian oil company (PT PHE ONWJ) which is great help in mangrove rehabilitation/ reforestation through their 'Corporate Social Responsibility or CSR" program, not only in this district, but also in 3 other districts, Karawang, Subang and Cirebon.

Although mangrove reforestation efforts have been made in almost all the northern coast of Java Island (western, central and eastern provinces), including the study sites, but most of the effort is wasted because many planted mangroves do not grow well and eventually died, as a result most of the planting is done on beaches that are eroded and in habitats that are not suitable for mangrove to grow and develop, such as in the temporary silt areas, sandy soil, and paddy fields. In this district a small successes have been shown in the Eretan Wetan Village of this districts (Figure 13)

Figure 12. Dozen km of high cost sea wall for protecting the beach in Indramayu District.

Figure 13. A small success in replanting mangrove (*Rhizopora* sp.) at Eretan Kulon Village,

To replant mangroves in the area that has been damaged it is need to consider several things. The most important thing is to know the history of the selected sites whether or not the species of mangrove ever grow there. Of the approximately 60 species of mangrove trees and shrubs, as well as some 20 species of associated mangroves, only 12 species are commonly used for restoration, ie Rhizophora, Avicennia, Sonneratia, Bruguiera, Heritiera, Lumnitzera, Ceriops, Excoecaria, Xylocarpus, Nypa, Cassurina, and Hibiscus. Determination of selected species also depends on soil texture, salinity, and long inundation, as well as other micro-climate **9, 11, 12].**

Cirebon District

The Distrcit of Cirebon consists of 40 subdistricts, in which 5 of then are coastal sub-districts. Field observation was conducted in the subdistrict of Kapetakan precisely in the Bunko Lor Village. The mangrove diversity is very poor, there are only 2 species of true mangroves and 2 species of

Figure 14. Very poor buidiversity of mangrove that grow at the edge of river (Left). Most of the mangrove has already converted to tambak (right).

associated mangrove**.** Most of mangrove has converted to tambak, so it does not seem to have grown in the embankment of tambak as in other districts (Figure 14).

Multi-temporal analysis of Landsat satellite imageries showed that mangrove areas in this sub-district showed a decreasing from 611.4 ha (1973) to 227.3 ha (1994), but slightly increased to 281.7 ha (2013). (Figure 15). Increase of mangrove areas is due to the efforts of many parties in

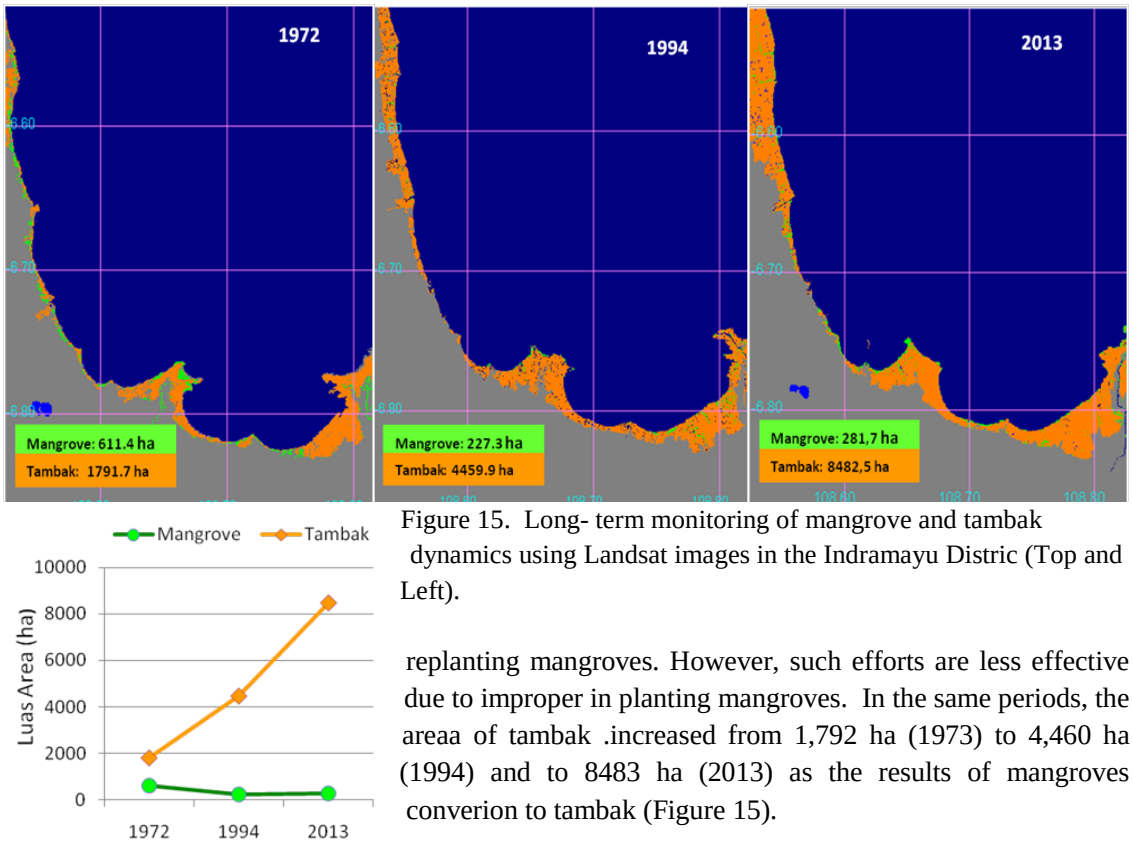


Figure 15. Long- term monitoring of mangrove and tambak dynamics using Landsat images in the Indramayu Distric (Top and Left).

replanting mangroves. However, such efforts are less effective due to improper in planting mangroves. In the same periods, the areaa of tambak .increased from 1,792 ha (1973) to 4,460 ha (1994) and to 8483 ha (2013) as the results of mangroves converion to tambak (Figure 15).

Erosion along the coast of Cirebon District due to reduced mangrove vegetation is now threatening the costal communities, while mangroves that are able to withstand the big waves have not been planted. It is estimated 3,000 hectares of coastal land has been eroded by the waves. Thus, If there is no effort in planting mangroves, the coastal erosian will be intensified, and damaging all sub district that located in the coastal zones.

Concluding Remarks

Study on land use conversion from mangrove ecosysrtems to tambak have been conducted in 4 districts along the northern cost of West Jawa Province. Mangrove ecosystems provide environmental services as well as goods, such as marine products to the comunities that live in Coastal areas, However, mangrove in all observed districts have been converted to tambak, some even dtrasticaly such as in Karawang District without considering the negative impacts as heavy erosion in the coastal line that destroyed the tambak themselves, community resident (housings), threatened the coastal structures such as streets, bridges, buidings, and seawater intursion, etc.

The main reasons of mangroves convesion is that the profit gained from fish and shrimp cultured in tambaks as shown in Table 2. However, those profits can only be perceived in just a short

time, when the tambaks are still in good condition, otherwise would be a disaster if the function of mangrove lost. Mangrove valuation study that we've done showed that let the mangove as it will provide longer benefits [8]. Once a mangrove ecosystem is damaged, then it is very difficult to recovery, it will consume times and require high cost.

Therefore, mangrove restoration should be done immediately. Great efforts have been widely shown; hundreds of thousands of mangrove trees have been planted by the various parties, but fail because it was done in the wrong procedures. Selection of mangrove species that appropriate to the location (habitat) that will be planted as well as considering the life requirements of each species of mangrove is a prerequisite in order to obtain the success, and thus, great efforts are not in vain.

Table2. Fish and shrimp production and values from tambak in each districts in 2011[13].

Fish & Shrimp Production and Values	Districts			
	Karawang	Subang	Indramatu	Cirebon
Production (tons)	35,459	1,361	101,455	15,821
Values (in million USD)	46.77	1.54	168.72	29.74

Acknowledgements

This paper is a part of study on the coastal biodiversity in the northern coast of West Java, which is funded by the national oil company PT PHE ONWJ, as aCorporate Social Responsibility (CSR) program of that company. We would deeply like to thanks for the permission in writing this paper and for a partial funding support.

We would like also to thank to GISUP especially to Prof. ISHIMATSU, Prof. Byundug JUN, and Prof. SUGIYAMA of Nagasaki University in inviting us to participate in the symposium of GISUP 2014 and for funding support.

References

1]. Adulyanukosol, K. & Poovachiranon, S., 2006. Dugong (*Dugong dugon*) and seagrass in Thailand: present status and future challenges. Proceedings of the 3rd International Symposium on SEASTAR2000 and Asian Bio-logging Science. Part II:41-50.

2]. Pramudji, 2008. Mangrove in Indonesia and its management effort. Unpublished report 53 pp. (in Indonesia).

3]. Hartini, S., Saputro, G.B., Suprajaka, M.Y., 2010. Assessing the use of remote sensed data for mapping mangrove Indonesia. Selected Topics in Power System and Remote Sensing. In 6th WSEAS International Converence on Remote Sensing (REMOTE 10). Iwate Prefectural University, Japan, October 4-6, 2010:210-215.

4]. Noor, Y.K., Khazali, M., dan Suryadiputra, N.N., 2006. Guide to introduction of Indonesian mangrove. PHKA/WI-IP, Bogor, 220 pp. (in Indonesian).

5]. Sukarjo, S., and Alongi D.M., 2012. Mangrove of the South China Sea: Ecology and Human Aspects of Indonesia's forest. Nova Science Publisher Inc.

6]. Anon, 2001. Philippine Coastal Management Guidebook No. 5: Managing Coastal Habitats and Marine Protected Areas. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines, 106 p.

7]. LPP Mangrove, 2004. Economic valuation of the mangrove ecosystem in Indonesia. LPP Mangrove Publication, Bogor.

8]. Supriyadi, H.I. and Wouthuyzen, S., 2005. Economic valuation of mangrove resources in the Cotania Bay, West Seram, Maluku Province. Oceanology and Oceanography in Indonesia. No. 38:1-27.

9]. Setyawan, A.D., Winarno, K., and Purnama, P.C., 2004. Mangrove ecosystem in Java: 2. Restoration. BIODIVERSITAS, Vol. 5(2): 105-118 (in Indonesian).

10]. Chavez, P.S., 1996. Image-based atmospheric corrections revisited and improved. Photo-gramengineering and Remote Sensing, 62:1025-1036.

11]. Setiyawan, W.B., 2010. Obrervation on replanting mangrove a long the coatal zone of northern Java. *Ilmu Kelautan*, Vol.15(2):91-102 (in Indonesian).

12]. Kusmana, C & Onrizal. 1998. Evaluation of damage level of mangrove area in Java island dan its rehabilitation technique. Main paper on symposium of network of mangrove conservation. 12 – 13 Agustus 1998 ini Pemalang, Middle Java (in Indoonesia).

13]. Anon, 2012. West Java in figures. Division of Integration Processing and Dissemination of Statistics, Center of Statistics Agency of West Java Province. 571 pp.

Long-term Monitoring of Mangroves Conversion Along the Nothern Coast of West Java Province, Indonesia Using Multi-temporal Landsat satellite images

by Melati Ferianita Fachrul

Submission date: 16-Jan-2021 06:36PM (UTC+0700)
Submission ID: 1488582862
File name: nce,_Indonesia_Using_Multi-temporal_Landsat_satellite_images.pdf (1.4M)
Word count: 3653
Character count: 19077

[Special Lecture]
GISUP2014(International),No.16,pp.3-13, February 19-21, 2014

Long-term Monitoring of Mangroves Conversion Along the Nothern Coast of West Java Province, Indonesia Using Multi-temporal Landsat satellite images

Sam Wouthuyzen[1)], Melati Ferianita[2)], Boy Fachrul[2)], Rustam Hakim[2)], Femmy D. Hukom[1)], and Helmi Purnama[3)]

1). Recearch Center for Oceanography, LIPI swouthuyzen@yahoo.com
2). LEMLIT - Trisakti University, melatif99@yahoo.com
3). PT PHE ONWJ, situgede@gmail.com

ABSTRACT: In this study, we monitor the land use conversion of mangroves to the fish pound or in Indonesian call "Tambak" along four districts situated in the north coast of West Java Province every 2 decades using multi-temporal Landsat Satellite images. A total of 17,028 ha mangroves areas in those districs recorded in 1972/73 that drastically decreased to 9,063 ha in 1993/94 and then drop to 6.003 ha in 2012/13. Mangroves were heavily converted to tambak between 1972/73 and 1993/94 with decreasing rate of 398 ha/year, but rather slower as 153 ha/year between 1993/94 to 2012/13. In the same periods, the tambak areas increased from 17,064 ha to 27.721 ha and to 42.610 ha, respectively, with the increasing rate of 533 ha/year (1972/73 - 1993/94) and 775/ha/year (1993/94-2012/13). The loss of the dense mangrove cause severe beach erosion in all districts with rate of 1-10 km/year and the intursion of seawater up to 17 km. Beach erosion damaged many tambaks and houses of the coastal comunities. Efforts to restore the damaged mangrove have been made by various parties. A small fraction of the effort is successful, but most of the others failed, because of the improper in replanting mangroves.

1. INTRODUCTION

Indonesia is the largest archipelago country in the world with the second longest coast lines after Canada (81,000 km) and have more than 17,000 big and small Islands. Therefore, the cosatal zones are very huge. Situated in tropical areas, the coastal zone of Indonesia generally has 3 important ecosystems, namely mangrove, seagrass and coral reef. These ecosystems serve as shelter, spawning, nursery and feeding grounds for many marine faunas, including protected faunas such as turtles and dugongs [1].

Indonesia also has the world's largest mangrove, ie 27% of the world's total mangrove, or 75% of the mangroves in Southeast Asia [2]. The Geospatisal Information Agency of Indonesia estimated a total area of 3.244 million ha based on 199 satellite images of Landsat-7 ETM+ [3]. The Biodiversity of mangroves in Indonesia are very varies. There are 75 species representing 24 family and 41 genera are found [2]. Other records at least 202 species that consists of 43 species true mangrove and the rest are associated mangrove [4], while update data mention that there are 92 species of true mangrove [5].

Ecosystem of mangrove, as well as seagrass and coral reefs are also known to have high productivity, exceeded the productivity of tropical rain forests [6]. Therefore, it is not be surprised that those ecosystems can make the coastal zones of Indonesia are very rich in marine resources. This leads Indonesia to become known as "mega marine biodiversity center in the world".

Economic valuation of mangrove ecosystems based on the benefits and functions such as production, ecological, and socio-economic functions show that mangroves provide high economic benefits to coastal communities. The average total economic value of mangrove ecosystems from various regions in Indonesia is about USD 3,750/ha/year [7, 8]. Nevertheless, the mangrove areas have been decreased drastically; due to high population pressure that causes the increase of many activities, such as deforestation and mangrove conversions to other land uses (reclamation for agiculture, industry, urban areas), as well as environmental pollution [9].

In a large-scale, mangrove area has been converted into brackish water fish ponds (in Indonesian called "Tambak"). The loss due to this conversion is estimated at 1.6 million ha. Conversion of mangrove areas in 1980s was 155,081 ha, mostly taking place in Java, Sumatra and Sulawesi and increased to 285,500 ha in the 1990s [2]. Actually, tambak has a long history in the northern coast of Java, where initialy milkfish (*Chanos Chanos*) has been cultivated since 15th century. However, in 1970 method of intensive shrimp farming in tambak was found, which coincided with high market demand and high prices of shrimp at that time caused large conversion of mangroves[9].

Changes in the function of mangrove to tambak have major impact on the eco-bio-physical processes, such as rapid erosion, loss of green belts, which serves as a natural buffer to protect the soil from large waves, water quality degradation, reduced marine biodiversity, loss of spawning, nursery and foraging habitats for fish, shrimp and other marine life. In this paper, we conducted study on the conversion of mangroves into fishponds (tambak) and its impact as well as conservation efforts along the northern coast of West Java Province.

2. Methods

This study was conducted along the northern coast of West Java Provinve. There are 16 districts and 7 municipals in this provinve. Among of them 4 districts are situated along the northern coast of West Java Province, namely: 1. Karawang, 2. Subang, 3. Indramayu and 4. Cirebon Districts that faced to Java Sea (Figure 1).

To map and to monitor mangroves and their changes due to conversion of mangrove into fish pond (tambak), we used effective and efficient methods by using remote sensing techniques utilizing multi-temporal Landsat images. Two-decadal (1972/73, 1993/1994 and 2012/2013) of 8 Landsat satellites images are used (Tablel-1).

Before the images analysis is done, first, all images were corrected for the atmospheric influences using a simple method known as Dark Object Subtraction (DOS) [10]. Map of habitats in 5 districts of study sites were made using cluster analysis module in the

Figure1. Map of study sites that conducted in 4 districts (Bekasi, Karawang, Subang, Indramatu and Cirebon) along the northern cost of West Java Province.

image processing packages (IDRISI ANDES soft-ware). Cluster analysis classified the study sites into 9 classes habitat (Sea, Mangrove-1, Mangrove-2, Tambak-1, Tamabak-2, Vegetation-1, Vegetation-2, Vegetation-3, Urban areas). After careful validation using field observation in 4 districts, the habitat were regroup again into 4 classes, namely Sea, Mangrove, Tambak and others (all other vegetation than mangrove + urban areas). Based on these maps the dynamics of mangroves and tambak can be observed, while the areas of both can be calculated.

Tablel-1. Two decadal of multi-temporal various Landsat satellite images use in this study.

Satellites	Path/Row	Date	Observed Districts			
			Kerawang	Subang	Indramayu	Cirebon
1. Landsat-1 MSS	131 /064	Oct. 1972	+	-	-	-
2. Landsat-1 MSS	130 / 064	Nov. 1972	-	+	+	-
3. Landsat-1 MSS	129 / 065	Aug. 1972	-	-	-	+
4. Landsat-5 TM	122 / 064	Dec. 1993	+	+	+	-
5. Landsat-5 TM	121 / 065	Aug, 1994	-	-	-	+
6. Landsat-8 OLI	122 / 064	Aug. 2013	+	+	-	-
7. Landsat-8 OLI	122 / 064	Sep. 2013	-	-	+	-
8. Landsat-8 OLI	121 / 065	Sep. 2013	-	-	-	+

3. Results and Discussions

Mangrove, as already mentioned provide products and environment services that are beneficial to the coastal communities. Large-scale mangrove conversion into tambak is the major causes of mangrove destruction along the northern coast of Java Island including the study sites that can be seen as follow:

Karawang Districts

This district consists of 30 sub-districts (kecamatan), 9 are located in coastal areas, but the observations only made in one sub-districts (Cimalaya District), in 4 vilages (Cemara jaya, Sungai Buntu and Sedari Villages) with the total cost line of 73.7 km. In general, mangrove has no longer formed forest, but only a few stands of trees that are grown in the dike, in the middle of the pond, in the left / right side of the river or the road and dry land (Figure-2) There were 14 species of true mangroves and 15 species of associated mangroves with *Rhizopora murconata, R. stylosa*, *Soneratia caeseolaris* dan *Avicennia officinalis* as dominant species.

Figure 2. Mangrove stands that no longer formed forest in some places of Karawang districts

Multi-temporal analysis of Landsat satellite images show a fairly dense mangroves found in 1972 (2,699 ha), but decreased in 1993 (1,159 ha) and dramatically decreased in 2013 (234 ha) (Figure 3). Conversion of mangroves to agricultural areas and fish pond (tambak) degraded the mangroves. This can be seen by the increase of tambak areas from 9,625 ha (1972) to 10,089 ha (1993) and became

wider to 11,411 ha (2013) (Figure 3). Degradation of mangrove caused coastal erosion that damaging many tambaks and residents (Figure. 4). The rate of erosion along the shoreline of this district reaches about 5 to 10 meters per year. As a result, sea water eroded the land to reach about 50-500 m.

Replanting hundred thousands of mangroves as an effort to rehabilitate mangroves have often attempted by many organizations, but some of them failed, because they used incorrect method or procedures, such as to plant a certain species of mangrove in the wrong habitat (substrate), some other just only plant the mangrove and left them without a properly maintained and monitor [11].

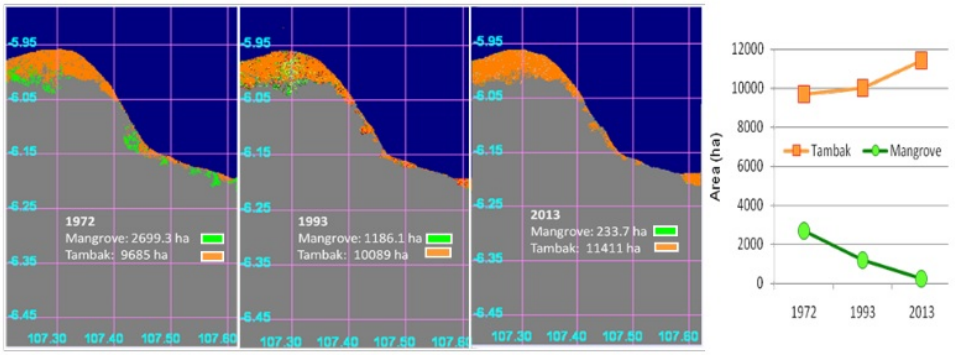


Figure 3. Long-term monitoring of mangrove and tambak dynamics using Landsat images in the Karawang District,

Subang Districts

This district cosisted of 30 sub-districts, and 4 among them are situated in coastal zone with the coastal line of 68 km. Field observation was conducted in sub-district of Blanakan in 3 villages. There are 10 species of true mangroves and 9 of associated mangroves. The dominant species for tree category is *Sonneratia caseolaris*, while for seed are *R. mucronata* and *A. marina*. High number of those seeds indicated that the study site could be served as a source of mangrove seeds.

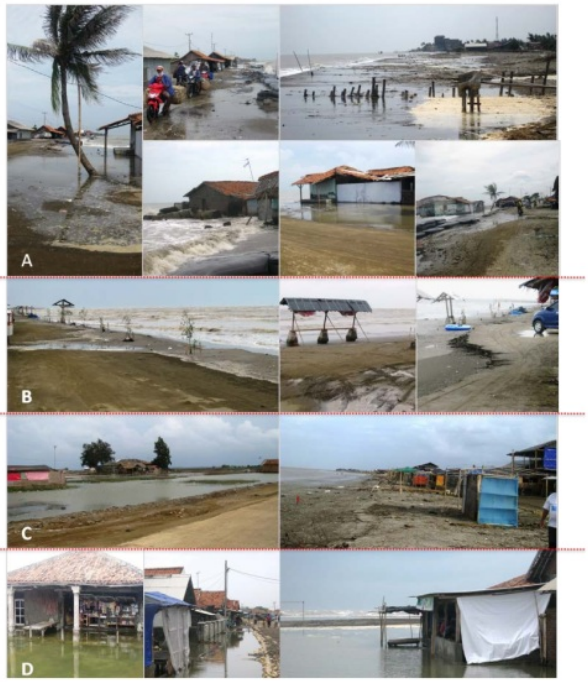


Figure 4. Coastal erosion in the some villages (A. Cemara Jaya, B. Samudra Jaya, C. Ciparage, D. Sedari) of Karawang District.

Multi-temporal analysis of Landsat satellite imageries showed relatively dense mangrove found in 1972 (3,100 ha). In 1993, the areas of mangrove increased (4,455 ha), but decreased in 2013 (3,873 ha) (Fig. 5). However, the areas were still bigger than those in 1972. Increase of mangrove areas in this districts demonstrated a success effort in mangrove replanting program both in the green belt areas, as well as in the tambak (Silva fishery

program), which was fostered by local Forestry Management Authority (Perum Perhutani). Such kind of conservation efforts need to be continued and spread to other districts.

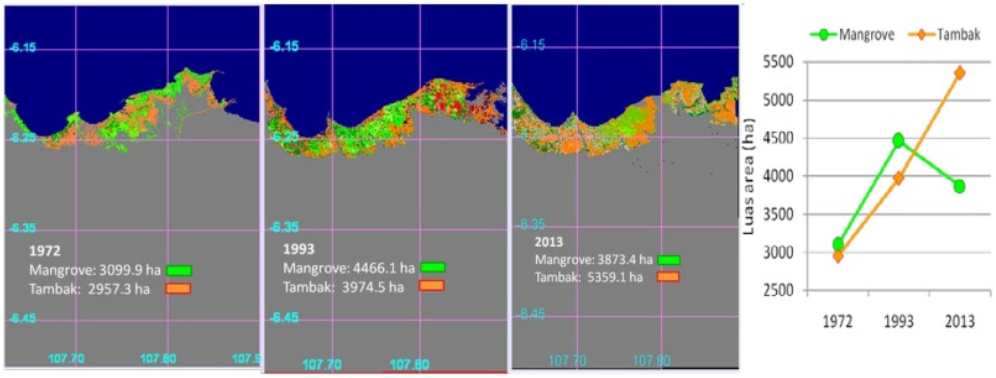


Figure 5. Long-term monitoring of mangrove and tambak dynamics using Landsat images in the Subang District,

At the same monitoring period, the areas of tambak increased from 2,957 ha to 3,875 ha and again to 5,359 ha (Figure 5). Although the areas of tambak in Subang were ½ of those in the Karawang, but the average of decline rate was similiar (69 ha/year). In this district, the coastal erosion relatively less then the other districts (karawang, Indramayu and Cirebon), because dense mangrove still grow in the coast line (figure 6). Thus, mangrove serves as a natural fortress that protects the coast from big waves, especially during west monsoon. Futhermore, fishermen in this sub-district, which are mostly focused on catching blue crabs (*Portunus pelagicus*) got the advantage of better catches due to mangrove services (Figure 7).

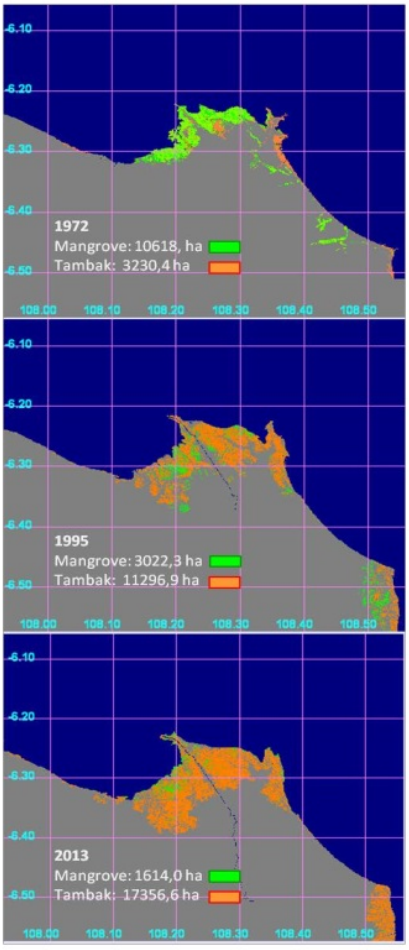
Figure 6. .Mangrove in the coast line of Subang District act as natrural fortress in protecting the beach from erosion (Top).

Figure 7. Crab fishermen got adventages of better catches due to mangrove services (Left).

Indramayu District

The district of Indramayu has 31 sub-districts among them, 11 sub-districts are in the coastal zone with the coast line length of 141.1 km. Observation conducted only in Sub-district of Kandanghaur (Eretan Wetan and Kulon villages). There were 14 species of true mangrove and 6 species of associated mangrove with the dominant species of *R. mucronata, R. stylosa* and *A. marina.* Mangrove distribution is very limited around the tambak and the river edge (Figure 9)

Figure 9. Distribution of limited mangorve in Indramayu District.



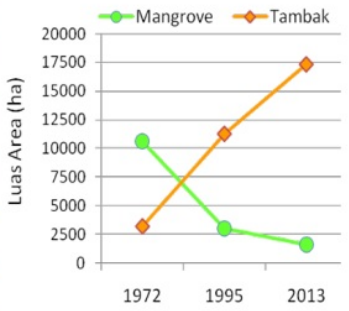


Figure 10. Long-term monitoring of mangrove and tambak dynamics using Landsat images in the Indramayu District,

Multi-temporal analysis of Landsat satellite imageries showed that initially, mangroves in this district were very dense, ie 10,618 ha (1972), but dropped dramatically to 3,222 ha (1995) and recently only 1,614 ha (2013) (Figure 10). The average of declining rate of mangrove was approximately 345 ha/year due to mangroves conversion to tambak. On the contary, a very sharp increase of tambak were shown from 3,230 ha (1972) to 11,297 ha (1995) and recently increased to 17,357 ha with a rate of 337 ha/year (Figure 10).

The impact of the damage mangroves along the coast of this district has resulted very broad erosion, and damaging many coastal structures (Figure 11). Coastal erosion occurs in many places within this district reaching 1-10 m/year and seawater intursion up to 17 km. To solve erosion problems, coastal structures such as dikes, sea wall, groyne or breaker waves are required, but this needs high costs as shown in Figure 12).

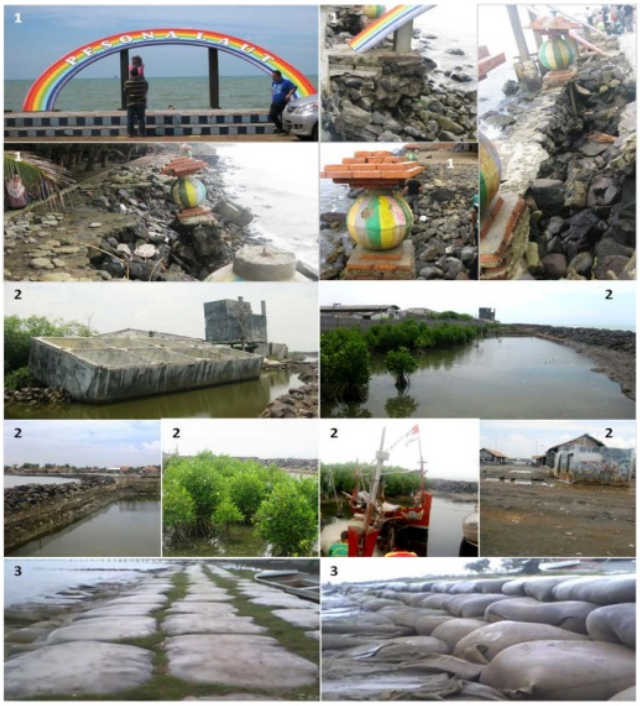


Figure 11. Coastal erosion in the some places of Indramayu District.

However, based on Fig. 10, the decreasing rate of mangrove significantly reduced in the period 1995-2013 compared to the period 1972-1995. These are due to:

- The Launch of mangrove rehabilitation movement by the Office of Forestry, Indramayu District since 2004 with a plan to plant 1.4 million mangrove trees in areas that mangrove condition was critical. Effort of coastal reforestation will continue until the damage condition of mangrove recovery.
- Increase in public awareness of the local communities about the importance of the role, functions and benefits of mangrove, so many communities begin to participate on mangrove planting and rehabilitation activities, although the participation is still low.
- There are many private companies, NGOs, universities, and other professional organizations also participated in mangrove conservation, such as the Indonesian oil company (PT PHE ONWJ) which is great help in mangrove rehabilitation/ reforestation through their 'Corporate Social Responsibility or CSR" program, not only in this district, but also in 3 other districts, Karawang, Subang and Cirebon.

Although mangrove reforestation efforts have been made in almost all the northern coast of Java Island (western, central and eastern provinces), including the study sites, but most of the effort is wasted because many planted mangroves do not grow well and eventually died, as a result most of the planting is done on beaches that are eroded and in habitats that are not suitable for mangrove to grow and develop, such as in the temporary silt areas, sandy soil, and paddy fields. In this district a small successes have been shown in the Eretan Wetan Village of this districts (Figure 13)

Figure 12. Dozen km of high cost sea wall for protecting the beach in Indramayu District.

Figure 13. A small success in replanting mangrove (*Rhizopora* sp.) at Eretan Kulon Village,

To replant mangroves in the area that has been damaged it is need to consider several things. The most important thing is to know the history of the selected sites whether or not the species of mangrove ever grow there. Of the approximately 60 species of mangrove trees and shrubs, as well as some 20 species of associated mangroves, only 12 species are commonly used for restoration, ie Rhizophora, Avicennia, Sonneratia, Bruguiera, Heritiera, Lumnitzera, Ceriops, Excoecaria, Xylocarpus, Nypa, Cassurina, and Hibiscus. Determination of selected species also depends on soil texture, salinity, and long inundation, as well as other micro-climate [9, 11, 12].

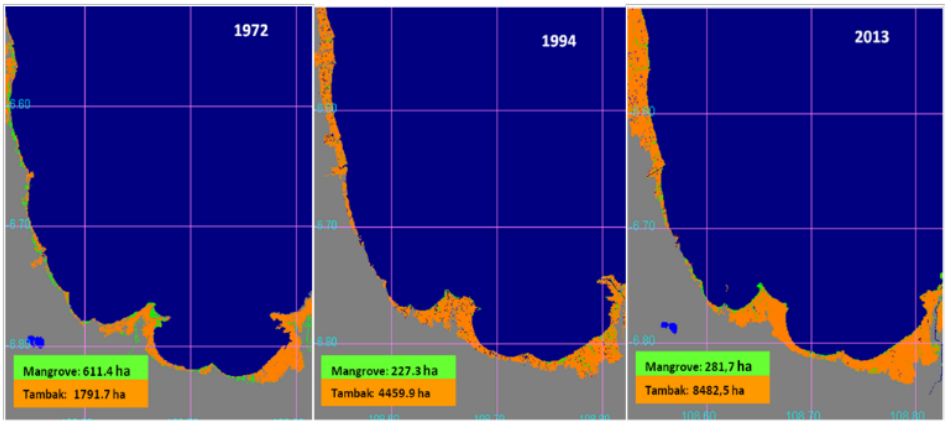
Cirebon District

The Distrcit of Cirebon consists of 40 subdistricts, in which 5 of then are coastal sub-districts. Field observation was conducted in the subdistrict of Kapetakan precisely in the Bunko Lor Village. The mangrove diversity is very poor, there are only 2 species of true mangroves and 2 species of

Figure 14. Very poor buidiversity of mangrove that grow at the edge of river (Left). Most of the mangrove has already converted to tambak (right).

associated mangrove. Most of mangrove has converted to tambak, so it does not seem to have grown in the embankment of tambak as in other districts (Figure 14).

Multi-temporal analysis of Landsat satellite imageries showed that mangrove areas in this sub-district showed a decreasing from 611.4 ha (1973) to 227.3 ha (1994), but slightly increased to 281.7 ha (2013). (Figure 15). Increase of mangrove areas is due to the efforts of many parties in



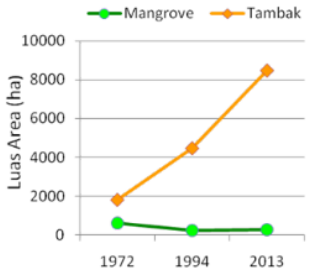


Figure 15. Long- term monitoring of mangrove and tambak dynamics using Landsat images in the Indramayu Distric (Top and Left).

replanting mangroves. However, such efforts are less effective due to improper in planting mangroves. In the same periods, the areaa of tambak .increased from 1,792 ha (1973) to 4,460 ha (1994) and to 8483 ha (2013) as the results of mangroves converion to tambak (Figure 15).

Erosion along the coast of Cirebon District due to reduced mangrove vegetation is now threatening the costal communities, while mangroves that are able to withstand the big waves have not been planted. It is estimated 3,000 hectares of coastal land has been eroded by the waves. Thus, If there is no effort in planting mangroves, the coastal erosian will be intensified, and damaging all sub district that located in the coastal zones.

Concluding Remarks

Study on land use conversion from mangrove ecosysrtems to tambak have been conducted in 4 districts along the northern cost of West Jawa Province. Mangrove ecosystems provide environmental services as well as goods, such as marine products to the comunities that live in Coastal areas, However, mangrove in all observed districts have been converted to tambak, some even dtrasticaly such as in Karawang District without considering the negative impacts as heavy erosion in the coastal line that destroyed the tambak themselves, community resident (housings), threatened the coastal structures such as streets, bridges, buidings, and seawater intursion, etc.

The main reasons of mangroves convesion is that the profit gained from fish and shrimp cultured in tambaks as shown in Table 2. However, those profits can only be perceived in just a short

time, when the tambaks are still in good condition, otherwise would be a disaster if the function of mangrove lost. Mangrove valuation study that we've done showed that let the mangove as it will provide longer benefits [8]. Once a mangrove ecosystem is damaged, then it is very difficult to recovery, it will consume times and require high cost.

Therefore, mangrove restoration should be done immediately. Great efforts have been widely shown; hundreds of thousands of mangrove trees have been planted by the various parties, but fail because it was done in the wrong procedures. Selection of mangrove species that appropriate to the location (habitat) that will be planted as well as considering the life requirements of each species of mangrove is a prerequisite in order to obtain the success, and thus, great efforts are not in vain.

Table2. Fish and shrimp production and values from tambak in each districts in 2011 [13].

Fish & Shrimp Production and Values	Districts			
	Karawang	Subang	Indramatu	Cirebon
Production (tons)	35,459	1,361	101,455	15,821
Values (in million USD)	46.77	1.54	168.72	29.74

Acknowledgements

This paper is a part of study on the coastal biodiversity in the northern coast of West Java, which is funded by the national oil company PT PHE ONWJ, as aCorporate Social Responsibility (CSR) program of that company. We would deeply like to thanks for the permission in writing this paper and for a partial funding support.

We would like also to thank to GISUP especially to Prof. ISHIMATSU, Prof. Byundug JUN, and Prof. SUGIYAMA of Nagasaki University in inviting us to participate in the symposium of GISUP 2014 and for funding support.

References

1]. Adulyanukosol, K. & Poovachiranon, S., 2006. Dugong (*Dugong dugon*) and seagrass in Thailand: present status and future challenges. Proceedings of the 3rd International Symposium on SEASTAR2000 and Asian Bio-logging Science. Part II:41-50.

2]. Pramudji, 2008. Mangrove in Indonesia and its management effort. Unpublished report 53 pp. (in Indonesia).

3]. Hartini, S., Saputro, G.B., Suprajaka, M.Y., 2010. Assessing the use of remote sensed data for mapping mangrove Indonesia. Selected Topics in Power System and Remote Sensing. In 6th WSEAS International Converence on Remote Sensing (REMOTE 10). Iwate Prefectural University, Japan, October 4-6, 2010:210-215.

4]. Noor, Y.K., Khazali, M., dan Suryadiputra, N.N., 2006. Guide to introduction of Indonesian mangrove. PHKA/WI-IP, Bogor, 220 pp. (in Indonesian).

5]. Sukarjo, S., and Alongi D.M., 2012. Mangrove of the South China Sea: Ecology and Human Aspects of Indonesia's forest. Nova Science Publisher Inc.

6]. Anon, 2001. Philippine Coastal Management Guidebook No. 5: Managing Coastal Habitats and Marine Protected Areas. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines, 106 p.

7]. LPP Mangrove, 2004. Economic valuation of the mangrove ecosystem in Indonesia. LPP Mangrove Publication, Bogor.

8]. Supriyadi, H.I. and Wouthuyzen, S., 2005. Economic valuation of mangrove resources in the Cotania Bay, West Seram, Maluku Province. Oceanology and Oceanography in Indonesia. No. 38:1-27.

9]. Setyawan, A.D., Winarno, K., and Purnama, P.C., 2004. Mangrove ecosystem in Java: 2. Restoration. BIODIVERSITAS, Vol. 5(2): 105-118 (in Indonesian).

10]. Chavez, P.S., 1996. Image-based atmospheric corrections revisited and improved. Photo-gramengineering and Remote Sensing, 62:1025-1036.

11]. Setiyawan, W.B., 2010. Obrervation on replanting mangrove a long the coatal zone of northern Java. *Ilmu Kelautan*, Vol.15(2):91-102 (in Indonesian).

12]. Kusmana, C & Onrizal. 1998. Evaluation of damage level of mangrove area in Java island dan its rehabilitation technique. Main paper on symposium of network of mangrove conservation. 12 – 13 Agustus 1998 ini Pemalang, Middle Java (in Indoonesia).

13]. Anon, 2012. West Java in figures. Division of Integration Processing and Dissemination of Statistics, Center of Statistics Agency of West Java Province. 571 pp.

Long-term Monitoring of Mangroves Conversion Along the Nothern Coast of West Java Province, Indonesia Using Multi-temporal Landsat satellite images

ORIGINALITY REPORT

11%	9%	4%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

4%

★ docplayer.net

Internet Source

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		