THESIS

ANALYSIS ON MANGROVE FOREST CHANGES IN RELATION TO COASTLINE CHANGES, AND ITS INFLUENCE TO COMMUNITY IN REMBANG DISTRICT, CENTRAL JAVA PROVINCE, INDONESIA

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DISCLAIMER

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Mochamad Budi Purnomo

ABSTRACT

Rembang District have been facing sedimentation and coastal erosion for recent years. It has not known the relation between this phenomenon with the dynamic of mangroves. The present study aimed to analyse the spatial and temporal changes of mangrove forest in relation to coastline changes, and its influence to local community.

Historical topography maps, Landsat images and Google Earth images were utilised in the present research. A maximum likelihood classifier for supervised image classification using band composite, and composite of difference NDWI-NDVI, bandratio SWIR/NIR and band SWIR of Landsat images was applied to map mangrove forest. Visual interpretation and on screen delineation using band composite and binary slicing were applied to detect coastline changes. While semi-structured interview using questionnaires was applied to analyse the influence of mangrove forest changes to community as well as their adjustment. A proportional random sampling protocol was applied to determine 81 respondents from the village of Pasarbanggi, Tasikharjo and Tunggulsari.

The extraction of mangroves area and coastline using the available dataset showed that sedimentation was the dominant process in study area, followed by the increases of mangrove forest. A maximum likelihood classifier for supervised image classification using band composite, and composite of difference NDWI-NDVI, bandratio SWIR/NIR and band SWIR of Landsat images leave a limitation for this study. The 30 m spatial resolution of Landsat images is considered too small to map mangroves which grow in narrow belt along the pond dike. While Google Earth images have provided a good visualisation of mangroves area and coastline. The dynamic of mangroves forest also corresponds to government intervention through mangroves programs and local community's participation in establishing mangrove forest. Pasarbanggi Village which received various program, both from government and other parties, combined with active participation of local people in establishing mangrove, has a stable increases of mangroves area between periods without significant disturbances in form of mangroves felling compared to Tasikharjo Village and Tunggulsari Village. In line with this situation, respondents have different response toward the changes of mangrove forest in their area. Respondents' response toward mangrove forest changes correlates to their participation in government mangroves program. Respondents in Pasarbanggi Village are apparently more benefited by the changes of mangroves forest including direct and indirect benefit from the forest, as well as from mangroves program, compared to another respondents in Tasikharjo Village and Tunggulsari Village. While respondents adjustment can be grouped into two category. First, structural adjustment in form of mangrove plantation, and second, economic adjustment in form of sided-income generation.

Keywords: mangrove forest changes, coastline changes, community's perception, community's adjustment

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Mochamad Budi Purnomo

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LIST OF ABBREVIATION

Bappeda	*Badan Perencanaan Pembangunan Daerah* Regional Development Planning Board
BLH	*Badan Lingkungan Hidup* Environment office
BMKG	*Badan Meteorology, Klimatology dan Geofisika* Meteorological, Climatology and Geophysic Board
BNPB	*Badan Nasional Penanggulangan Bencana* National Board on Disaster Management
Dishut	*Dinas Kehutanan* Forestry office
Distanhut	*Dinas Pertanian dan Kehutanan* Agriculture and Forestry Office
DKP	*Dinas Kelautan dan Perikanan* Marine and Fishery Office
GNRHL	*Gerakan Nasional Rehabilitasi Hutan dan Lahan* national movement on forest and land rehabilitation
IR	infrared
KBR	*Kebun Bibit Rakyat* Nursery for people
NDVI	The Normalized Difference Vegetation Index
NDWI	The Normalized Difference Water Index
NTFP	non timber forest products
SBRD	Statistic Board of Rembang District
SWIR	shortwave infrared

CHAPTER I
INTRODUCTION

This chapter describes the introduction of the research, consisting of research background, research problems, research objectives and questions, and scientific significance.

1.1. Research Background

Mangrove forest is recognised as one of valuable resources at coastal area which provides various function and benefit. Mangroves are defined as formation of intertidal plants which grow on sheltered tropical and subtropical coastlines (Saenger, 2002). Mangroves are belived could provide some utilisation such as sources of timber and non-timber forest products, nutrient provider and habitat for marine animals (Tomlinson, 1988) and protect coastal area from storm and high wind (Saenger, 2002).

Mangrove forest is believed provides protection toward natural processes at coastal area such as coastal erosion and sea wave, as well as promotes deposition of soil materials to contribute land extension. Mangrove vegetation have developed cable root system that could be used for binding sediments (Saenger, 2002). Marfai (2011), Marfai (2012) and Prasetya (2011) pointed out that beach plantation using beach vegetation and mangrove is considered as soft engineering effort to minimize the impacts of coastal erosion. Mazda *et al*. (2002) founded that the reduction of mangrove forest by human intervention and strong tidal flows has exacerbated the rate of coastal erosion.

Mangrove establishment through both natural and man-made regeneration is considered as one efforts to enhance coastline protection. This effort can be executed by local people with their own initiative or by assistance from government. Local people-initiated plantation, government-initiated plantation, or combination between these efforts have resulted both failure and succesfull in mangrove forest establishment (Amri, 2005). Amri (2005) also pointed out that government intervention in mangrove establishment should consider both ecological function of planted mangrove and economic benefit for local people. Participation of various elements in community, and government intervention in form of providing mangroves program (such as mangroves nursery and tourism demonstration site) are the key elements of the succesfull of mangrove establishment (Pribadiningtyas *et al*., 2013). In broader context, allowing community's involvement to participate and share reponsibilities as well as benefit from mangrove forest is essential to achieve sustainable management of mangrove forest (Takama & Iftekhar, 2008). While Nguyen *et al*., (2013) argued that protecting and preserving mangrove forest can be achieved by involving community in managing the forest.

Coastline dynamic which represented by the occurence of coastal erosion and sedimentation is highly corresponds to the dynamic of mangrove forest. Mangrove forest is believed could promote the sedimentation through its mechanism to trap sediments (Furukawa & Wolanski, 1996). Mangroves are actively catch and deposit sediments to establish mudflat as their own environment (Furukawa & Wolanski, 1996). On the other hand, Woodroffe (1992) proposed different perspective that mangroves are not the cause of sedimentation but only accelerate the process which also depends on the other factors in surrounding areas. Meanwhile, mangrove forest also offers physical protection toward coastal erosion. Coastal area which covered by mangroves would less suffered by coastal erosion than non-mangroves area (Thampanya *et al*., 2006). The displacement of mangrove forest could lead the initial stage of coastal erosion (Blasco *et al*., 1996).

Since mangrove forest is highly corresponds with coastal erosion and sedimentation, its development also influenced by the factors which regulate the process of coastal erosion and sedimentation. The net rate of coastal erosion and sedimentation will affects the mechanism of mangroves dynamic. Wave energy, wave direction, tidal fluctuation and littoral currents are considered as the natural factor which regulate the rate of coastal erosion and sedimentation (Kaliraj *et al*., 2013; Mujabar & Chandrasekar, 2011). Human intervention such as disruption on sediments supply, coastal sand mining, removal of vegetation and natural protection (Mujabar & Chandrasekar, 2011) and construction of aquaculture pond (Thampanya *et al*., 2006) is another factor which affects the rate of coastal erosion and sedimentation. High velocity of winds and high waves during the monsoon will promote seasonal sediments displacements and would erode the mangroves vegetation and initiate coastal erosion (Blasco *et al*., 1996).

Sedimentation and coastal erosion have been recognized as natural phenomenon along the coastline of Central Java Province (Wahyudi *et al*., 2012). Rembang District which situated at the most eastern part of coastal area of Central Java has been facing with these isues for recent years. Rembang District is situated at north coast area of Central Java Province, with its geographic location at 111° 00' - 111° 30' E and 6° 30' - 7° 06' S. The extent of Rembang District is 1,014 km^2 area and consists of 14 sub-districts, with 6 of which are located at north coast, and 294 villages.

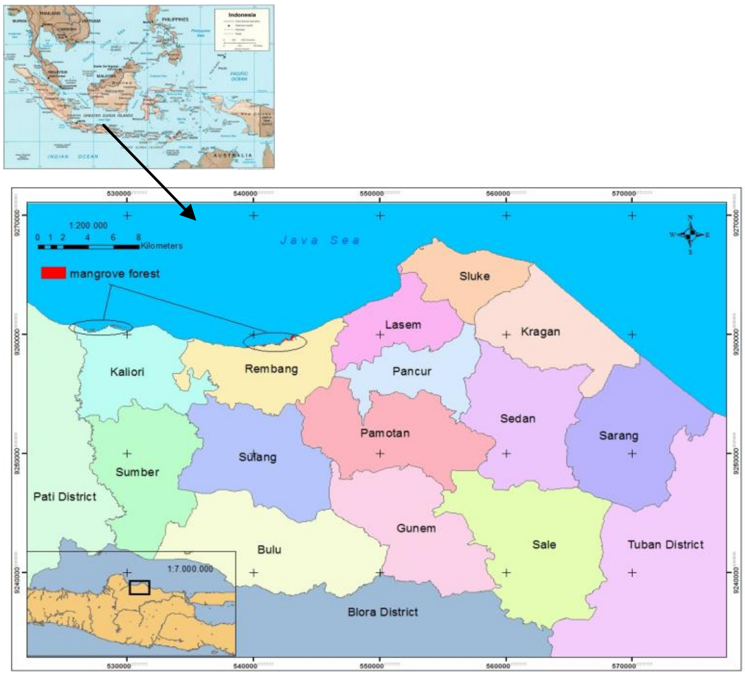


Figure 1.1. Administration map of Rembang District

Marine and Fishery Office (DKP, 2011) of Central Java Province described that 6 sub-districts in north coast area of Rembang District are affected by sedimentation and coastal erosion. According to DKP (2011), coastal erosion is the most dominant process along the coastal area of Rembang District. Sunarto (1999) and Setiady & Usman (2008) in their research also explained that parts of Rembang District were affected by sedimentation process.

The National Board on Disaster Mitigation (BNPB) of Indonesia classify the coastal area of Rembang District as area with low level risk of coastal erosion

(BNPB, 2010). In line with this classification, The Development Planning Board (Bappeda) of Rembang with its main function to arrange, to control and to evaluate the regional development planning, has recognized all the 6 sub-districts in coastal areas are affected by coastal erosion (Bappeda of Rembang District, 2011).

Some authors have conducted research to investigate the correlation between mangrove forest and sedimentation, as well as coastal erosion. Azlan & Othman (2009) investigated mangrove area toward shoreline protection using remote sensing in Kukup Island, Johor Malaysia. The authors utilised multi-temporal images of Landsat and applied image classification technique to identify the changes of coastline and mangrove forest. Overlying between two images from different period using matrix process was applied to compare the changes of mangrove area. One of the results indicated that certain parts of mangrove forest have disappeared due to extreme coastal erosion. On the other side, the mangrove forest has increased due to sediments produced by coastal erosion procces. In this research, the authors did not take into account the spatial and temporal changes of coastal erosion and sedimentation within the same period of analysis.

Meanwhile, Rahman (2012) conducted research on time-series analysis in order to investigate the correlation between coastal erosion and mangrove forest in Sundarban, Bangladesh. The authors used the series of Landsat images and employed image classification to map the mangrove forest from different period. Time series analysis was implemented along the coastline which placed randomly. One of the results showed that the mangrove forest has decreased due to coastal erosion. Unfortunately, the author did not examine the changes of mangrove forest due to the changes of coastal erosion.

The two studies mentioned before applied the similar technique to investigate the correlation between coastal erosion and mangrove. The studies merely emphasized on the physical aspects of coastal erosion and mangrove, and did not take into account the presence of community in neighboring area.

This study intends to provide information on correlation between the dynamic of mangrove forest and coastline changes. Historical topographic maps, multi-temporal images of Landsat and high resolution images of Google Earth were used as sources the investigate the changes of mangrove area and coastline. Analysis on coastline changes is considered as one method to provide information on sedimentation, as well as coastal erosion (Marfai *et al*., 2008). Government intervention in managing mangrove forest in form of providing mangroves program also considered as one influencing factors in the dynamic of the forest itself. The dynamic of mangrove forest in different areas might affected by the different approaches by government through its mangroves program. This study also takes into account the presence of community who live near mangrove forest by investigating their perception toward the influence of mangrove forest changes into their daily life, as well as benefit obtained. Considering the presence of surrounding community is important since managing human interactions with surrounding environment considered as important factor to prevent coastal erosion (Mazda *et al*., 2002).

1.2. Research Problem

Rembang District has been facing sedimentation for recent years, as well as coastal erosion, as reported before by Sunarto (1999), Wahyudi *et al*. (2012), DKP of Central Java Province (2011) and Setiady & Usman (2008). Coastal erosion has resulted physical loss in several areas as reported by Muria News (2014) and Radar Pekalongan (2014). It has not known if the mangrove forest affected by sedimentation and coastal erosion.

The previous research have not completely examine the spatial and temporal changes of mangrove area and sedimentation, as well as coastal erosion. Aziz *et al*. (2014) investigated the spatial and temporal mangrove extent changes in Rembang District using multi-temporal images of Landsat, without correlate it with sedimentation and coastal erosion. Furthermore, the studies did not take into account the influence of mangrove forest changes to surrounding community. Government intervention in managing mangrove forest also plays important role in the dynamic of mangrove forest. The deployment of various mangroves program is expected to increase mangroves extent as well as to promote additional benefit for community. However, it has not been observed yet the influence of government intervention to mangrove forest dynamic and its influence to community. It has not been known the influence of mangrove forest changes to surrounding community. The surrounding community might get advantages, loss or even not affected due to the changes of mangrove forest.

1.3. Research Objectives and Questions

The main objective is to survey the mangrove forest in relation to coastline changes in Rembang District. Furthermore, the specific objectives are:

1. To analyse spatial and temporal changes of mangrove forest due to coastline changes
2. To analyse community's perception toward the influence of mangrove forest changes due to coastline changes

There are some research questions that need to be addressed in order to achieve the research objectives, which are described in Table 1.1 below

Table 1.1. Research's objectives and questions

No	Research Objectives	Research Questions
1	To analyse spatial and temporal changes of mangrove forest due to coastline changes	1. How to apply historical topography maps to analyse mangrove forest changes due to coastline changes? 2. How to use medium resolution images of Landsat to analyse mangrove forest changes due to coastline changes? 3. How to include high resolution images of Google Earth to analyse mangrove forest changes due to coastline changes?
2	To analyse community's perception toward the influence of mangrove forest changes due to coastline changes	1. How the community perceive about mangrove forest changes? 2. What are community's perception toward the influence of mangrove forest changes? 3. How the community adjust toward the changes of mangrove forest? 4. What are community's perception toward benefit from mangroves non-timber forest products? 5. What are community's acceptance on government mangrove program? 6. What are correlation between community's perception toward the influence of mangrove forest changes, adjustment toward mangrove forest changes, perception toward benefit from mangroves non-timber forest products, and acceptance on government mangrove program?

1.4. Scientific Significance

The results of study are expected could give new information on how mangrove forest correlate with coastline changes. Furthermore, information that will gathered from community in surrounding area could be used as additional sources to investigate the nature of mangrove and its relation to sedimentation and coastal erosion. Both these information can be used by local government to evaluate the ongoing programs and to formulate the new programs toward mangroves, as well as sedimentation and coastal erosion.

CHAPTER II
LITERATURE REVIEW

This chapter elaborates literature which support the present research which is comprised general information on mangroves, winds, waves, currents, tides, sediment transports, concept of perception, detection of coastline changes, image classification, and NDWI and NDVI.

2.1. Mangroves

Mangroves forest mainly can be found on sheltered area of tropical coastline. Mangroves can be defined as the characteristic of intertidal plant formation of sheltered tropical subtropical coastlines (Saenger, 2002). This plant communities have been widely decribed as coastal woodlands, mangals, tidal forest or mangrove forest. The development and composition of mangroves communities highly influenced by temperature, soil type, salinity, duration and frequency of innundation, silt accretion, tidal and wave energy and another aperiodic factors such as cyclone or flood frequencies (Blasco *et al*., 1996).

Mangroves have been widely known could provide many benefits for human. Saenger (2002) argued that mangroves forest provides shoreline protection due to coastal erosion and sediment regulation. Monostand of *Kandelia kandel* efectively reduce the drag force of wave with wave period 5-8 second (Mazda *et al*., 1997). The authors explained that the effects of wave reduction are not much changes even when water depth increase due to the distribution of high density of tree throughout the water depth. Mazda *et al*. (2002) described that coastal erosion in mangroves forest is not merely correspond to wave action, but also affected by tidal forces due to the interference of human activities inform of the riverine mangroves felling.

Despite its function in providing coast protection, mangrove forest also sensitive to coastal erosion. Ramasubramanian *et al*. (2006), Azlan & Othman (2009), and Thampanya *et al*. (2006) which used remotely sensed data in their research investigated that coastal erosion is one factor that contributes to the mangrove forest loss.

Meanwhile, in relation to sediment regulation in coastal area, mangrove forest plays important role to trap sediment. According to Furukawa & Wolanski

(1996), mangroves vegetation maintenance water turbulence which flow to the forest and this mechanism generate the fine sediment to be suspended. While Kathiresan (2003) added that mangrove forest impede tidal flows and triggered deposition of soil particles during low tide. The numerous aerial roots of Avicennia and stilt-root of Rhizophora highly correspond to the deposition of sediment materials.

Direct benefit from mangrove forest could be obtained from some utilisations. Setyawan & Winarno (2006a) described that there are some types of direct utilisation of mangroves in Central Java Province, including fishery sector, wood, fooder, medicine, industry supply, and education and tourism. Direct cathing of fish using fishnet in mangrove forest is the most common type of fishery activity in mangrove forest. While in some areas, people have utilised mangroves wood for charcoal, firewood or even construction, mainly from genus Rhizophora species. Parts of mangroves vegetation also considered can be used as food and fooder. People in coastal area in Central Java Province, such as in Demak District and Rembang District are accustomed to eat Avicennia's fruit as snack. While some other are used Avicennia's and Rhizophora's leaf as fooder. The pond farmers in Rembang District, for instance, cultivate their pond using rotary system. They cultivate milky fish in rainy season, while in dry season they used their pond as saltpan (Auliyani *et al*, 2013).

Economic value of mangrove forest can be grouped into some categories. Hanifa *et al*. (2013) classified economic value of mangrove forest in Pasarbanggi Village, Rembang District into four categories. These values encompassed direct benefit such as benefit from fishpond and saltpan, mangroves seedlings, protein resources; indirect benefit in form of physical protection toward wave and saltwater intrusion; optional benefit in form of biodiversity; and existence benefit in form of mangroves habitat (Hanifa *et al*., 2013).

Mangroves species in Rembang is mainly dominated by genus Rhizoporaceae, Avicenniaceae and Sonneratiaceae. According to Wicaksono (2014), the dominant species that can be identified in Pasarbanggi Village are *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia marina* and *Sonneratia alba*.

Certain mangrove forest area in Rembang District is considered as the result of plantation which conducted by local people and government. Obtaining benefit in form of physical protection toward waves is the main consideration of mangrove plantation by local people. Local people planting mangrove in mudflat to protect their pond from high wave (Auliyani *et al*., 2013).

2.2. Winds

In general, Java Sea is highly influenced by monsoon climate. According to Wyrtki (1961), monsoonal climate in Java Sea, just like other any part of Indonesia, can be classified into three categories:

a. West monsoon or northwest monsoon (locally known as *musim barat*). This season ussually hapens during October-April and reach its peak season on December-January. The wind blows from northwest to southeast direction, and resulted high frequent rainfall and windy period.
b. East monsoon or southeast monsoon (locally known as *musim timur*). This period ussually occurs during April-October and reach its peak season on June-August. The wind blows southeast to northwest direction and ussually resulted dry season in Java Island
c. Interchange season or locally known as *musim peralihan*. In general there are two interchange season (1) Interchange change season I which ussually occurs during March-May, and (2) Interchenge season II which ussually happens during September-November.

According to wind data which obtained from Meteorological, Climatology and Geophysic Board (BMKG), the wind direction in coastal Rembang District during peak season of west monsoon 2013, tended to blow from southwest-west to east with average speed on 0-5 knot and 5-10 knot. While during peak season of east monsoon 2013, the wind tended to blow from southeast to northeast with speed average on 0-5 knot and 6-10 knot.

2.3. Waves

Wave is considered as one main factors that contributes to the procces of coastal erosion as well as sedimentation. The magnitude of the process depends on the amount of energy which resulted by the wave. Marfai & Permana (2014) described that coastal erosion along Jepara District Central Java Province was highly influenced by wave which generated by strong wind. Coastal area on west part of Jepara is vulnerable to be eroded during northwest monsoon due to waves exposure which generated by wind (blow from west to east). During this monsoon, the waves dominantly move from west and northwest with height average 1.21-2.63 m which strike along west part of Jepara coast. Poro (2011) also argued that high velocity of wind exceed 10 knot will generate destructive wave which contributes to coastal erosion during northwest monsoon in Jepara District. While during east monsoon and interchange season, the waves will slowly bring the sediment materials back to the eroded area.

Waves along coastal area of Java have different characters due to the monsoonal condition. Sunarto (1999) explained that along coastal area of Central Java Province, during April-October low waves ussualy occurs with height, length and period of wave were 0.43-0.61 m, 12.19-17.98 m and 3.4-4.0 second, respectively. High waves ussually happens during Desember-February with height, length and period of wave were 1.95-2.93 m, 40.84-57.3 m and 6.3-7.9 second. While during March-November, medium waves ussually occurs with height, length and period of wave were 0.88-1.52 m, 21.64-33.83 m and 4.6-5.7 second, respectively.

According to wave data which obtained from BMKG, the wave direction during peak season of west monsoon 2013 in Rembang District tended to move from northwest to southeast direction. The average of waves level during peak season of west monsoon was in range 0.5-1.5 m. While during the peak season of east monsoon 2013 tended to move from southeast to west direction. The average of wave high during peak season of east monsoon was in range 0.5-1.0 m.

2.4. Currents

Surface current is often affected by wind direction. According to Marfai and Permana (2014), surface currents on Java Sea is more influenced by wind direction. The authors analysed Observed Ocean Current Data year 1900-1993 from Japan Oceanographic Data Center (JODC) and described that during northwest monsoon the surface currents relatively move to east-southeast direction. While during east monsoon, the surface currents relatively move to west-northwest direction. During May-September, the average of currents maximum velocity was 0.28 m/s (observed on March and September) and the average of currents minimum velocity was 0.05 m/s (observed on April).

According to field measurement conducted by Bappeda of Rembang District (2003) at offshore area of Kartini Beach in Rembang Sub-District, the direction of surface current when high tide tended to flow on northwest, southwest and north direction with velocity 0.09 m/s, 0.02 m/s and 0.06 m/s, respectively. While when low tide, the surface currents tend to flow on north, northwest and southwest direction with velocity 0.085 m/s, 0.064 m/s and 0.1 m/s, respectively.

According to data which obtained from BMKG, the monthly average of surface currents direction during peak season of west monsoon 2013 in Rembang District tended to move from east to west with average speed on 0-5 cm/s and 5-15 cm/s. While during the peak season of east monsoon, the currents tended to move west to east with average speed on 5-15 cm/s and 15-25 cm/s.

2.5. Tides

According to Bird (2008), tides are movements of the oceans set up by the gravitational effects of the moon and the sun in relation to the earth. They are very long waves that travel across the oceans and are transmitted into bays, inlets, estuaries or lagoons around the world's coastline.

According to Wyrtki (1961), the tides in Indonesia can be classified into four categories as follows:

a. Diurnal tide. There is one high and one low tide which occurs in one day
b. Semi-diurnal tide. There are two times high tide and two times low tide with nearly the same height of water
c. Mixed tide prevailing diurnal. There is one high tide and one low tide in one day, but sometimes there will be two times high tide and two times low tide with very different in height and duration
d. Mixed tide prevailing semi diurnal. There are two times high tide and two times low tide in one day, but sometimes there will be one high tide and low tide with very different in height and duration.

The tides type of Rembang District is classified as diurnal tide (Bappeda of Rembang District, 2003). It is mean that in one day there will be one high tide and low tide. In line with this classification, Wyrtki (1961) also classified the tides type around Rembang District as diurnal tide.

2.6. Sediment Transport

Susiati *et al*. (2010) investigated distribution patterns of total suspended sediment in coastal area of Muria Peninsula, Jepara District, Central Java Province, which the area also covers western parts of Rembang District. The authors utilised multi-temporal images of Landsat year 1989 (September), 2001 (September) and 2004 (August), combined with SPOT images year 2008 (October).

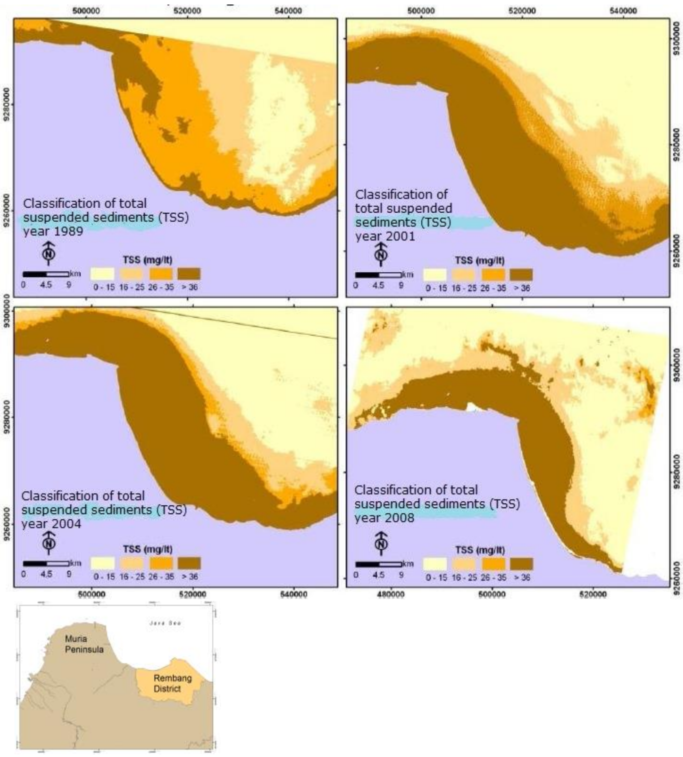


Figure 2.1. Distribution of total suspended sediments around Muria Peninsula (modified from Susiati *et al*., 2010)

Based on the results, Susiati *et al*. (2010) revealed that distribution pattern of total suspended sediment around Muria Peninsula shows dynamic patterns. There was a tendency that distribution of total suspended sediments has been increased during period 1989-2008. The concentration of total suspended sediments was in range 1.5-2,140 mg/l, with average 55.18 mg/l. Total suspended sediments along coastal area in west part of Rembang District during period 1989-2008 was remain the same at level > 36 mg/l.

2.7. Concept of Perception

According to Aaronson (1914), perception defined as temporal procces that opens up new things to stimulate people. This is a progresive discovery of values or revelation of reality. Aaronson (1914) then added that perception is a peculiar kind of action, the organism's incipient act, its internal and partial activity leading to overt action and to knowledge.

Meanwhile, Walgito (2003) defined perception as a procces of organizing and interpretating toward stimulus which received by organism or individual thus become a something worthy, and an individual's integrated activity. Walgito (2003) described that there are two factors that affecting individual's perception. The first factor is internal factor which comes from individual itself, such as feeling, experience and knowledge. The second factor is external factor that comes from environment, such as living environment and community.

There were various studies already conducted in order to investigate and analyse community's perception toward particular matters. Dewi (2007) and Febrianti (2010) applied descriptive statistic and cross tabulation technique, in form of frequency and percentage, to observe and analyse community's perception toward coastal flooding and river flooding, respectively. While Heryanti (2012) implemented cross tabulation with chi-square test to investigate the difference of perception among communities toward lahar flood. Heryanti (2012) applied binary regression analysis to investigate correlation between community's perception and socio-economic factors. The author found that gender and length of stay have a significant contribution on community's perception toward the risk of lahar flood.

Setiawan (2013) also applied cross tabulation with chi-square test to observe the difference on perception between communities in relation to landslide risk. In order to investigate the correlation between community's perception and socio-economic factors, the author applied multiple linear regression technique. Furthermore, Setiawan (2013) applied Spearman correlation test to analyse correlation between community's perception and community's acceptance on government program in relation to landslide risk reduction.

Data cross tabulation can be followed by chi-square test. This test is considered as a technique to assess comparative hypothesis of more than two variables in form of nominal data (Sugiyono, 2012). Furthermore, correlation test in form of contingency test also can be applied to analyse the correlation between variables. This test is considered as a method to assess the correlation between two variables in form of nominal data (Siregar, 2013; Sugiyono, 2012).

Nfotabong-atheull *et al*. (2011) investigated community's perception toward utilisation of mangroves and environmental changes of mangrove forest. The authors revealed that local communities are accustomed to utilise mangrove forest products for various purposes, such as firewood and charcoal, house construction, medicine, boat/canoe, wall/roof materials, and dyeing materials. Local communities also well recognise the environmental changes around mangrove forest, such as mangrove stand changes and faunal composition changes. Takama & Iftekhar (2008) also revealed that local communities can recognised flora and fauna composition in mangrove forest.

Local communities perceived that mangrove forest could provide benefits or advantages for them. The most important function of mangrove forest is as the supplier for raw materials, followed by the other function such as prevention against natural disaster, climate regulation and soil retention (Takama & Iftekhar, 2008). While the other benefits offered by mangrove forest such as aesthetic value, augmentation of agricultural production, and protection from salt water intrusion (Badola *et al*., 2012).

The changes of mangrove forest are considered could influence the surrounding community. For instance, the succesfull of mangrove plantation program could give advantages to local community (Auliyani *et al*., 2013; Gamayanti, 2013; Amri, 2005). In line with the progression of mangrove forest area, local community made particular adjusments to adapt with situation (Gamayanti, 2013). Gamayanti (2013) analysed that in order to adapt with the progression of mangrove forest area due to mangrove plantation program, local communities have adjusted their life in form of economic, fishpond management, mangrove plantation, mangrove forest management, and collective adaptation.

2.8. Detection of Coastline Changes

Identifying coastline changes is one supreme method in order to analyse the phenomenon of coastal erosion, as well as sedimentation (Marfai *et al*., 2008). The combination of historical topographic maps and multi-temporal satelite images can be used for long term investigation on coastline changes. Li & Damen (2010) and Marfai *et al*. (2008) combined the utilisation of historical topographic maps and multi-temporal satelite images for analyzing the coastline changes in Pearl River China and Semarang Indonesia, respectively.

Various techniques have been applied in order to utilise multi-temporal satelite images to extract coastline. Binary slicing technique is considered as usefull technique to extract coastline based on contrast between land and water. Mid-infrared of Landsat images (band 5 for Landsat 7 and Landsat 5) provides a good contrast between land and water due to high absorption of mid-infrared energy by water and high reflectance of mid-infrared energy by vegetation and natural features (Alesheikh *et al*., 2007). Marfai *et al*. (2008) applied this technique to investigate the spatial and temporal changes of coastline in Semarang, Indonesia. While, Li & Damen (2010) have employed this technique for analysing coastline changes in estuarine of Pearl River, China. The slicing map usually better than composition image to extract the coastline (Li & Damen, 2010).

Visual delineation of coastline based on image color composite also provides a good distinction between land and water. Li & Damen (2010) considered that image color composite 742 of Landsat images is the most effective combination to map coastline and river band. While Tarigan (2007) and Alesheikh *et al*. (2007) utilised image color composite 542 and 543 of Landsat images to extract the coastline, respectively.

On the other hand, the free downloaded of high resolution images of Google Earth also can be used to extract the coastline as well. Dewangga (2011) utilised the free downloaded high resolution images of Google Earth to extract coastline year 2007 and 2010 in relation to coastal erosion by applying visual interpretation and on screen delineation.

2.9. Image Classification

According to Lillesand *et al*. (2004), image classification process is aiming to automatically categorize all pixels in an image into land cover classes or themes. Automatic process of image classification can be divided into two technique, supervised classification and unsupervised classification (Danoedoro, 2012). The fundamental difference between these tehniques is that supervised classification involves a training steps followed by classification steps. While in unsupervised classification, the images data are classified into natural spectral grouping, then determination of land cover class carried out by comparing the classified image data to ground reference data (Lillesand *et al*., 2004).

Supervised image classification is considered as the most frequent method by which remotely sensed data of mangrove areas has been classified (Green *et al*., 1998). Supervised classification is a pixel-based process where pixels of known classes are used for classifying unknown classes (Nguyen *et al*., 2013). Data from field observation and aerial photographs can be used as reference to collect training data. Several authors have been applied this method for mapping mangrove forest.

Azlan & Othman (2009) applied this technique for mapping mangrove in relation to coastal erosion in Kukup Island, Johor National Park, Malaysia. The authors utilised the multi-temporal images of Landsat 7 ETM+ to map the changes of mangrove forest due to coastal erosion. While Purwanto *et al*. (2014) also utilised the multi-temporal images of Landsat 7 and Landsat 8 to investigate the distribution of mangrove forest in Segara Anakan Lagoon, Cilacap, Indonesia.

Nguyen *et al*. (2013) executed maximum likelihood algorithm for supervised image classification using medium resolution images of Landsat to map fringe mangrove forest along coastal area of Kien Giang, Vietnam. According to Nguyen *et al*. (2013), the utilisation of multi-temporal of Landsat images are adequate to map mangrove extent in case when higher spatial resolution data limited.

2.10. NDWI and NDVI

The Normalized Difference Water Index (NDWI) in general can be used to assess the vegetation water contents using remote sensing data based on physical principle (Kobayashi & Hoan, 2013). According to authors, NDWI is sensitive to changes of water content of vegetation canopy. NDWI is expressed using formula as follows:

“ NDWI = (NIR-SWIR)/(NIR+SWIR) “

with NIR and SWIR are the reflectance in near infra red wavelength band and short wave infra red wavelength band, respectively. The leaf internal structure and leaf dry matters are highly affect the reflectance of NIR band. While SWIR reflectance is highly correlated with the changes of water vegetation contents and sensitive to water condition in leaves (Kobayashi & Hoan, 2013).

Meanwhile, the Normalized Difference Vegetation Index (NDVI) in general can be used to monitor the quality and distribution of vegetation (Kobayashi & Hoan, 2013). NDVI can be expressed using equation as follows:

“ NDVI = (NIR-Red)/(NIR+Red) “

with NIR and Red are the reflectance in near infra red wavelength and red wavelength, respectively.

Kobayashi & Hoan (2013) utilised NDWI and NDVI to map mangrove at regional scale at Southern Japan. The authors have combined the utilisation of the difference between NDWI-NDVI, band ratio SWIR/NIR and band SWIR of Landsat ETM+ images, and digital elevation model (DEM). The authors argued that this method is effective for mapping mangrove forest at regional scale with not too large extension of mangrove forest.

CHAPTER III
RESEARCH METHOD

This chapter describes data required in the present research, data analysis and data output. Data required includes secondary and primary data. While data analysis divides into two part according to main objectives, those are spatial and temporal analysis on mangrove forest changes due to coastline changes, and community perception toward the influence of mangrove forest changes.

3.1. Data Required

Data required in this study encompasses secondary and primary data to address the main objectives. Spatial analysis on mangrove forest changes due to coastline changes required data as follows:

1. Secondary data
   - Medium resolution images of Landsat: Landsat 8 path/row 119/65, acquisition date 20 June 2014 local time 9.41 am; Landsat 7 ETM+ path/row 119/65, acquisition date 14 August 2002 local time 9.30 am; and Landsat 5 path/row 119/65 acquisition date 28 May 1994 local time 9.01 am (all images downloaded from http://earthexplorer.usgs.gov)
   - Topographic map year 1881 (downloaded from http://maps.library.leiden.edu; screen shot and saved in JPEG format; original scale 1:100,000). Covered Rembang Sub-District and Kaliori Sub-District
   - Topographic map year 1943. Downloaded from http://maps.library.leiden.edu for Kaliori Sub-District (screen shot and saved in jpeg format; original scale 1:50,000) and from http://www.lib.utexas.edu for Rembang Sub-District (downloaded and saved in jpeg format; original scale 1:50,000)
   - Tidal table which obtained from Meteorological, Climatology and Geophysic Board (BMKG) of Semarang, Central Java Province
   - High resolution images of Google Earth. Downloaded from Google Earth, imagery date 18 March 2009 and 15 July 2014
2. Primary data. Primary data required was coast slope which obtained by field measurement.

While data required for analysis on community's perception toward mangrove forest changes due to coastline changes as follows:

1. Secondary data. The data includes socio-economic condition which obtained from village office and statistic board
2. Primary data. The data encompassed respondents perception toward mangrove forest changes (knowledge, influence to daily life, adjustment/response, benefit obtained from mangroves ntfp, and acceptance on government mangrove program), and socio-economic condition of respondents. The data was gathered by interviewing respondents using questionnaires.

The utilisation of secondary and primary data in order to answer research questions can be observed in Table 3.1 below

Table 3.1. Research questions and methods

Sub Objective	Research question	Data and method	Output
1.1	How to apply historical topography maps to analyse mangrove forest changes due to coastline changes?	– Topographic maps year 1881 and 1943 – Visual interpretation and on screen delineation to map coastline year 1881 and 1943	Coastline maps year 1881 and 1943 in vector format
1.2	How to use medium resolution images of Landsat to analyse mangrove forest changes due to coastline changes?	– Landsat images year 2014, 2002 and 1994 – Supervised image classification based band composite, and the composite of difference NDWI-NDVI, bandratio SWIR/NIR and SWIR band – Visual interpretation and on screen delineation using band composite and binary slicing to extract coastline	– Mangrove forest map year 2014, 2002 and 1994 in raster format – Coastline maps year 2014, 2002 and 1994 in vector format
1.3	How to include high resolution images of Google Earth to analyse mangrove forest changes due to coastline changes?	– Two sets of Google Earth images, imagery date 18 March 2009 and 15 July 2014 – Visual interpretation and on screen delineation to map mangrove forest and coastline year 2009 and 2014	– Mangrove forest maps year 2009 and 2014 in vector format – Coastline maps year 2009 and 2014 in vector format
2.1	How the community perceive about mangrove forest changes?	– Data on community's perception – Interview with local people using questionnaire	Description and graphs showed respondents' perception toward the changes of mangrove forest, as well as sedimentation and

		– Descriptive, data cross tabulation	coastal erosion
2.2	What are community's perception toward the influence of mangrove forest changes?	– Data on community's perception – Interview with local people using questionnaire – Descriptive, data cross tabulation, chi-square test, multiple linear regression	Description and graphs showed respondents' perception toward how mangrove forest changes affects their daily life and influencing factor
2.3	How the community adjust toward the changes of mangrove forest?	– Data on community's perception – Interview with local people using questionnaire – Data cross tabulation, chi-square test, multiple linear regression	Description and graphs showed respondents' adjusment/response toward the changes of mangrove forest and influencing factor
2.4	What are community's perception toward benefit from mangroves non-timber forest products?	– Data on community's perception – Interview with local people using questionnaire – Descriptive, data cross tabulation, chi-square test	Description and graphs showed respondents' perception toward benefit obtained from mangroves non-timber forest products
2.5	What are community's acceptance on government mangrove program?	– Data on community's perception – Interview with local people using questionnaire – Descriptive, data cross tabulation, chi-square test	Description and graphs showed respondents' perception toward benefit obtained from government programs
2.6	What are correlation between community's perception toward the influence of mangrove forest changes, adjustment toward mangrove forest changes, perception toward benefit from mangroves non-timber forest products, and acceptance on government mangrove program?	– Data on community's perception – Interview with local people using questionnaire – Descriptive, data cross tabulation, correlation test	Description on correlation between parameters

Research flowchart can be observed in Figure 3.1 below

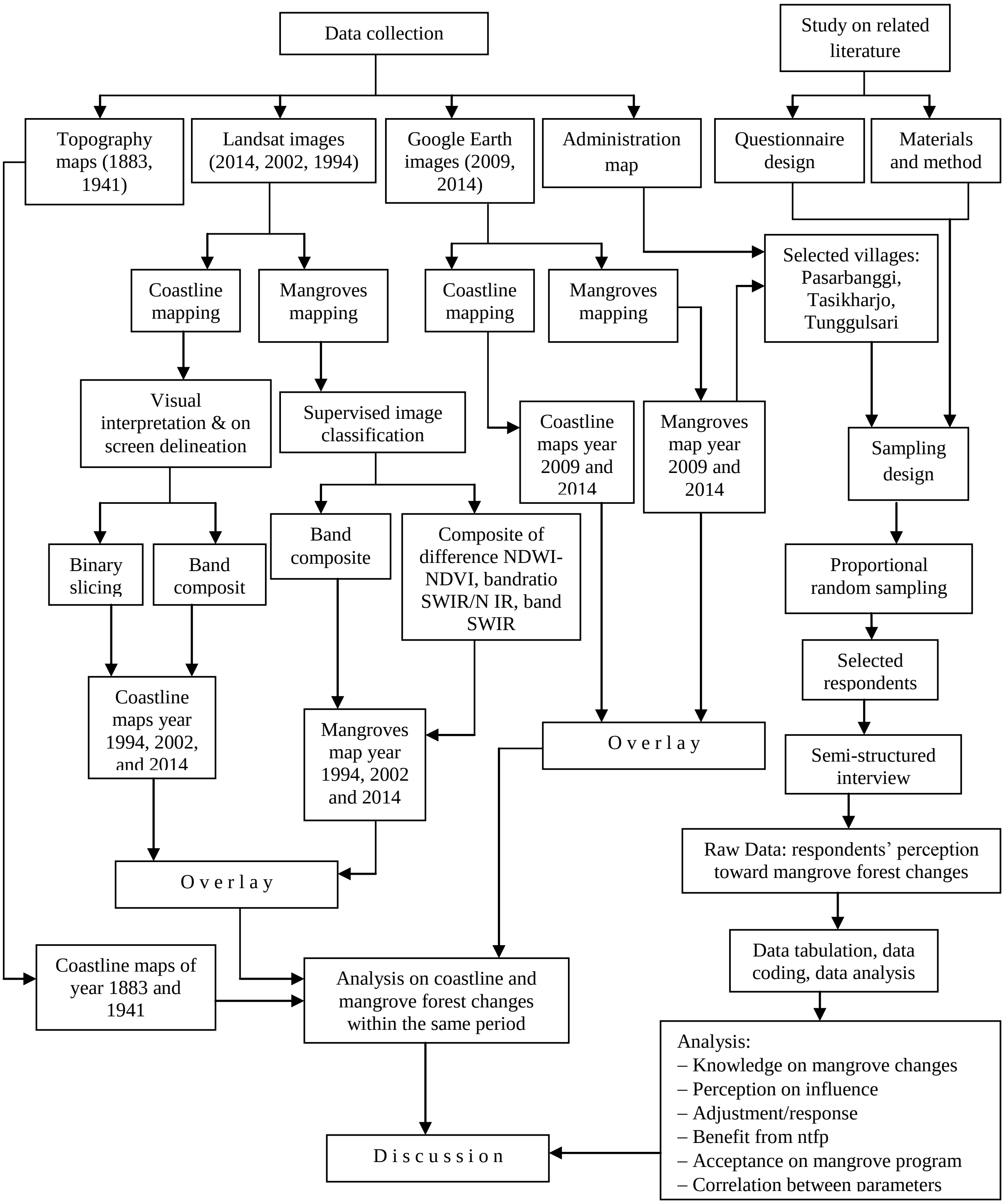


Figure 3.1. Research flowchart

3.2. Data Analysis and Data Output

Data analysis divided into two steps based on specific objectives, which are analysis on spatial and temporal changes of mangrove forest due to coastline changes, and analysis on community's perception toward mangrove forest changes due to coastline changes.

3.2.1. Analysis on spatial and temporal changes of mangrove forest due to coastline changes

Data analysis for addressing this analysis were divided into three parts according to the research questions due to the availability of dataset used.

3.2.1.1. Analysis on spatial and temporal changes of mangrove forest due to coastline changes utilising historical topography maps

Topographic maps year 1881 and 1941 were used in this research to investigate the changes of mangrove forest due to coastline changes. Image to image rectification was applied in order to georeference three topomaps mentioned above. Three layers of topomap included Sheet 1509-132 Year 1999 Juwana, Sheet 1509-141 Year 2000 Rembang, and Sheet 1509-142 Year 1998 Lasem scale 1:25,000 were used as reference maps. These three topomaps were previously scaned and rectified into pixel size 2.5 m x 2.5 m. The affine (first order) polynomial transformation was used to georeference topomap year 1881 and 1943. Both of the topographic maps then resampled using nearest neighbour method into 10 m x 10 m of pixel size.

Since the mangrove forest does not appear in these topographic maps, analysis on mangrove forest changes then can not be executed. Extraction of coastline then performed in order to investigate the occurence of sedimentation as well as coastal erosion. The coastlines of these three topographic maps were carefully delineated based on visual interpretation.

The results of this steps are coastline map year 1881 and 1943 in vector format. Analysis on spatial and temporal changes of coastline performed by overlaying between the two coastline maps from different year. Coastline changes between these two periods measured by placing transect lines between two coastlines and distance between transect is 30 m. The average on coastline change between two period then calculated using simple formula:

average_coastline changes = (transect 1 + transect 2 +......+ transect n)/n

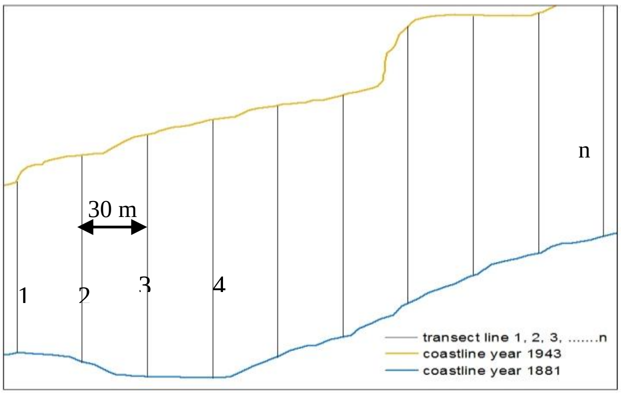


Figure 3.2. Measurement of coastline changes

Analysis on spatial and temporal changes of coastline using historical topographic maps can be observed in Figure 3.3 below

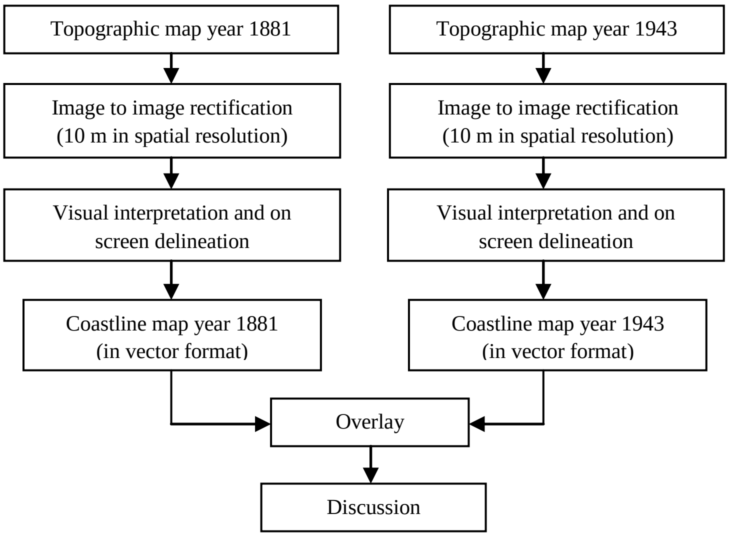


Figure 3.3. Analysis on spatial and temporal changes of coastline using historical topographic maps

3.2.1.2. Analysis on spatial and temporal changes of mangrove forest due to coastline changes utilising medium resolution images of Landsat

Data analysis using medium resolution images of Landsat encompassed two steps, which are spatial and temporal changes of mangrove forest, and spatial and temporal changes of coastline to detect sedimentation as well as coastal erosion.

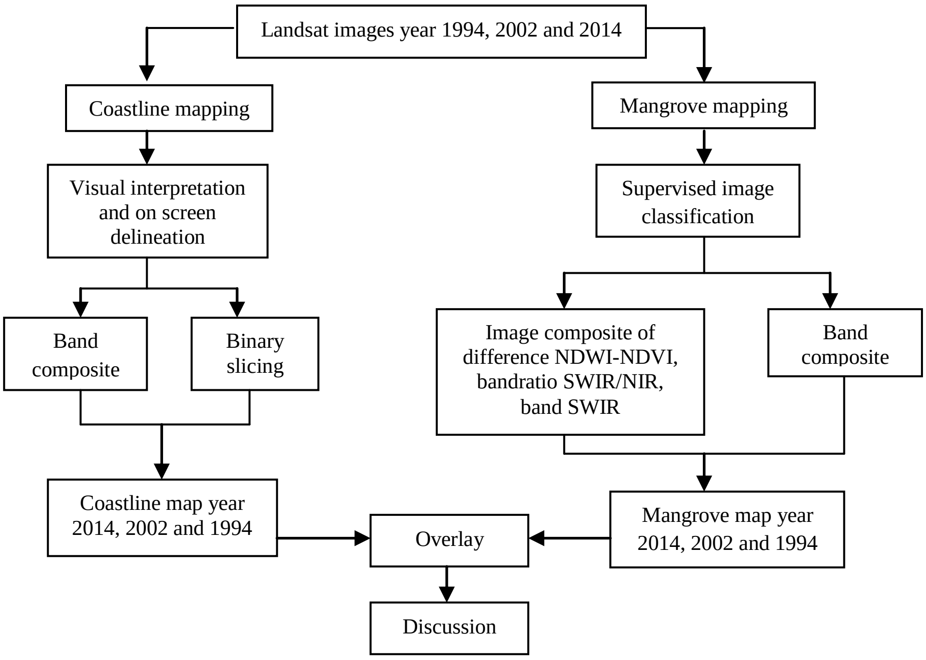


Figure 3.4. Analysis on spatial and temporal changes of mangrove forest due to coastline changes using medium resolution images of Landsat

3.2.1.2.1. Analysis on spatial and temporal changes of mangrove forest

In this research, supervised image classification based on band composite, and the difference between NDWI-NDVI, band ratio of SWIR/NIR and band SWIR band were performed to map the mangrove forest.

1. Supervised image classification using band composite

A supervised image classification based on band composite was applied in order to map the mangrove forest. Ground referenced data has been collected during the fieldwork to assist the process of image classification, included train the classification of images and analyse the accuracy of classification results. A number of 50 points have been observed during the fieldwork and mainly to location where the mangrove forest exist and its surrounding, where the mangroves area have been changed over the past years. Google Earth images also used to assist the classification process, mainly during the selection of training areas. Band composite 453 (corresponds to infra red band, near infra red band and red band, respectively) of Landsat 5 1994 and Landsat 7 2002, and band composite 564 (corresponds to infra red band, short wave infra red band and red band) of Landsat 8 2014 were mainly used for recognizing the mangroves area. In these band composites, mangroves area represented by red color.

The maximum likelihood classifier for supervised classification was performed to classify the images into several class. Image classification tools in ArcGis 10.1 were performed during the classification process, included determination of training areas and signature files. The training areas were carefully delineated in form of polygon to represent the real extent of mangrove forest, and other land cover.

The filtering process was applied in order to remove isolated pixels and smooth the classified images using majority filter tool in ArcGis 10.1. Post classification editing then executed to merge some land cover. Then the final classified images contain four main land covers, those are mangrove forest, water, saltpan/fishpond, and non-mangrove. The error matrix then performed to asses the accuracy of the classified map. Due to the lack of reference dataset, the assessment limited to the classified map year 2014. The ground referenced data during field observation was used as reference data.

2. Supervised image classification using composite of the difference between NDWI and NDVI, band ratio shortwave infrared/near infrared, and shortwave infrared band

Image classification using this method follows the previous study by Kobayashi & Hoan (2013). The classification encompassed some steps as follows:

a. The Difference between NDWI and NDVI

NDWI is expressed using formula as follows:

“ NDWI = (NIR-SWIR)/(NIR+SWIR) “

with NIR and SWIR are the reflectance in near infra red wavelength band and short wave infra red wavelength band, respectively. In Landsat 8 dataset, NDWI was calculated using NIR and SWIR 1 channel with NIR and SWIR 1 correspond to band 5 and band 6, respectively. While in Landsat 5 1994 and Landsat 7 ETM+ 2002, NIR and SWIR correspond to band 4 and band 5, respectively.

While NDVI can be expressed using equation as follows:

“ NDVI = (NIR-Red)/(NIR+Red) “

with NIR and Red are the reflectance in near infra red wavelength and red wavelength, respectively. In Landsat 8 dataset, NIR and Red channel correspond to band 5 and 4, respectively. While in Landsat 5 1994 and Landsat 7 ETM+ 2002, NIR and Red correspond to band 4 and band 3, respectively.

Then the difference between NDWI and NDVI executed by applying equation as follows:

$$\text{Diff\_NDWI\_NDVI} = \text{NDWI} - \text{NDVI}$$

b. Band Ratio of shortwave infra red and near infra red

Band ratio 5/4 or shortwave infra red/near infra red of Landsat 5 1994 and Landsat ETM+ was applied to improve the difference between mangrove and non-mangrove forest. While in Landsat 8 2014 data, the band ratio was correspond to band ratio 6/5, with band 6 refers to SWIR 1 channel and band 5 refers to NIR channel.

c. Shortwave infra red band

Band 5 or shortwave infra red of Landsat ETM+ was frequently used to monitor vegetation content, and very usefull to distinguish between mangrove forest and non-mangrove forest (Kobayashi & Hoan, 2013). In this research, band 5 of Landsat 5 1994 and Landsat ETM+, band 6 or SWIR 1 of Landsat 8 2014 were used to map mangroves area.

d. Layer stacking and image classification

The three images, which are the difference between NDWI-NDVI, bandratio SWIR 1/NIR and SWIR band then merged and stacked together into one single image composite. A supervised image classification then performed to map the mangrove forest.

The maximum likelihood classifier for supervised classification then performed to classify the images into several class. Image classification tools in ArcGis 10.1 were performed during the classification process, included determination of training areas and signature files. The training areas were carefully delineated in form of polygon to represent the real extent of mangrove forest.

The filtering process was applied in order to remove isolated pixels and smooth the classified images using majority filter tool in ArcGis 10.1. Post classification editing then executed to merge some land cover. Then the final classified images contain two main classes, those are mangroves and non mangroves. The error matrix then performed to asses the accuracy of the classified map. Due to the lack of reference dataset, the assessment limited to the classified map year 2014. The ground referenced data during field observation was used as reference data.

3.2.1.2.2. Analysis on spatial and temporal changes of coastline

In this research, two different methods based on visual interpretation have been examined in order to identify the coastline changes. The method were coastline delineation based on band composite and binary slicing technique.

1. Coastline delineation using band composite

Band composite images were generated from band 5 (near infra red), band 6 (mid infra red) and band 3 (green) of Landsat 8 2014, and from band 4 (near infra red), band 5 (mid infra red) and band 2 (green) of Landsat 5 1994 and Landsat 7 ETM+ 2002, and displayed in red, green and blue (RGB) colors, respectively. These band composites considered provide a clear demarcation between land and water. Image to image rectification then applied in order to georeference these band composite. Three layers of topomap included Sheet 1509-132 Year 1999 Juwana, Sheet 1509-141 Year 2000 Rembang, and Sheet 1509-142 Year 1998 Lasem scale 1:25,000 were used as reference maps.

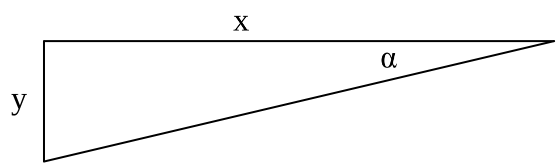
The boundary between land and sea water then carefully delineated to extract the coastline. In mangrove environment, mangrove forest is considered as land. In both band composites, the mangroves area appears in red color and sea water represented by blue color. The results of this steps were coastline maps in vector format year 1994, 2002 and 2014.

2. Coastline delineation using binary slicing

Mid-infrared band with 30 m in spatial resolution has been used to produce masking map of land and water. This band is corresponds to band 5 of Landsat 5 and Landsat 7, and band 6 of Landsat 8. Image to image rectification applied in order to georeference these bands. Three layers of topomap included Sheet 1509-132 Year 1999 Juwana, Sheet 1509-141 Year 2000 Rembang, and Sheet 1509-142 Year 1998 Lasem scale 1:25,000 were used as reference maps.

Masking operation has been executed to distinguish between land and water. Digital number value analysis through observing the image histogram and pixel value along the coastal area were the basic technique to execute the masking operation. Band 6 of Landsat 8 was previously strecthed into 8 bit size in order to make easy of observing the pixel value. The pixel value which chosen as treshold were 12, 25 and 23 for Landsat 1994, Landsat 2002 and Landsat 2014, respectively. Its mean that any pixel with value less than these values then considered as water. Reclassify tool in ArcGis 10.1 with Natural Breaks (Jenks) method was performed to produce the mask. The boundary between land and sea water then carefully delineated. The results of this steps were coastline maps in vector format year 1994, 2002 and 2014.

The extracted coastlines from these two methods are based on actual condition of tidal level when the images acquired. The highest water level was selected as benchmark to calibrate the coastline. Trigonometry principle has applied to calibrate the extracted coastline, as suggested by Bachrodin (2012). Illustration of trigonometry principle to deal with the different level of tidal height as follows:



$x = y / \tan \alpha$, with

y : difference on highest water level and water level when images acquired (meter)

x : shiftness distance of extracted coastline (meter)

α : coast slope (°)

The formula requires coast slope to calibrate the coastline. Coast slope measurement has been conducted in 15 points along coastal area Kaliori Sub-District and Rembang Sub-District. Suunto tandem (clionometer) has been used to measure the coast slope. The results of this steps were calibrated coastline maps in vector format year 2014, 2002 and 1994.

3.2.1.3. Analysis on spatial and temporal changes of mangrove forest due to coastline changes using high resolution images of Google Earth

Two sets of free cloud covered images of Google Earth along the coastal area of Kaliori Sub-District and Rembang Sub-District were downloaded with imagery date 18 March 2009 and 15 July 2014, respectively. Each set of image year 2009 and 2014 consists of four layers. Each layer was downloaded with the same level of zoom (eye altitude 4.06 km) and saved in JPEG format with maximum resolution.

Image to image rectification was performed to georeference all the layer from two datasets. Three layers of topomap scale 1:25,000 included Sheet 1509-132 Year 1999 Juwana, Sheet 1509-141 Year 2000 Rembang, and Sheet 1509-142 Year 1998 Lasem were used as reference maps. The affine (first order) polynomial transformation was applied to georeference these images. All the layers of Google Earth images then resampled using nearest neighbor method into 2.5 m x 2.5 m pixel size.

Visual interpretation and on screen delineation was performed to map the mangrove forest and coastline. The results are mangrove forest maps and coastline maps year 2009 and 2014 in vector format. The coastline divided into two types, coastline outer edge of mangroves (on seaward margin) and coastline inner edge of mangroves (on landward margin), in case if there is mangrove forest in coastal area. Overlaying between coastline maps and mangrove forest maps from period 2009 and 2014 then applied in order to analyse relation between the changes of mangrove forest and the changes of coastline.

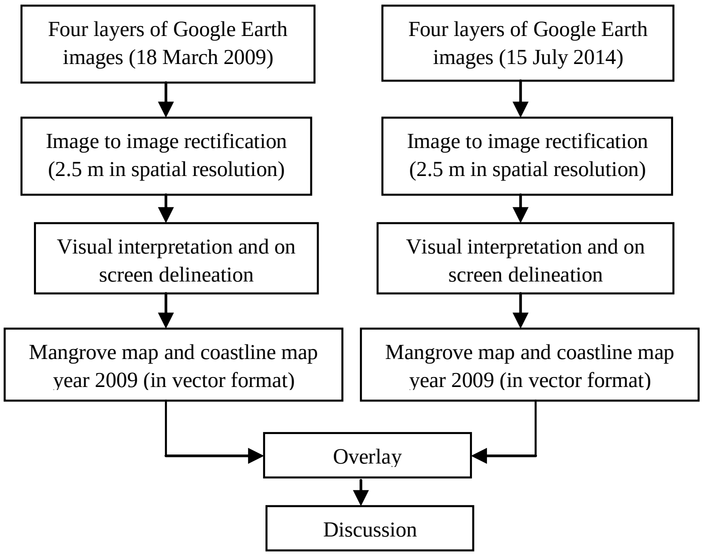


Figure 3.5. Analysis on spatial and temporal changes of mangrove forest due to coastline changes using Google Earth images

3.2.2. Analysis on community's perception toward mangrove forest changes due to coastline changes

3.2.2.1. Sampling design

A purposive sampling was applied to determine villages as sample. In this research, three villages have been chosen as sample area, those are Pasarbanggi (Rembang Sub-District), Tasikharjo and Tunggulsari (Kaliori Sub-District). These villages have been chosen as sample area due to the existence of mangrove forest in surrounding area, the existence of governments mangroves program and the proximity of villages to mangrove forest.

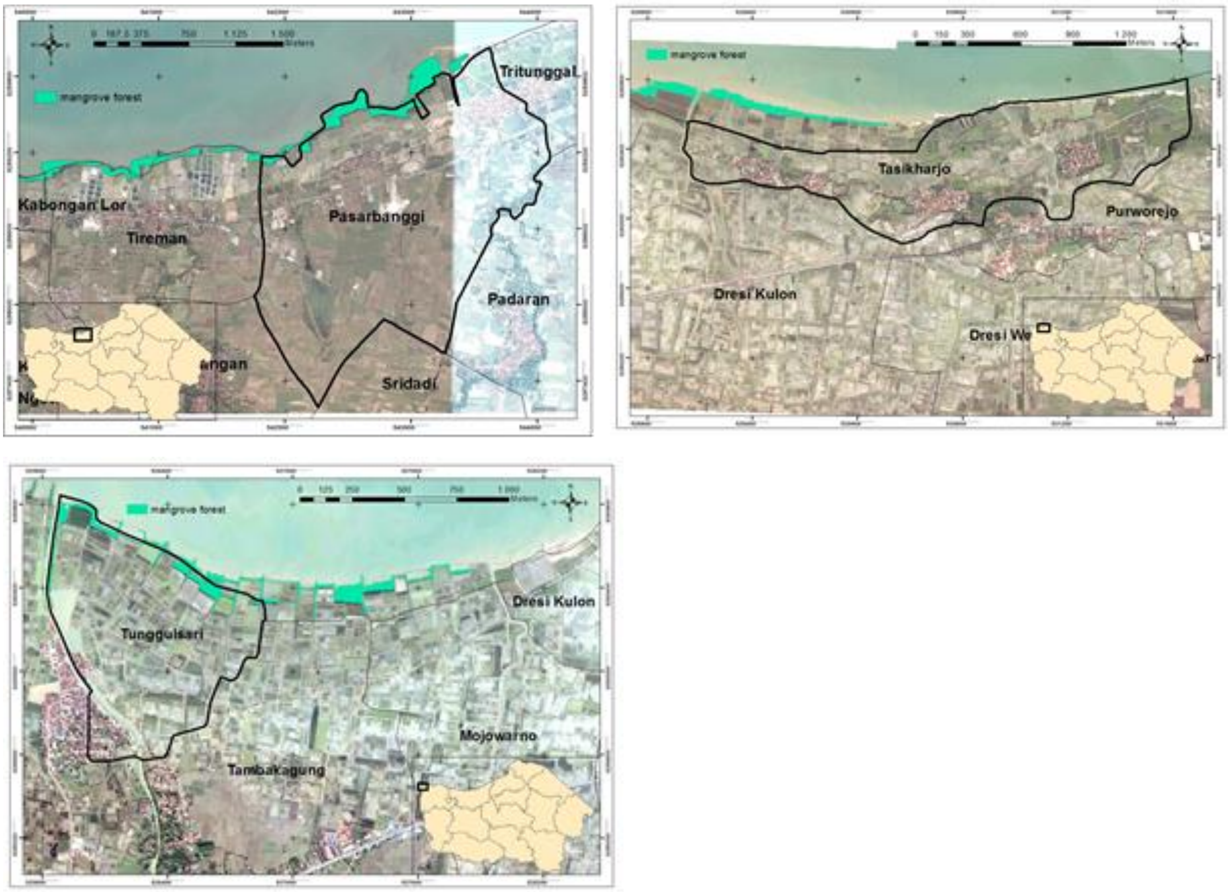


Figure 3.6. Administration map of Pasarbanggi Village, Tasikharjo Village and Tunggulsari Village

The present research applied proportional random sampling to determine the respondents in the surveyed villages. The respondents were local people which considered have correlation with mangrove forest in their daily activity. Based on field observation and interview with key person in villages (such as head of village, village officer and head of mangrove farmer groups), there were some groups which identified have relation with mangrove forest (see figure 3.7). The Slovin formula with 10% of error level applied to determine the number of respondents in each village. Gamayanti (2013) applied this formula to calculate the number of respondents for the research of investigating community's perception toward mangrove plantation program.

$n = N/(1+N.e^2)$, with

n : the number of respondents in sample village
N : population in sample villages
e : error level

Then the number of respondents for each group can be counted using formula as follows

$$n_i = (N_i/N) \times n, \text{ with}$$

n_i : the number of respondents group i

N_i : population of group i in sample village

The procedure of selecting respondents can be observed in Figure 3.7 below

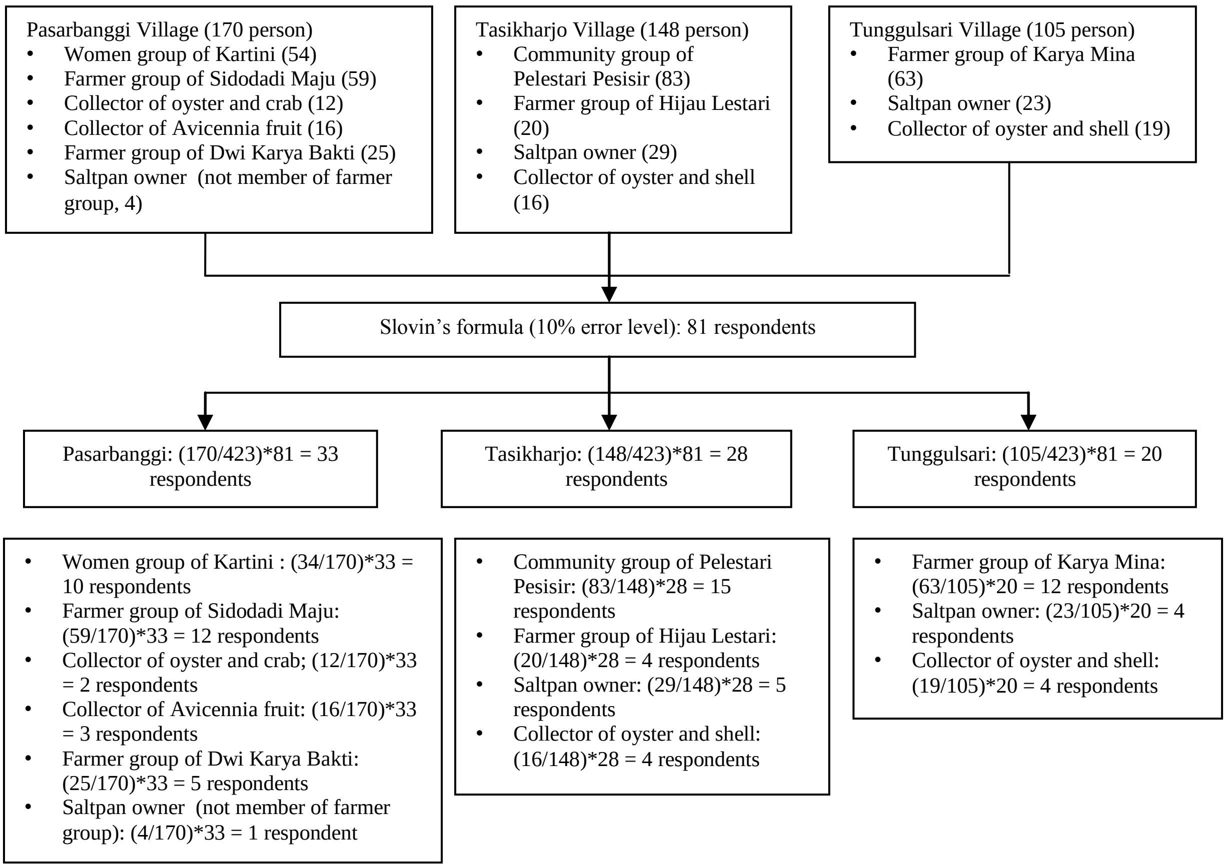


Figure 3.7. The procedure of selecting the respondents

3.2.2.2. Questionnaire

Questionnaires with open and close questions were utilised in order to collect primary data from respondents. The questions encompassed some aspects of respondents' perception, such as knowledge, experience and behavior related to mangrove. Open questions will allow the respondents to talk more freely to explore their knowledge. Qualitative information on mangrove and its relation to coastal erosion can be obtained using this question, such as effects of mangrove changes to daily life, effects of coastal erosion to mangrove, mangrove utilisation, etc. Furthermore, close questions have been applied to obtain respondent's perception in form of agreement. Questions were attributed by optional answer "yes and no".

3.2.2.3. Data Coding

In the present study, data coding was assigned to some parameters which considered have influence on respondents' perception, encompassed respondents' socio-economic factors and proximity to mangrove forest.

Table 3.2. Data coding

Criteria	Code	Data Type
Age	1: < 30 years; 2: 31-40 years; 3: 41-50 years; 4: 51-60 years; 5: > 60 years	Ordinal
Gender	1: male; 2: female	Nominal
Education	1: not schooling; 2: elementary school; 3: junior high school; 4: senior high school; 5: university	Ordinal
Income	1: < Rp 985,000; 2: Rp 985,000-2,000,000; 3: Rp 2,000,000-3,000,000; 4: > Rp 3,000,000	Ordinal
Occupation	1: fisherman; 2: laborer; 3: trader; 4: pond farmer; 5: housewife; 6: farmer	Nominal
Length of stay	1: < 5 years; 2: 5-10 years; 3: > 10 years	Ordinal
Distance from mangrove forest	1: < 500 m; 2 : > 500 m	Ordinal
Involvement in mangrove program	1 : participate; 2: no participate	Nominal
Perception on influences toward mangroves changes	1: influenced by the changes; 2: no influenced by the changes	Nominal
Adjustment/response toward mangroves changes	1: adjusted toward the changes; 2: no adjusted toward the changes	Nominal

3.2.2.4. Data analysis on community's perception toward mangrove forest changes

Some techniques have been employed to analyse community's perception toward the changes of mangrove forest. These technique included descriptive statictis analysis, data cross tabulation, chi-square test, multiple linear regression and correlation test.

3.2.2.4.1. Community's Perception Toward Mangrove Forest Changes

Descriptive statistic was used to observe respondents perception toward the changes of mangrove forest, as well as their knowledge on mangrove species and sedimentation as well as coastal erosion.

3.2.2.4.2. Community's Perception Toward the Influence of Mangrove Forest Changes

Descriptive statistic was applied to observe respondents perception wheter the changes of mangrove forest can affects their daily life in form of frequency and percentage. While data cross tabulation with chi-square test was applied to observe the differences community's perception between villages. Multiple linear regression was applied to investigate which factor that influence community's perception.

3.2.2.4.3. Community's Adjusment/Response Toward Mangrove Forest Changes

Descriptive statistic was executed to observe respondents adjustment toward the changes of mangrove forest. Data cross tabulation with chi-square test was applied to analyse the difference on respondents response between villages. While multiple linear regression was applied to analyse which factor that contribute to respondents' response toward the changes of mangrove forest.

3.2.2.4.4. Community's Perception Toward Benefit from Mangroves Non-timber Forest Products

Descriptive statistic was applied to observe respondents' perception toward benefit obtained from mangroves non-timber forest products. Data cross tabulation with chi-square test also executed to investigate the difference respondents' perception between villages.

3.2.2.4.5. Community's Acceptance on Government Mangroves Program

Descriptive statistic in form of number and percentage have been employed to observe and analyse respondents' knowledge in relation to mangrove programs in their village. While data cross tabulation was used to describe benefit obtained by respondents in each villages.

Data cross tabulation with chi-square test has been applied in order to analyse the differences on respondents' perception toward benefit obtained from mangrove program in their villages.

3.2.2.4.6. Correlation Between Community's Perception Toward the Influences of Mangroves Forest Changes, Adjustment/Response Toward Mangrove Forest Changes, Perception Toward Benefit from Mangroves Non-timber Forest Products, and Acceptance on Government Mangroves Program

Correlation test in form of contingency test has been used to observe the correlation between respondents' perception toward the influence and response due to the changes of mangrove forest, respondents' response toward the mangrove changes and their perception on benefit from mangroves ntfp, and respondents' response toward the changes of mangrove forest and their acceptance on government mangrove program.

CHAPTER IV

STUDY AREA

The study area comprised two sub-districts in Rembang District, those are Rembang and Kaliori. This chapter describes general overview of Rembang District, Kaliori Sub-District and Rembang Sub-District.

4.1. General Overview of Rembang District

4.1.1. Geographical Situation

Rembang district is located in the north eastern part of Central Java Province. Geographicaly located between 111° 00’ - 111° 30’ E and 6° 30’ - 7° 06’ S. This region is a peripheral region of Central Java region, which is directly adjacent to Pati District in the west, Blora District in the south, Tuban District in the east and Java Sea in the north. Rembang District is divided into administrative regions covering 14 districts, 287 villages, 7 villages, with an area of about 101,408 ha. Among these 14 sub-districts, 7 of which are located at coastal area.

Tabel 4.1. Sub- Districts of Rembang District

No	Sub-District	Extent (ha)	Number of Village	Non-Coastal Area	Coastal Area
1	Rembang	5,881	34	22	12
2	Kaliori	6,150	23	14	9
3	Sulang	8,454	21	21	-
4	Sumber	7,673	18	18	-
5	Bulu	10,240	16	16	-
6	Lasem	4,504	20	16	4
7	Pancur	4,594	23	23	-
8	Sluke	3,759	14	6	9
9	Kragan	6,166	27	14	13
10	Sarang	9,133	23	17	6
11	Sedan	7,964	21	21	-
12	Pamotan	8,156	23	23	-
13	Gunem	8,020	13	13	-
14	Sale	10,714	15	15	-
Total		101,408	294	241	53

(source: www.rembangkab.go.id)

4.1.2. Hidrology and Climatology

Rembang District has a dry tropical climate with two seasons alternated throughout the year , those are the dry and rainy season. The average temperature of about 21.55° C to 32.71° C, with an average rainfall of 1,500 mm/year. Meanwhile, the rainy days is about 153 days/year. In every 4 or 5 years, there will be a decline in the number of rainy days in below average. This situation allows agricultural methods which are using irrigation and rain-fed systems.

Tabel 4.2. The number of rainy days and rainfall intensity in 2012

No.	Sub-District	Rainy Days	Rainfall Intensity (mm)
1	Sumber	94	1.311
2	Bulu	92	1.245
3	Gunem	66	1.336
4	Sale	77	1.067
5	Sarang	67	785
6	Sedan	53	1.124
7	Pamotan	50	560
8	Sulang	85	1.607
9	Kaliori	49	794
10	Rembang	70	1.015
11	Pancur	68	1.403
12	Kragan	52	1.007
13	Sluke	51	1.016
14	Lasem	72	870

(source: Rembang in Figure, 2013)

4.1.3. Geological Setting

According to physiographic setting, Rembang District is located at Rembang Zone (Rembang basin or cavity), which is a mountainous region that forms anticlinorium fold with axes relatively west-east and elongated from Rembang-Jatirogo-Tuban-Madura Island, so known as anticline Rembang-Madura.

While according to morphology setting, the area can be grouped into four area, those are: (1) Low land which have a height of 0-50 m above sea level and occupies the northern coast area. This area is extends from west to east along the coastal areas Pati-Juwana-Rembang-Lasem, with a height of less than 50 m. This plain is mainly composed by alluvium sediments, clay stone formations, partly marl formation of Mundu, and Karst formation of Selorejo. This morphological unit is commonly used as rice fields and a small portion in the coastal area as saltpan; (2) undulating hills which is the widest part of Rembang District and have a height of between 50-400 m above sea level. This area is mainly located in the middle and south of Rembang District; (3) Karst morphology unit has a height of between 50-400 m above sea level and is characterized by rugged and steep hills, dolina, caves and underground rivers. This unit occupies the southern part of Rembang District and the longitudinal direction of the west - east. Morphology

Karst limestone formations formed by Paciran, Bulu Formation, Tuban Formation and Ngrayong Formation; (4) Mountainous morphological unit have a height of between 400-800 m above sea level, occupies the northern part of the district includes the mountainous complex Lasem (800 m) and Bugel Mountain, and occupies the southern part of the district of including Butak Mountain (631 m above sea level).

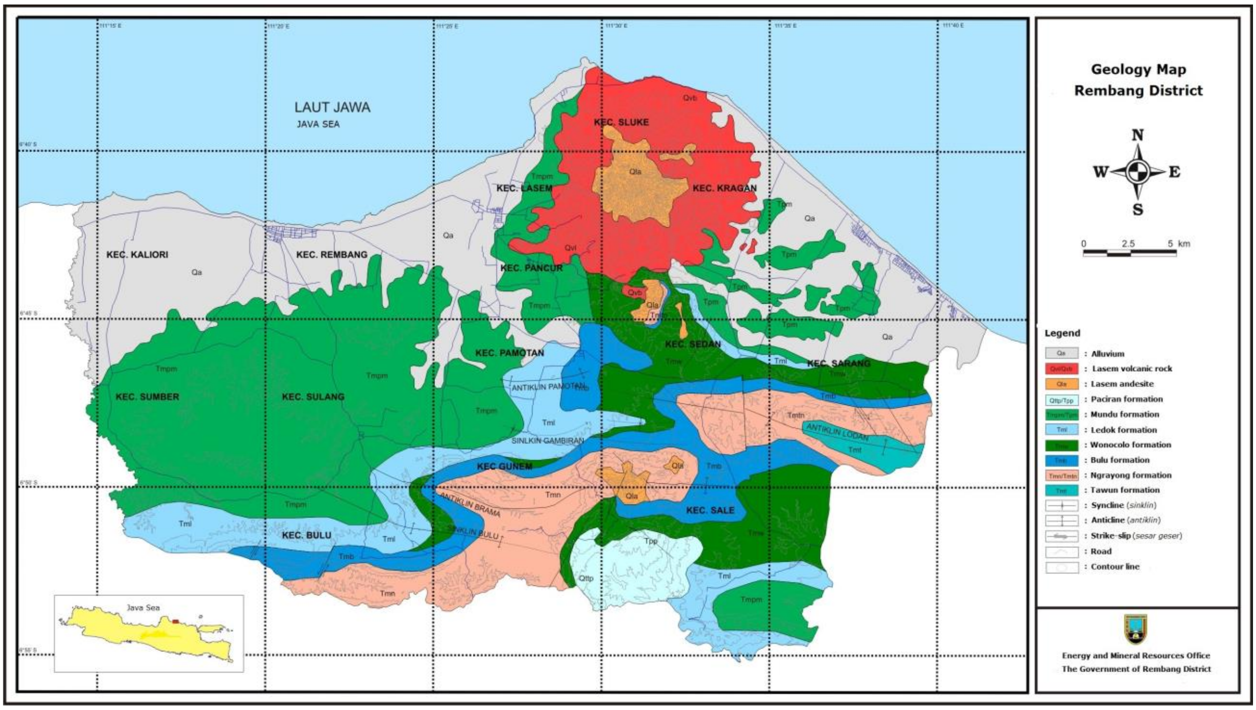


Figure 4.1. Geology map of Rembang District
(Source: modified from Energy and Mineral Resources Office of Rembang District)

4.2. General Overview of Kaliori Sub-District

Kaliori Sub-District is situated at the tip of north-west part of Rembang District. This sub-district borders with Java Sea at north, Rembang Sub-District at east, Sumber Sub-District at south and Batangan Sub-District (Pati District) at west. The sub-district consists of 6,150 ha of area and 23 villages. Among 23 villages in Kaliori Sub-Districts, 9 of which are located at coastal area, those are Tunggulsari, Tambakagung, Mojowarno, Dresi Kulon, Tasikharjo, Purworejo, Bogoharjo, Banyudono and Pantiharjo.

The area lays on altitude between 0-100 meters above sea level and 0-2% of slope. Out of this area, 2,500.2 ha is situated on 0-7 meters above sea level and the rest is situated on 8-100 meters above sea level. The north part of Kaliori Sub-

District mainly is being cultivated for saltpan/pond which covers 12.54% of total area or 771.47 ha.

Population of Kaliori Sub-District in 2013 was 41,954, consisting of 20,832 men and 21,122 women and 12,147 households. The most populated village was Sendang Agung with 4,033 of people, meanwhile the lowest populated village was Pantiharjo with 329 of people. Kuangsan was the most dense village (1,409 people/km^2), meanwhile Dresi Wetan was the lowest dense area (208 people/km^2) (SBRD[a], 2014).

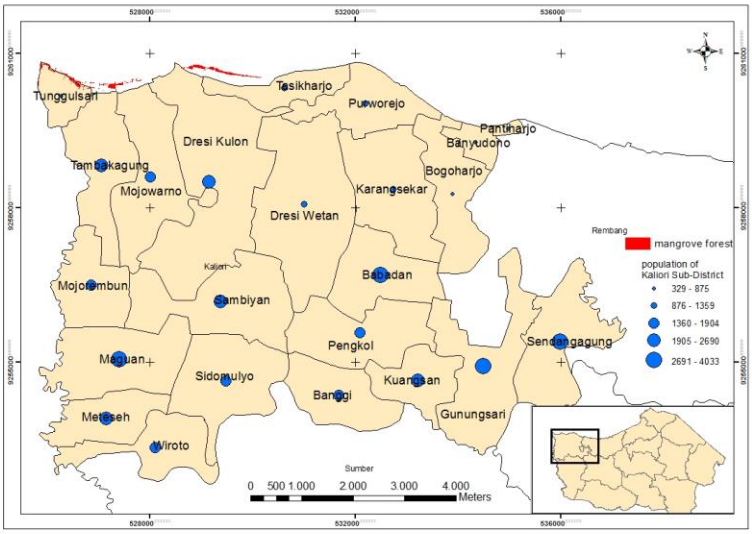


Figure 4.2. Population of Kaliori Sub-District

According to age class, the class age 20-59 years old is the dominant population with proportion 62.2%. While the proportion of class age 0-19 years old and 60+ years old are 30.6% and 7.1%, respectively ("SBRD," 2014a).

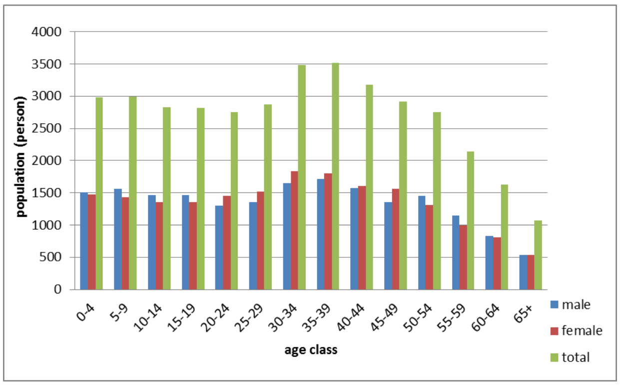


Figure 4.3. Population distribution based on age class in Kaliori Sub-District

Agriculture sector is the leading sector of economic activity in Kaliori Sub-District. This sector provides job opportunity for a number of 9,296 people during 2014. The other sectors which provide a large of job opportunity are manufacture industry (3.408 people), trading (2,499 people), services (2,000 people), and fishery (1.306 people) ("SBRD," 2014a).

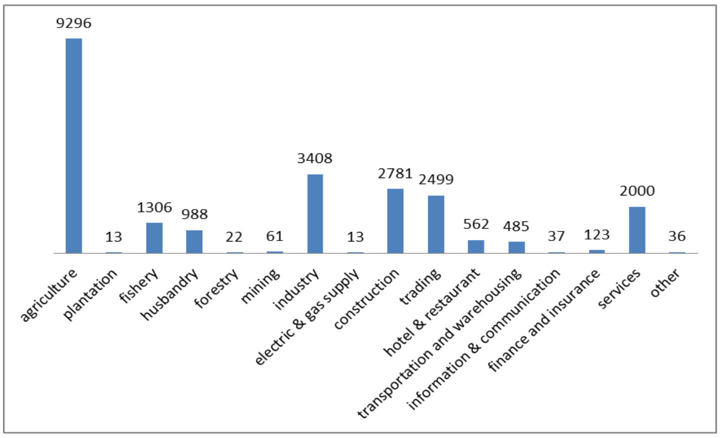


Figure 4.4. Job opportunity in Kaliori Sub-District

4.3. General Overview of Rembang Sub-District

Rembang Sub-District is situated at the central government of Rembang District. This sub-district borders with Kaliori Sub-District at west, Java Sea at north, Lasem Sub-District at east and Sulang Sub-District at south. The sub-district covers 5,881 ha of area with 34 villages. Some parts of the area, are being cultivated for saltpan/pond which covers 231.5 ha of area.

The area lays between 0-500 meters above sea level and 0-2% of slope. Out of this area, 2,225 ha of which is located on 0-7 meters above sea level and the rest is situated on 8-500 meters above sea level.

Total population of Rembang Sub-District was 87,431 in 2013, consisting of 42,859 of men, 44,522 of women and 23,240 households. Waru and Leteh were the most populated villages, with 5,261 and 5,166 villagers, respectively. Meanwhile, Weton and Gegunung Kulon were the lowest populated villages, with 755 and 961 villagers respectively ("SBRD," 2014b).

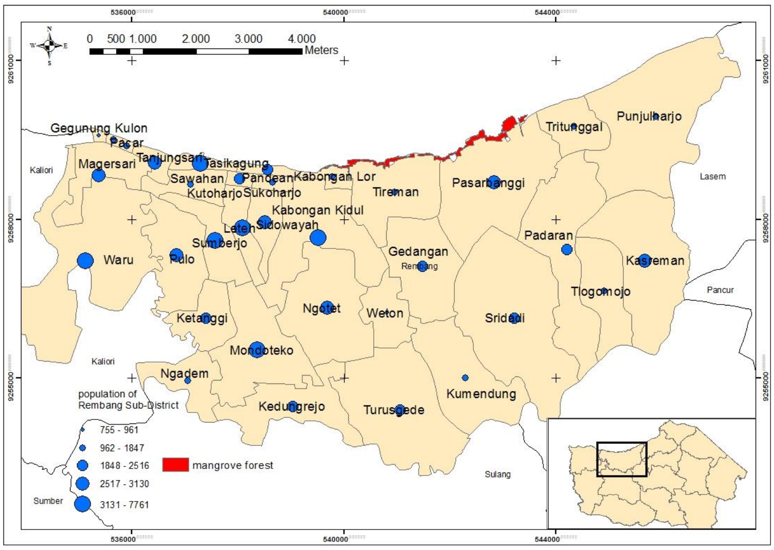


Figure 4.5. Population of Rembang Sub-District

According to age class, the class age 20-59 years old is the dominat population with proportion 57.8%. While the proportion of class age 0-19 years old and 60+ years old are 32.3% and 9.8%, respectively (“SBRD,” 2014b).

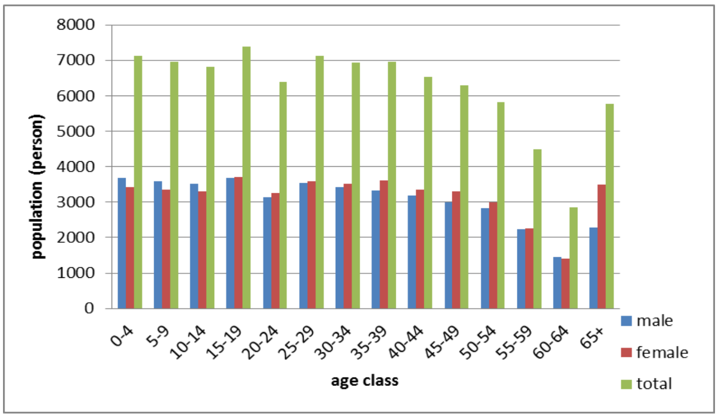


Figure 4.6. Population distribution based on age class in Rembang Sub-District

Trading and services are the leading sectors of economic activity in Rembang Sub-District. These sectors provide job opportunity for a number of 9,518 and 7,763 people during 2014, respectively. The other sectors which provide a large of job opportunity are manufacture fishery (4,460 people), industry (3,662 people), construction (2,141 people), hotel and restaurant (2,093 people), and information and communication (1,456 people) (“SBRD,” 2014c).

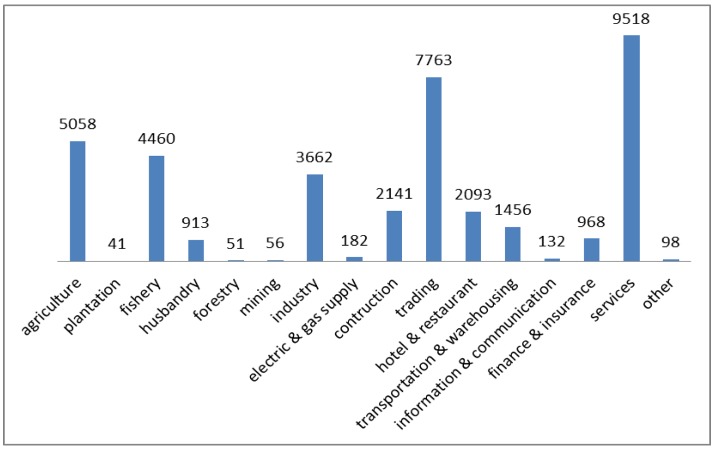


Figure 4.7. Job opportunity in Rembang Sub-District

CHAPTER V
RESULTS AND DISCUSSION

This chapter describes the main results of the present study. First, analysis on spatial and temporal changes of mangrove forest changes due to coastline changes using available dataset. Second, analysis on community's perception toward the influence of mangrove forest, which encompassed their socio-economic characteristic, knowledge on mangrove forest, perception on benefit from mangroves ntfp, and acceptance on government mangroves program.

5.1. Analysis on Spatial and Temporal Changes of Mangrove Forest due to Coastline Changes

5.1.1. Analysis on spatial and temporal changes of mangrove forest due to coastline changes utilising historical topography maps

Based on georeferencing results, the root mean square error (RMSE) of topographic map year 1881, 1943 sheet Kaliori and 1943 sheet Rembang were 0.712903, 0.72102 and 0.747548, respectively. The extraction of mangrove forest could not performed due to the absence of information on mangrove forest in all topomaps. Then the extraction of coastline performed by on screen delineation based on visual interpretation.

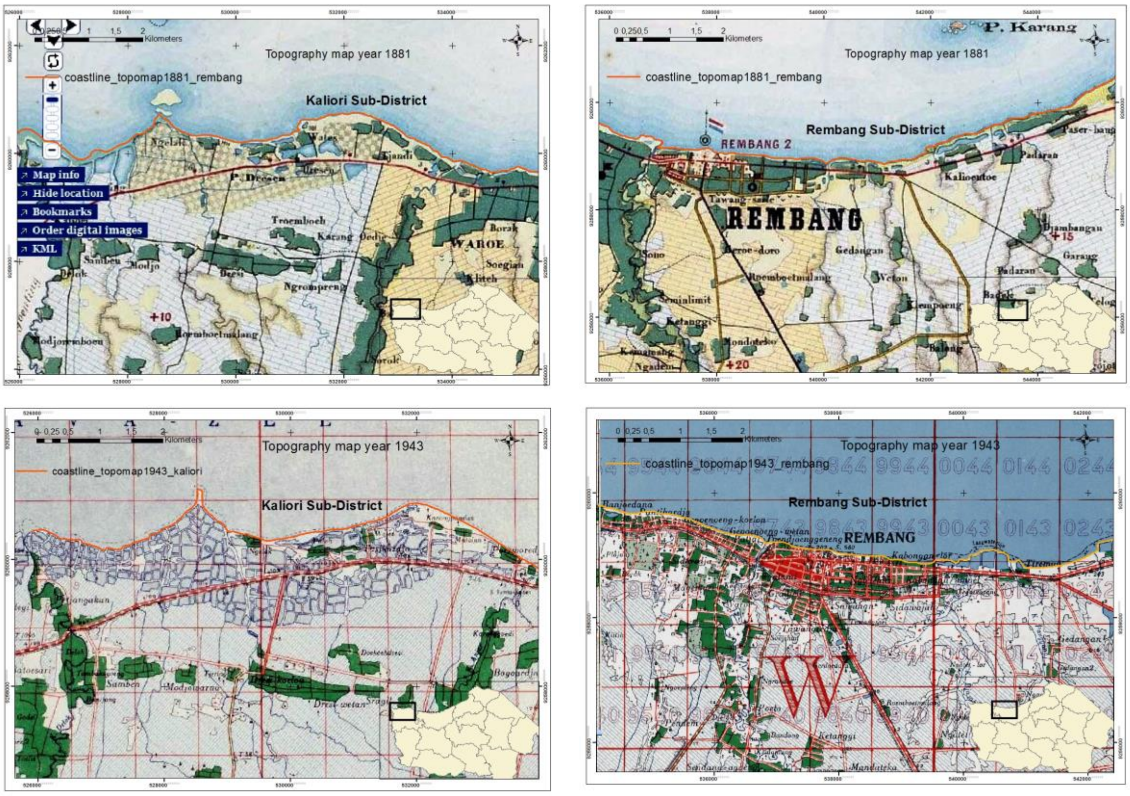


Figure 5.1. Topographic maps year 1881 and 1943 of Rembang District

Three profiles installed across the coastline in order to make easy for understanding the changes of coastline. These three profile were placed purposively due to the presence of mangrove forest in present days. Profile 1 located near the estuarine of Randugunting River, Kaliori Sub-District. The dominant landuse in present days is fishpond/saltpan with scatered mangrove forest near the estuarine and pond, as well as along the dike. The earthen dykes and scatered mangrove vegetation are the most dominant features along the coastline. Profile 2 located near the estuarine of Tasikharjo River, Kaliori Sub-District. Similar with Profile 1, the dominant landuse in present days is fishpond/saltpan with thin man-made mangrove forest along the coastline in western part. While Profile 3 located near the estuarine of Pasarbanggi Village, Rembang Sub-District. Fishpond/saltpan also the dominant landuse in present days, covered with man-made mangrove forest along outside the pond embankment on seaward direction.

During this period, sedimentation was the dominant process in Profile 1 and 2 with coastline shifted into seaward direction. While in Profile 3, the coastline also shifted into seaward direction in small part of western area. But overall, in Profile 3, coastal erosion was the dominant process during this period indicated by the coastline shifted into landward direction. The average of coastline changes in Profile 1, Profile 2 and Profile 3 during 1881 and 1943 were about +179 m, +106 m and -47 m, respectively.

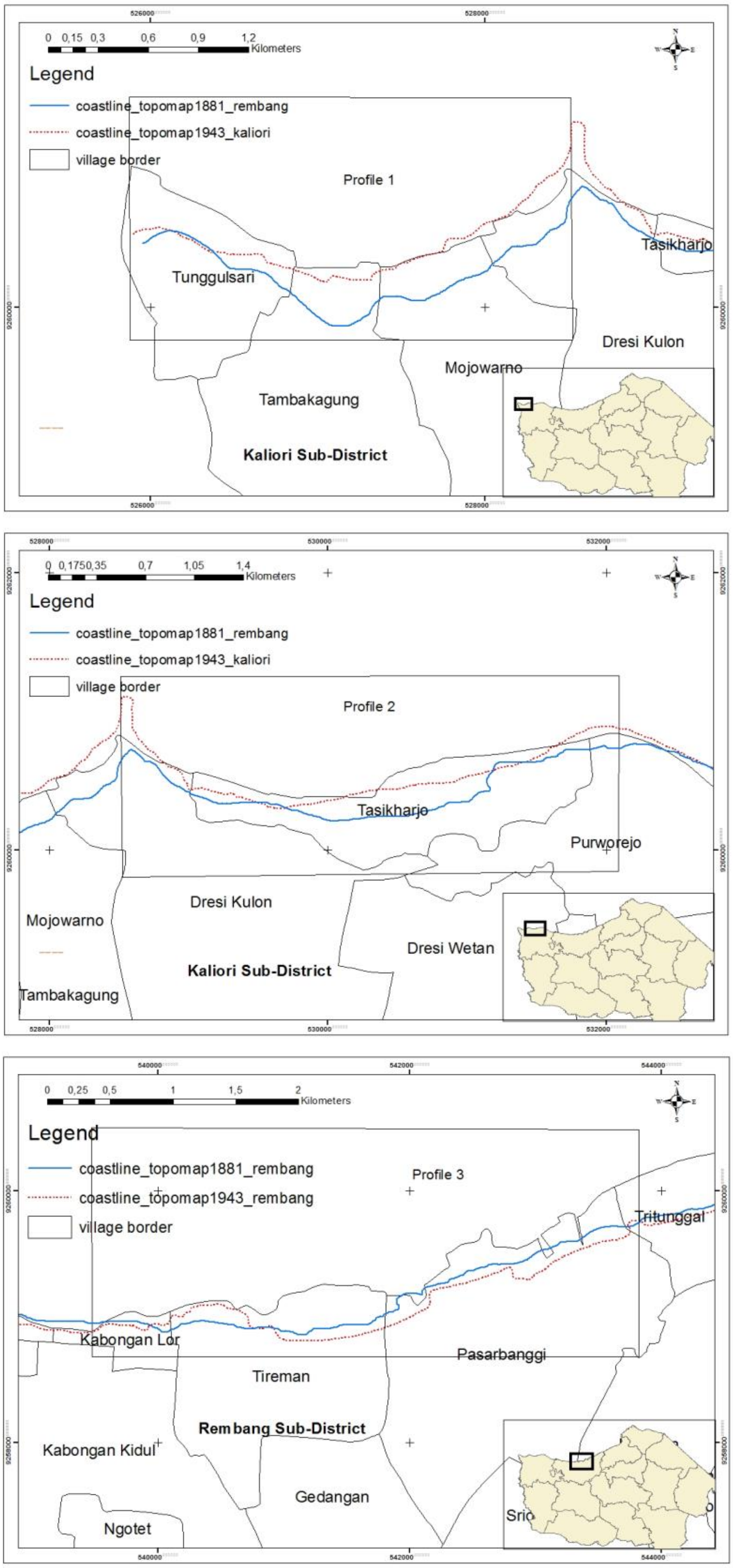


Figure 5.2. Coastline maps extracted from topography map year 1881 and 1943

5.1.2. Analysis on spatial and temporal changes of mangrove forest due to coastline changes utilising medium resolution images of Landsat

The band composite 453 of Landsat 5 1994 and Landsat 7 2002, and band composite 564 of Landsat 8 2014 were performed to recognise the mangroves area for supervised image classification based on band composite. The distribution of mangroves area can be recognised by the occurence the red color in coastal area. The mangroves area in study area are mainly associated with fishpond/saltpan.

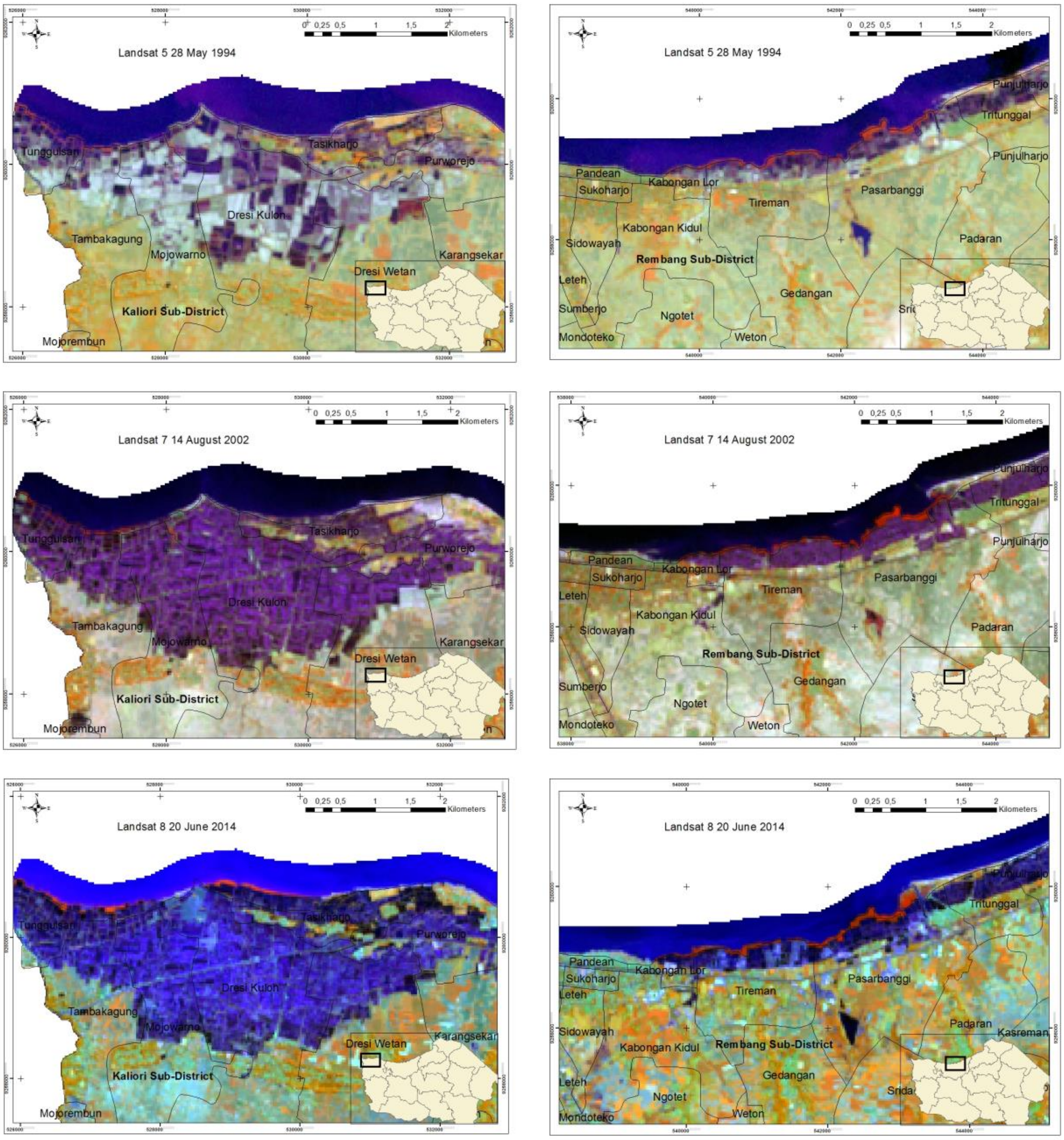


Figure 5.3. Band composite of multi-temporal images of Landsat for collecting training areas in supervised image classification based on band composite

While the procedure of supervised image classification using the composite of the difference between NDWI-NDVI, bandratio SWIR/NIR, and band SWIR can be observed in Figure 5.4 below

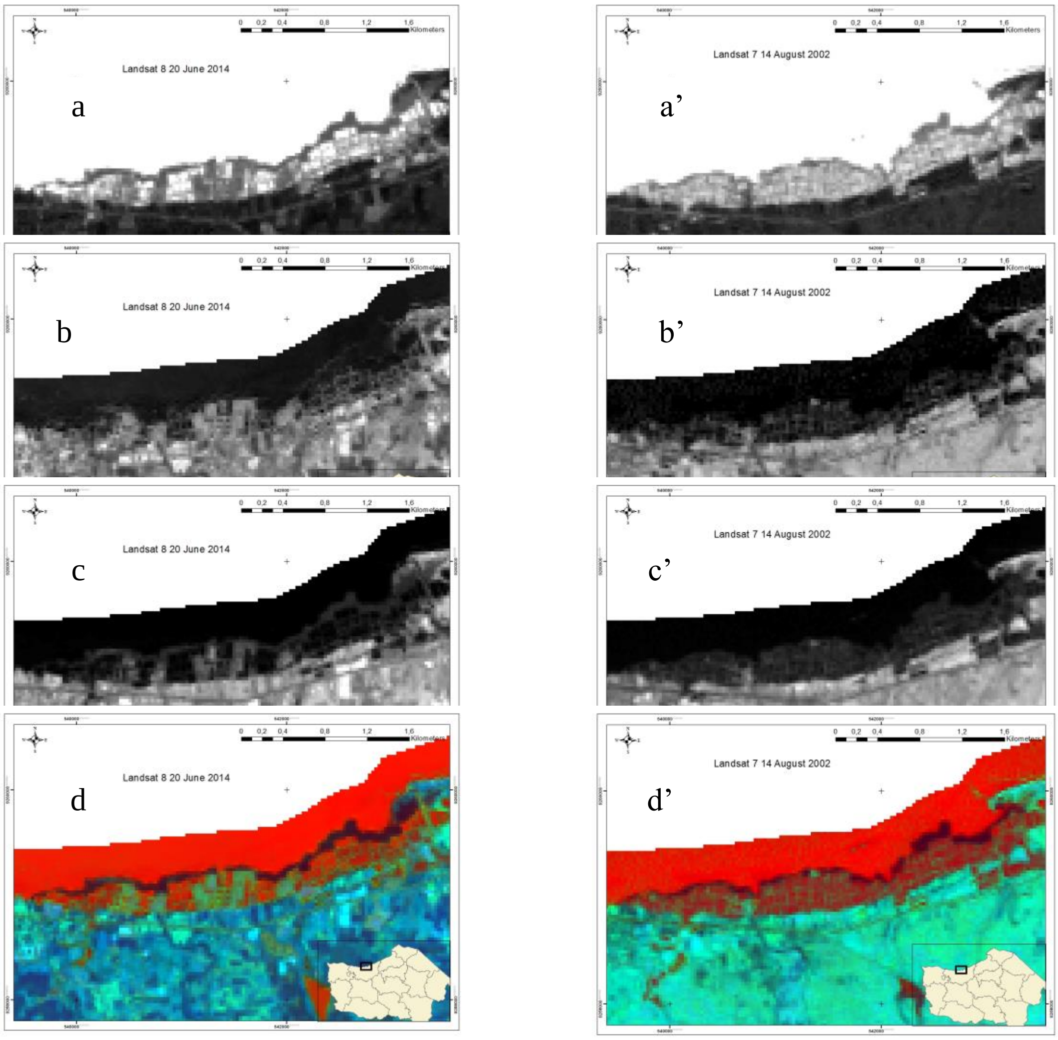


Figure 5.4. The images used for extracting mangrove forest in supervised image classification of Landsat images based on the composite of difference between NDWI-NDVI, band ratio SWIR/NIR, and SWIR band. (a, a’) the difference between NDWI-NDVI, mangroves appears in light grey color. (b, b’) band ratio SWIR/NIR, showed mangroves in dark grey color. (c, c’) band SWIR, mangroves appears in dark grey color. (d, d’) image composite of the difference between NDWI-NDVI, band ratio SWIR/NIR, and SWIR band, mangroves appears in dark blue color

The classified map of supervised image classification using multi-temporal images of Landsat based on band composite, and composite of the difference between NDWI-NDVI, bandratio SWIR/NIR, and band SWIR can be observed in Figure 5.5 and 5.6 below

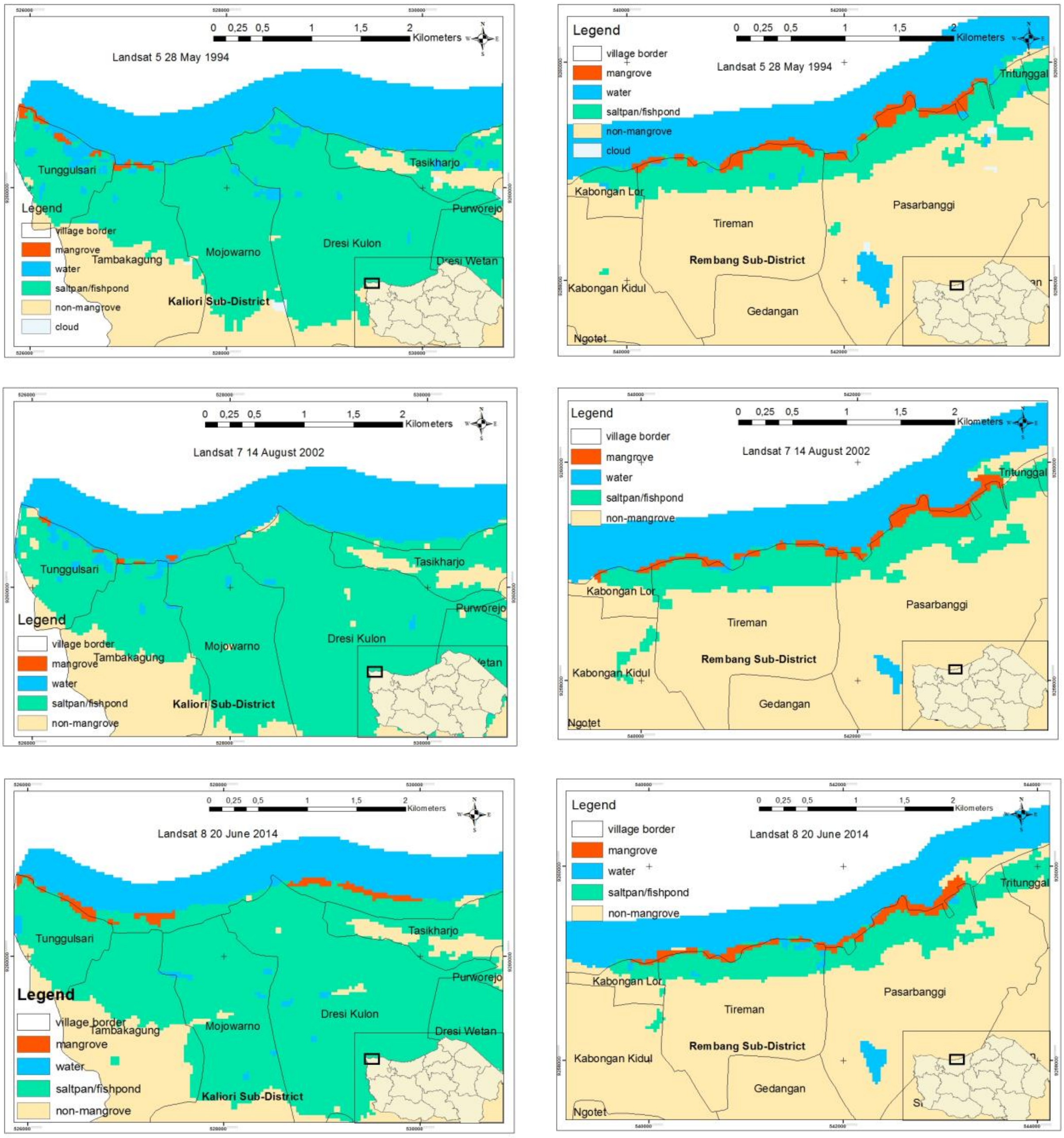


Figure 5.5. Classified map using supervised classification based on band composite

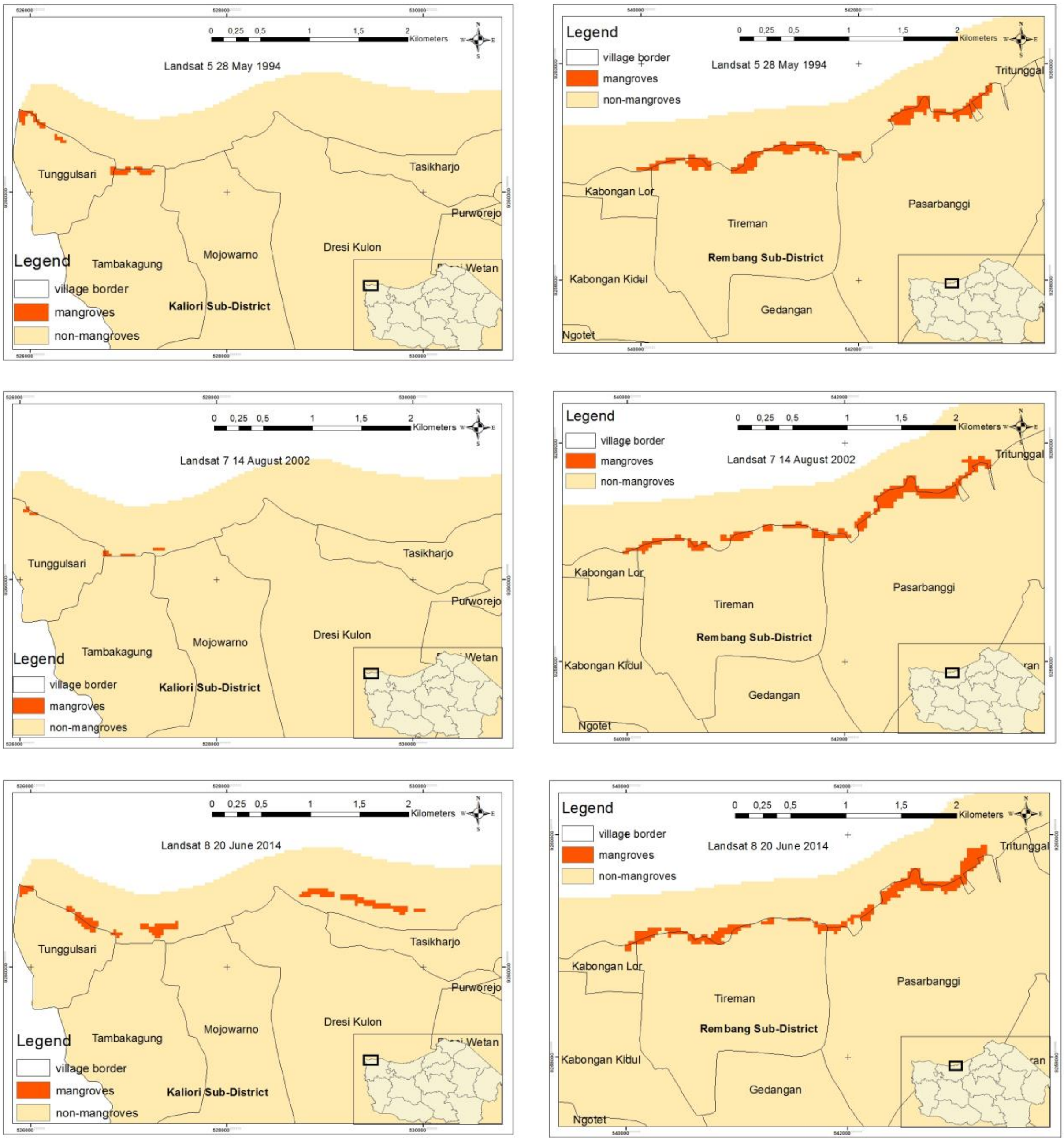


Figure 5.6. Classified map using supervised classification based on difference of NDWI-NDVI, bandratio SWIR/NIR, and SWIR band

The accuracy evaluation showed that overall accuracy of classified image year 2014 for supervised classification using band composite of Landsat 8 was 72% with user’s and producer’s accuracy for mangrove forest extent were 88.9% and 72%, respectively. A similar results also showed by accuracy evaluation of classified image year 2014 for supervised classification using composite the difference NDWI-NDVI, bandratio SWIR/NIR, and SWIR band. The overall accuracy of this method was 68% with user's and producer's accuracy for mangroves extent were 79.3% and 69.7%, respectively.

Table 5.1. Accuracy assessment of classified image year 2014 from supervised image classification using band composite

Ground reference data		Mangroves	Water	Saltpan/pond	Non-mangroves	Row total	User's accuracy
Classified map of Landsat 8 2014	Mangroves	24	3	-	-	27	88.9%
	Water	2	5	-	-	7	71.4%
	Saltpan/pond	6	2	7	-	15	46.7%
	Non-mangroves	1	-	-	-	1	0%
	Column total	33	10	7	-	50	-
	Producer's accuracy	72.7%	50.0%	100%	-	-	Overall accuracy 72%

Table 5.2. Accuracy assessment of classified image year 2014 from supervised image classification using composite of difference NDWI-NDVI, bandratio SWIR/NIR, and SWIR band

Ground reference data		Mangroves	Non-mangroves	Row total	User's accuracy
Classified map of Landsat 8 2014	Mangroves	23	6	29	79.3%
	Non-mangroves	10	11	21	52.4%
	Column total	33	17	50	-
	Producer's accuracy	69.7%	64.7%	-	Overall accuracy 68%

According to the results of supervised image classification using band composite, and the difference between NDWI-NDVI, bandratio SWIR/NIR, and SWIR band, both methods produced the similar results of mangroves extent in Rembang District. Mangrove forest in Kaliori Sub-District and Rembang Sub-District decreased during period 1994-2002 and increased during period 2002-2014. Mangroves area in Kaliori Sub-District can be found along coastal area in 5 villages, those are Tunggulsari, Tambakagung, Mojowarno, Dresi Kulon and Tasikharjo. While in Rembang District, mangroves area grow in narrow strip along coastal area of three villages, those are Pasarbanggi, Tireman and Kabongan Lor.

According to the result of supervised image classification using band composite, mangroves area in Rembang District decreased from 31 ha in 1994 into 27.9 ha in 2002. During period 1994-2002, mangrove forest area in Kaliori Sub-District decreased from 6.7 ha to 2.4 ha. The development of saltpan/fishpond contributed to the changes as much as 3.8 ha. On the other hand, there was also new establishment of mangrove area from water area (indicated that mangrove area shifted to seaward direction) as much as 1.1 ha. Similar condition also happened in Rembang Sub-District. An amount of 6 ha mangrove forest in 1994 changed into saltpan/fishpond in 2002. The new establishment of mangrove area into seaward direction also occured as amount of 3 ha and 5.9 ha in saltpan/fishpond area. But overall, the mangroves area increased from 24.3 ha to 25.5 ha.

Table 5.3. Cross tabulation of land cover class between 1994 and 2002 from supervised image classification using band composite

Kaliori Sub-District						
Year	2002 (ha)					
1994 (ha)		Mangroves	Water	Saltpan/ Fishpond	Non-mangroves	Total
	Mangroves	1.2	1.2	3.8	0.5	6.7
	Water	1.1	434.6	54.8	10.1	500.6
	Saltpan/fishpond	0.2	11.3	824.9	43.2	879.5
	Non-mangroves		2.8	130.4	1416.7	1549.9
	Cloud		1.0	7.5	9.5	18.0
	Total	2.4	450.8	1021.3	1480.1	2954.6
Rembang Sub-District						
Year	2002 (ha)					
1994 (ha)		Mangroves	Water	Saltpan/ Fishpond	Non-mangroves	Total
	Mangroves	16.7	1.6	6		24.3
	Water	3	491	17.9	30.7	542.5
	Saltpan/fishpond	5.9	4.1	231.9	27.5	269.4
	Non-mangroves		0.7	37	2580.5	2618.2
	Cloud		0.5	9.1	39.2	48.8
	Total	25.5	498	302	2677.8	3503.2

Similar results also showed by supervised image classification using difference of NDWI-NDVI, bandratio SWIR/NIR, and SWIR band. During period 1994-2002, mangroves area in Kaliori Sub-District decreased from 6.4 ha into 1.8 ha. While in Rembang Sub-District, there was an increases of mangroves area from 22.7 ha to 24.7 ha.

Meanwhile, during period 2002-2014, the mangroves area in Kaliori Sub-District and Rembang Sub-District from supervised image classification using band composite increased from 27.9 ha to 44 ha. New establishment in water area as much as 15.1 ha in Kaliori Sub-District indicated that the land area has expanded to seaward direction. The mangrove area also increased as much as 1.1 ha in saltpan/fishpond environment. While in Rembang Sub-District, there was also an increases of mangroves area from 25.5 ha to 26.9 ha. An amount of 4.1 ha mangroves area changed into saltpan/fishpond area. But on the other hand, there was also an increases of mangroves area as much as 5.4 ha in water area and 2.3 ha in saltpan/fishpond area.

Table 5.4. Cross tabulation of land cover class between 2002 and 2014 from supervised image classification using band composite

Kaliori Sub-District						
Year	2014 (ha)					
2002 (ha)		Mangroves	Water	Saltpan/ Fishpond	Non-mangroves	Total
	Mangroves	0.6		1.8		2.4
	Water	15.1	381.3	48.3	6.1	450.9
	Saltpan/fishpond	1.1	11	959.1	50.1	1021.3
	Non-mangroves	0.3	3.4	95.6	1380.8	1480.1
	Total	17.1	395.7	1104.8	1437	2954.7
Rembang Sub-District						
Year	2014 (ha)					
2002 (ha)		Mangroves	Water	Saltpan/ Fishpond	Non-mangroves	Total
	Mangroves	19.2	1.8	4.1	0.4	25.5
	Water	5.4	470.3	4.8	17.5	498
	Saltpan/fishpond	2.3	7.6	257.9	34.2	302
	Non-mangroves		6.7	19.9	2651.2	2677.8
	Total	26.9	486.4	286.7	2703.2	3503.2

The classified image from supervised image classification using difference of NDWI-NDVI, bandratio SWIR/NIR, and SWIR band also showed that there was an increases of mangroves area during 2002-2014. In Kaliori Sub-District, the mangroves area increased from 1.8 ha in 2002 to 15.5 ha in 2014. While in Rembang Sub-District, there was an increases of mangroves area from 24.7 ha into 25.9 ha.

Meanwhile, visual interpretation and on screen delineation were performed to extract the coastline based on band composite and binary slicing method using multi-temporal images of Landsat. The RMSE resulted from rectification for band composite 452 Landsat 5 and Landsat 7, and 563 Landsat 8 were 0.57839, 0.530003 and 0.635039. While the RMSE resulted from rectification band 5 of Landsat 5 and Landsat 7, and band 6 of Landsat 8 were 0.601674, 0.454252 and 0.501374.

The band composite 452 of Landsat 5 1994 and Landsat 7 2002, and band composite 563 of Landsat 8 2014 were used to extract the coastline. The band composite and the results of masking operation can be observed in Figure 5.7 and 5.8 below

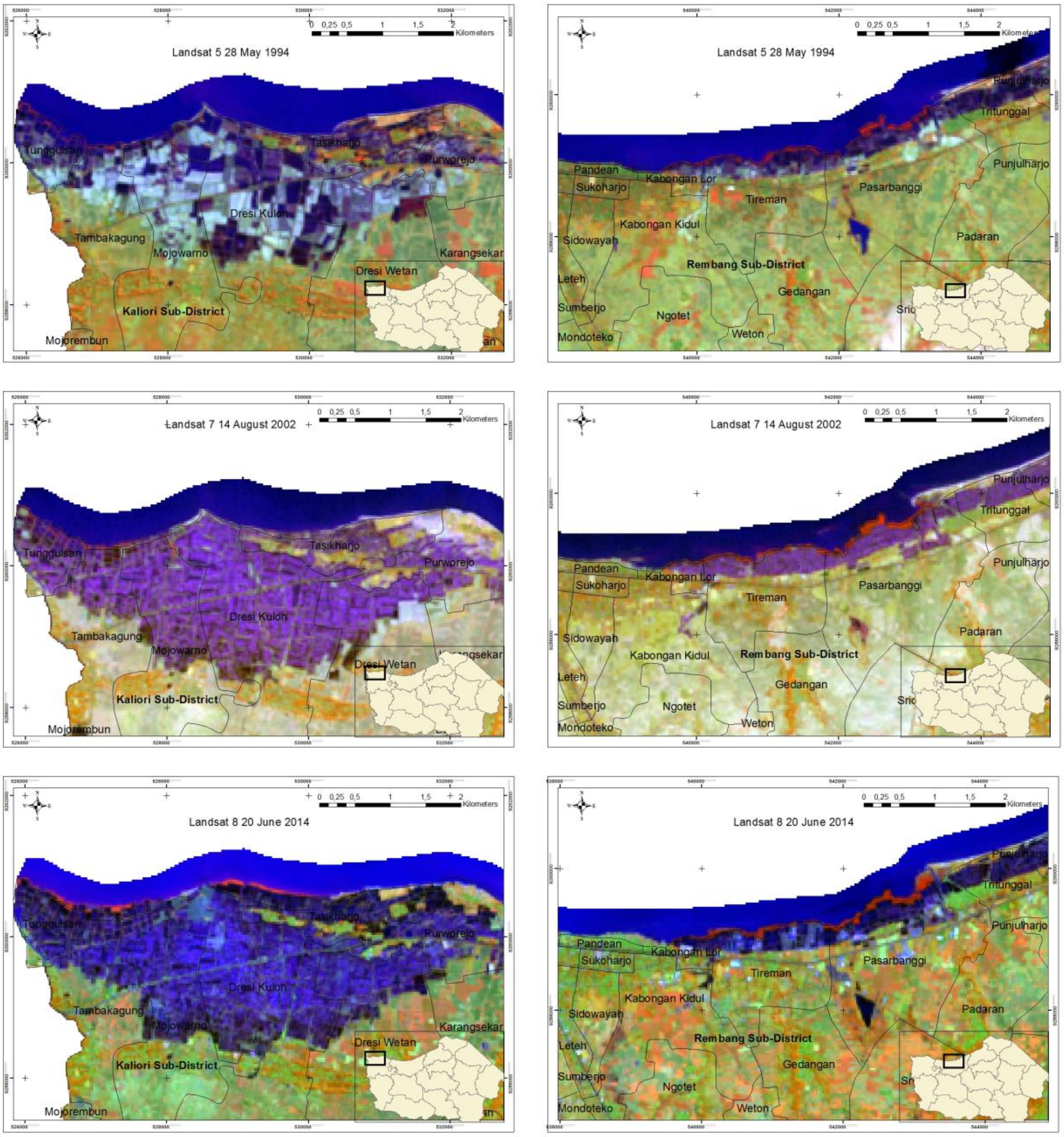


Figure 5.7. The band composite of Landsat images for extracting coastline

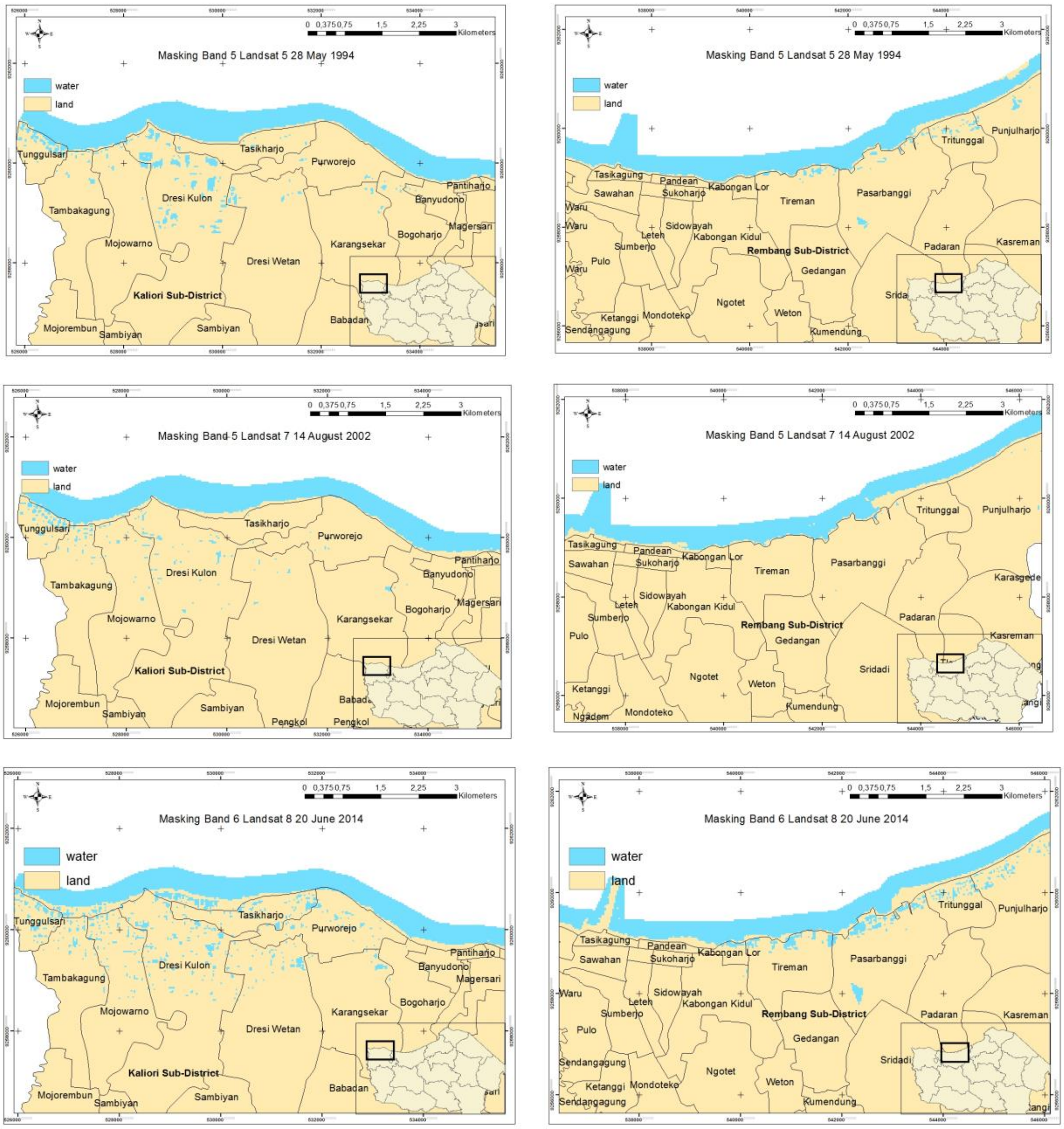


Figure 5.8. Masking operation results of mid-IR band of Landsat using binary slicing method

The extracted coastline using the both methods then calibrated using the principle of trigonometry. Based on field measurement, the average of coast slope was 1°. Water level according to local time when images acquired for Landsat 5 (28 May 1994), Landsat 7 ETM+ (14 August 2002) and Landsat 8 (20 June 2014) were 0.7 m, 0.7 m and 0.8 m, respectively. While the highest water level from these different period was remain the same, 1.1 m. By applying the concept of trigonometry, then the extracted coastline year 2014, 2002 and 1994 should be shifted into landward direction as far as 23 m, 23 m and 17 m, respectively (less than one pixel of Landsat image).

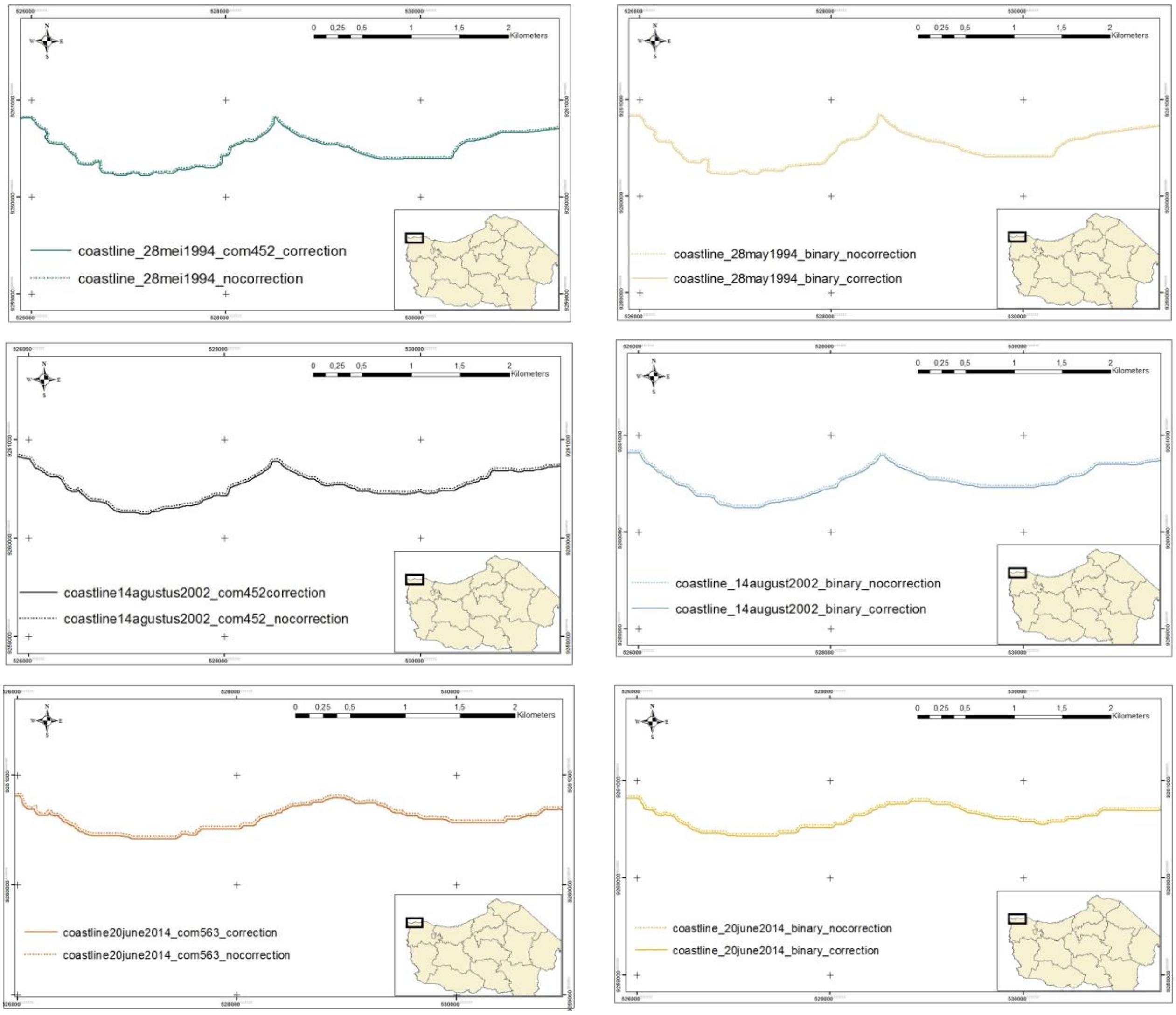


Figure 5.9. The calibrated coastline of Landsat images using trigonometry principle

According to visual interpretation and on screen delineation using band composite and binary slicing of multi-temporal images of Landsat, the coastlines which extracted from these methods showed a similar trend. The coastline changes between periods using the two methods can be observed in Figure 5.10 below

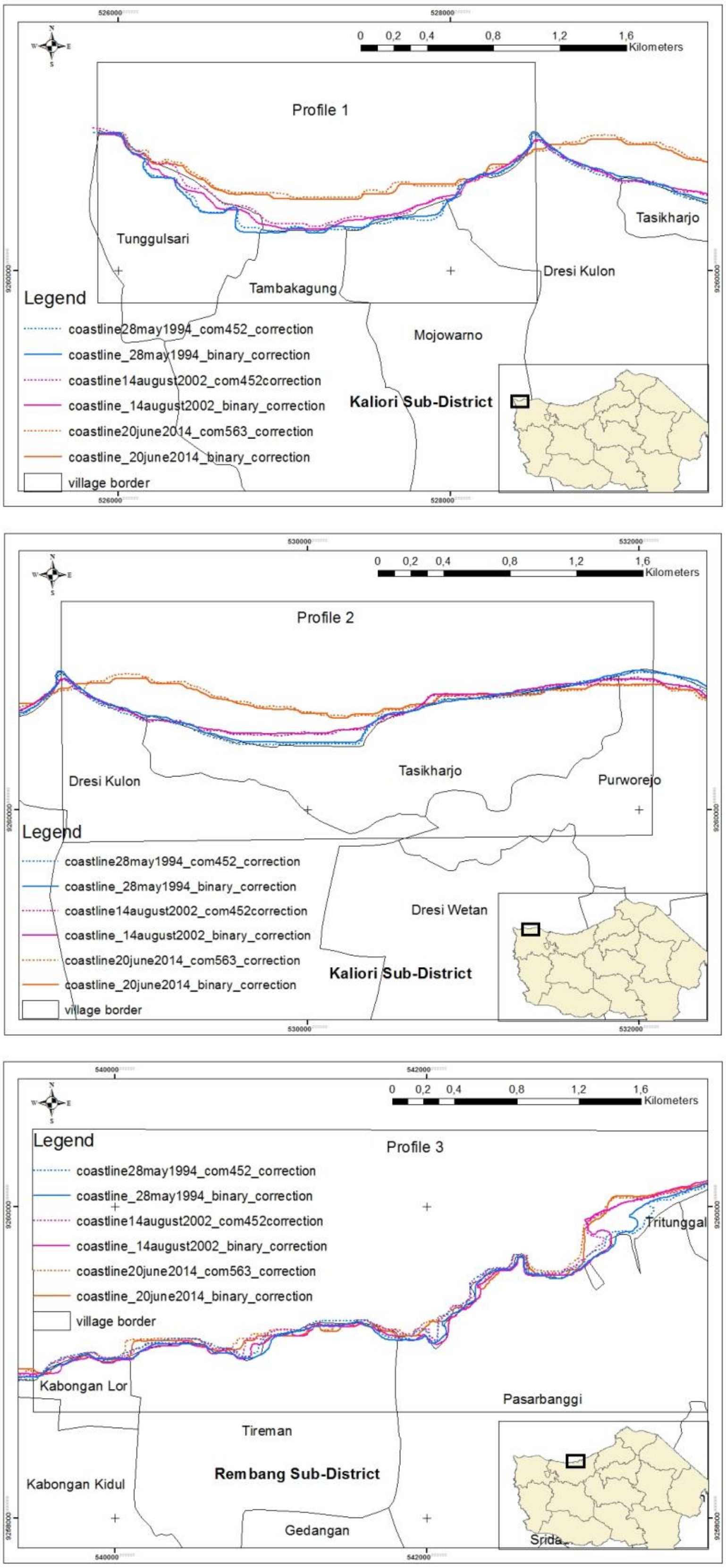


Figure 5.10. Coastline maps extracted from multi-temporal images of Landsat year 1994, 2002 and 2014 based on band composite and binary slicing

Sedimentation was the dominant process in three profiles during period 1994-2002. Based on band composite, during period 1994-2002, the coastline shifted into seaward direction in Profile 1, Profile 2 and Profile 3 as much as 44 m, 17 m and 20 m, respectively. While based on binary slicing, it was also a tendency that the coastline shifting into seaward direction as far 28 m, 14 m and 13 m in Profile 1, Profile 2 and Profile 3, respectively. However, there was coastal erosion in eastern part of Profile 1 in adjacent area with Profile 2, and also in eastern part of Profile 2.

While during period 2002-2014, the coastlines resulted from on screen delineation based band composite and binary slicing also showed a similar trend with the previous period. During this period, coastlines resulted from band composite shifted into seaward direction, mainly in Profile 1 and Profile 2, as much as 82 m and 80 m, respectively. While based on binary slicing, the coastline also shifted into seaward direction as far 90 m and 70 m in Profile 1 and Profile 2. The coastline was not much changes in Profile 3. The average of changes in Profile 3 based on band composite and binary slicing were 13 m and 20 m, respectively.

Table 5.5. Coastline changes during period 1994-2014 from multi-temporal images of Landsat

Profile	1994-2002 (m)		2002-2014 (m)	
	Band composite	Binary slicing	Band composite	Binary slicing
1	+44	+28	+82	+90
2	+17	+14	+80	+70
3	+20	+13	+13	+20

+ : sedimentation; - : coastal erosion

In general, the coastlines extracted from the two methods showed a similar trend. The difference on average of coastline changes between 1994-2002 and 2002-2014 from the two methods were less than one pixel (30 m spatial resolution of Landsat images).

Furthermore, the difference between coastlines extracted from the two methods from the same period in general also less than one pixel (30 m spatial resolution of Landsat images). In 1994, the difference between coastline extracted from band composite and binary slicing in Profile 1, Profile 2 and Profile 3 were 11 m, 12 m and 12 m. While in 2002, the difference between coastline extracted from band composite and binary slicing in Profile 1, Profile 2 and Profile 3 were 10 m, 9 m and 12 m. In 2014, the difference between coastline extracted from band composite and binary slicing in Profile 1, Profile 2 and Profile 3 were 11 m, 9 m and 9 m.

According to the results of mangroves and coastline mapping using multi-temporal images of Landsat, in general it can be observed that the shiftness of coastline into seaward direction followed by the increases of mangroves area. For instance in Profile 1, during period 2002-2014, the shiftness of coastline as much 82 m (using band composite) or 90 m (using binary slicing) followed by the increases of mangroves area as much 7.1 ha (supervised image classification using band composite) or 6.4 ha (supervised image classification using band indices and band ratio).

Table 5.6. The changes of mangroves and coastline extracted from multi-temporal images of Landsat

Profile	Period 1994-2002				Period 2002-2014			
	Mangroves changes (ha)		Coastline changes (m)		Mangroves changes (ha)		Coastline changes (m)	
	1	2	3	4	1	2	3	4
1	-4.3	-3.5	+44	+28	+7.1	+6.4	+82	+90
2	0	0	+17	+14	+7.6	+7.3	+80	+70
3	+1.2	+2.0	+20	+13	+1.4	+1.3	+13	+20

Remark:
1. Supervised image classification using band composite
2. Supervised image classification using the image composite of difference between NDWI-NDVI, band ratio SWIR/NIR, and band SWIR
3. Visual delineation of coastline using band composite
4. Visual delineation of coastline using binary slicing

5.1.3. Analysis on spatial and temporal changes of mangrove forest due to coastline changes utilising high resolution images of Google Earth

The resulted values of RMSE of four layer Google Earth images year 2009 were 0.638511, 0.643472, 0.696836 and 0.605845. While for images year 2014, the resulted values of RMSE were 0.587771, 0.86932, 0.750133 and 0.534271. The extraction of coastline and mangroves area using Google Earth images were performed by visual interpretation and on screen delineation.

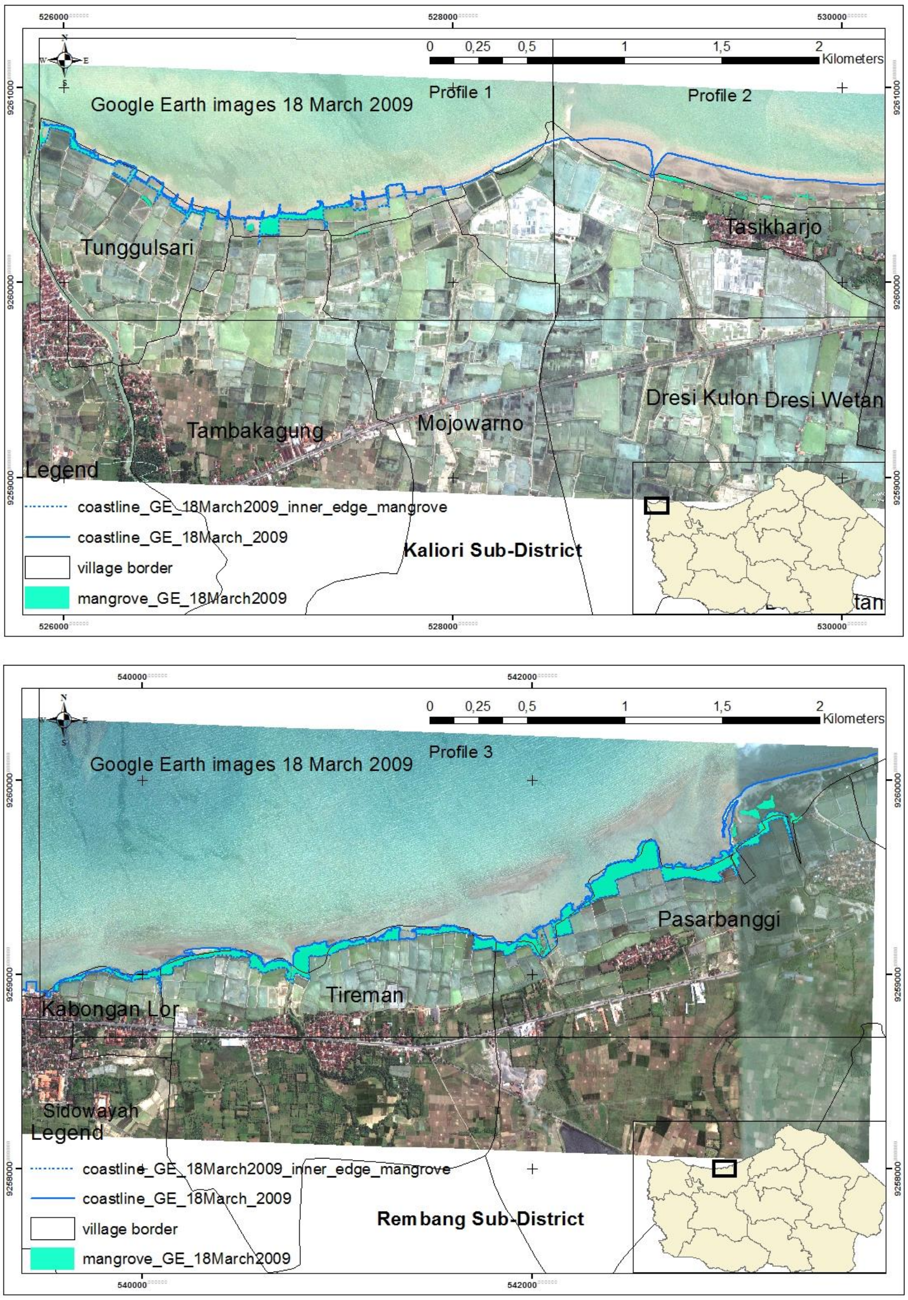
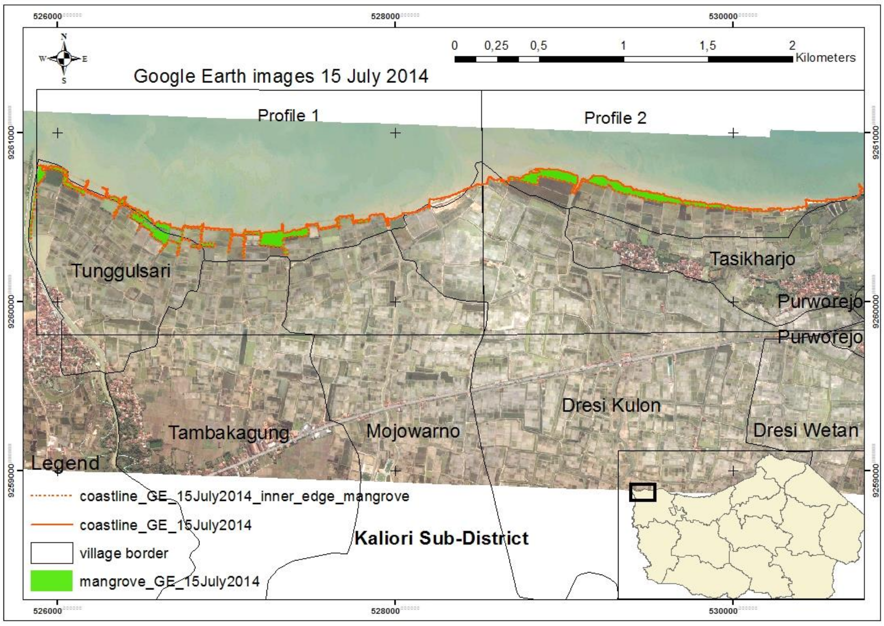


Figure 5.11. The extracted mangrove forest and coastline year 2009 from Google Earth images



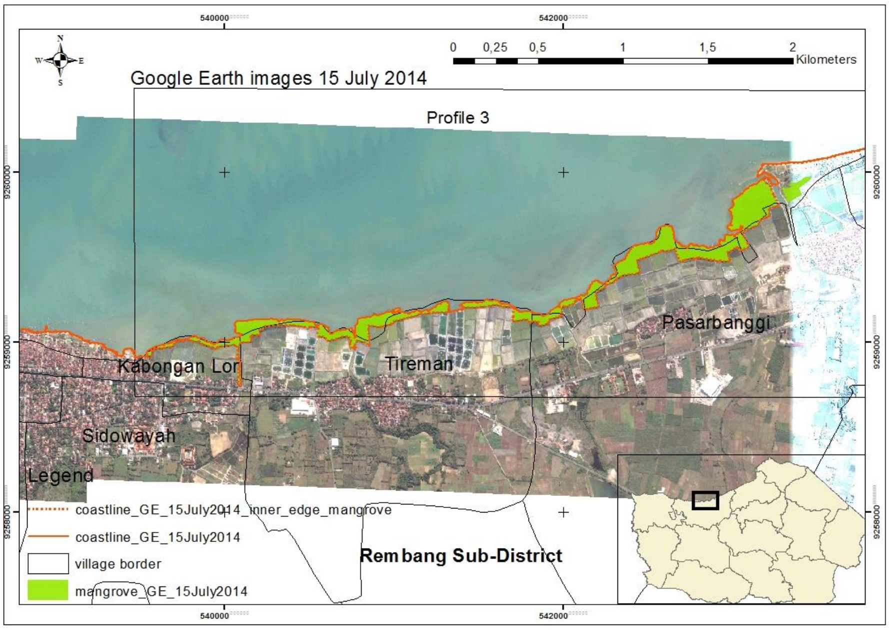


Figure 5.12. The extracted mangrove forest and coastline year 2014 from Google Earth images

Based on visual interpretation, mangroves forest can be identified in Kaliori Sub-District and Rembang Sub-District. In 2009, mangroves area in Kaliori Sub-District was 5.90 ha which distributed along coastal area of five villages, those are Tunggulsari, Tambakagung, Mojowarno, Dresi Kulon and Tasikharjo. While in Rembang Sub-District, there was 20.69 ha of mangroves area which distributed along coastal area of three villages, those area Pasarbanggi, Tireman and Kabongan Lor.

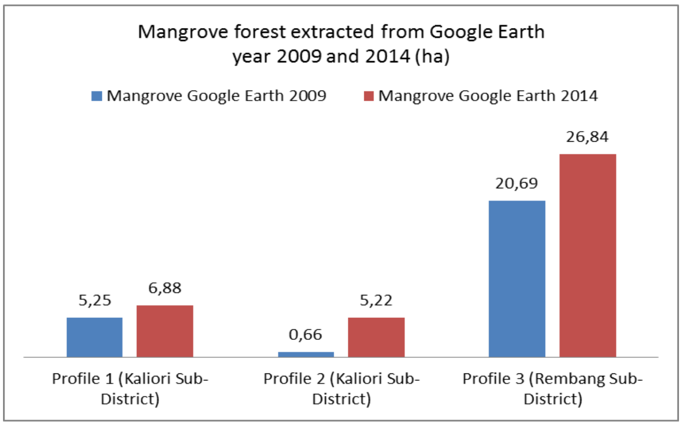


Figure 5.13. The extent of mangroves area in selected profiles using Google Earth images

The extent of mangroves in Profile 1 increased from 5.25 ha in 2009 to 6.88 ha in 2014. In 2009, mangroves area in Profile 1 mainly distributed along the pond dike, as well as inside the pond and along outside the dike on seaward margin. The average of mangroves width was 14 m. The width of mangroves area is vary, from 5 m which can be observed along the dike, to 120 m which can be identified inside the pond. The similar condition also found in year 2014. The average of mangroves width was increase into 18 m. It was a tendency that the mangroves area has expanded into seaward direction, in line with the new establishment of new pond dike.

While in Profile 2, the extent of mangroves area increased from 0.66 ha in 2009 to 5.22 ha in 2014. In 2009, the mangroves area was scatered on muddy flat along the outside of pond dike on seaward margin. The width of mangroves area was vary from 4-18 m, with average about 8 m. The condition then changed in 2014. In 2014, the mangroves area has expanded into seaward direction along outside the pond dike on seaward margin. The width of mangroves area are vary from 9-60 m, with average of width around 34 m. But on the other hand, the former mangroves area in 2009 then replaced by saltpan/fishpond.

Furthermore, in Profile 3, there was an increases of mangroves area during 2009-2014. The mangroves extent changed from 20.69 ha into 26.84 ha. The average on mangroves width increased from 48 m into 66 m. The mangroves grow along outside the pond dike on seaward margin. There was increases on mangroves area in some parts, mainly contributed by man made regeneration. But there was also mangroves removal due to new establishment of new pond and river normalisation on the eastern part of area.

Meanwhile, the coastlines extracted from Google Earth images year 2009 and 2014 was divided into two criterias, those are the coastline which covers outer edge of mangrove (seaward direction) and the coastline which covers inner edge of mangroves (landward direction). Both of the extracted coastlines mainly correspond to man-made regeneration of mangroves and new establishment of pond dike, mainly in Profile 1. While in Profile 2 and profile 3, the new establishment of mangroves area due to man made regeneration was the main contributor of the extracted coastline. The extracted coastlines year 2009 and 2014 from Google Earth images can be observed in Figure 5.14 and Figure 5.15 below

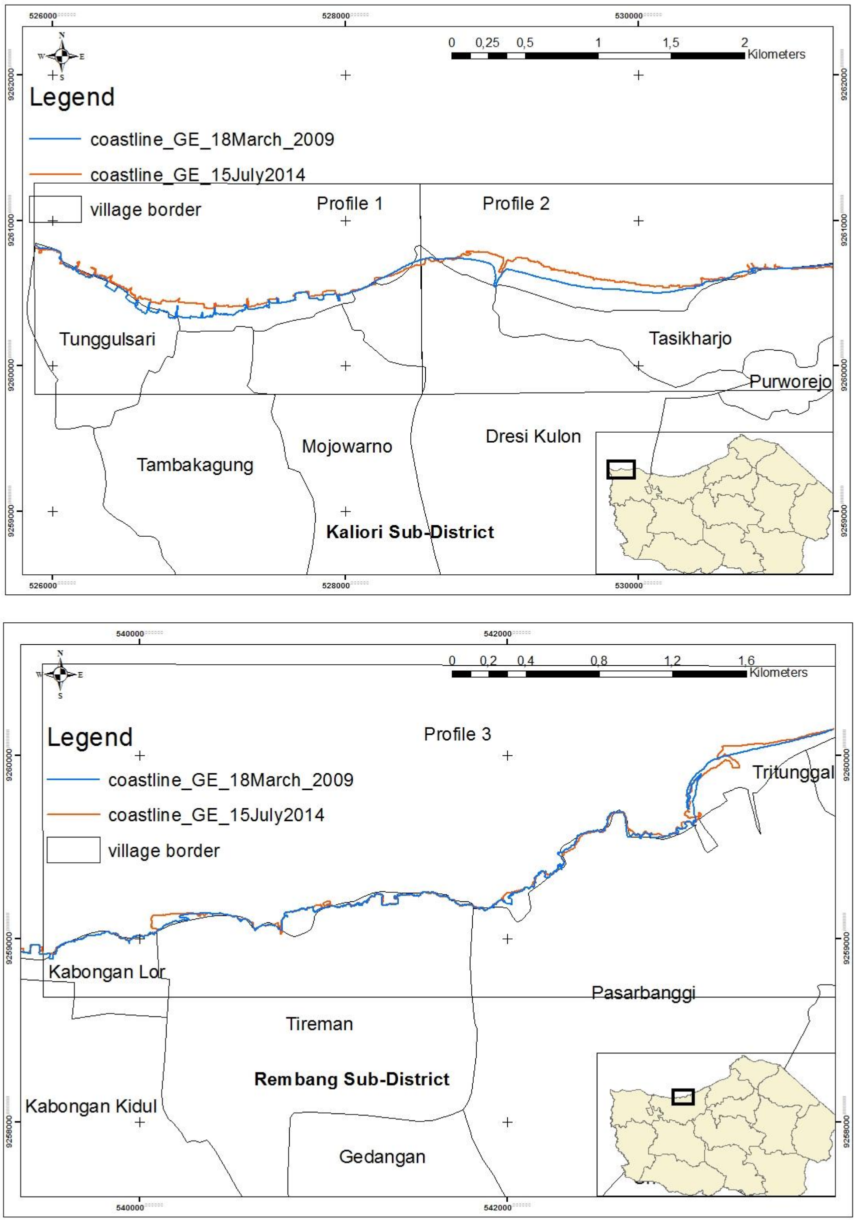
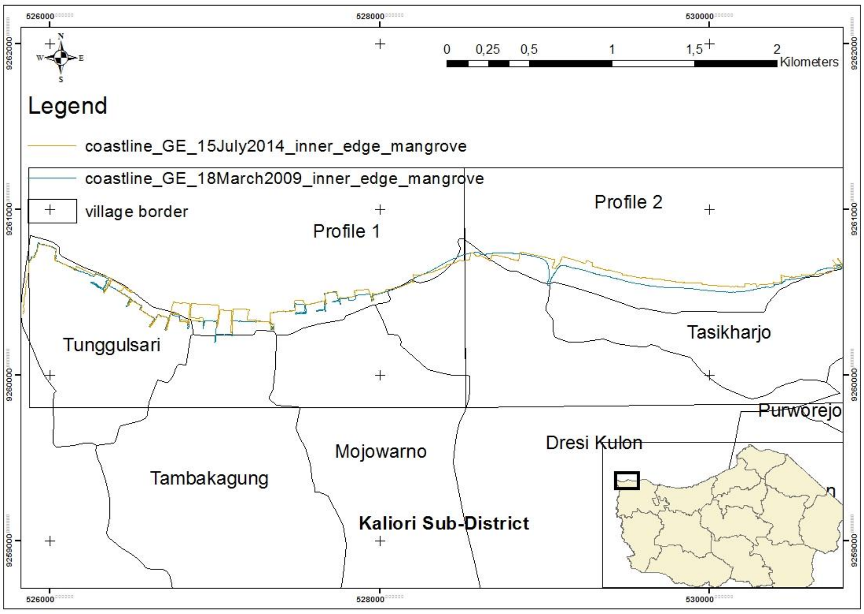


Figure 5.14. Coastline outer edge of mangroves extracted from Google Earth images year 2009 and 2014



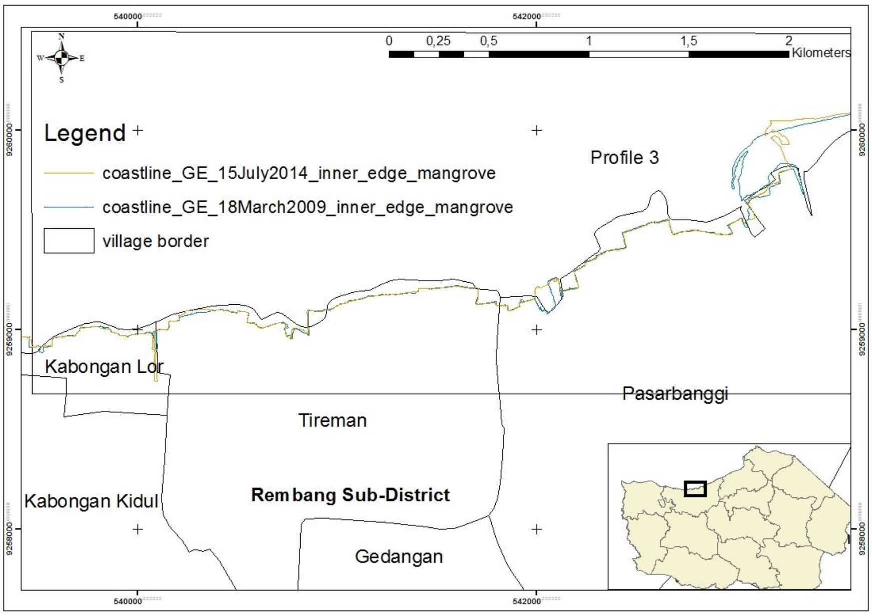


Figure 5.15. Coastline inner-edge of mangroves extracted from Google Earth images year 2009 and 2014

During period 2009-2014, the coastline in both three profiles had a tendency to shift into seaward direction. In Profile 1, the coastline of outer edge of mangroves shifted into seaward direction with average of changes about 26 m. In line with this situation, the coastline inner edge of mangroves also shifted into seaward direction with average of changes was about 18 m. The establishment of pond embankment followed by man-made mangrove regeneration along the embankment, as well as inside the pond, were the main causes of this condition.

Its mean that the movement of coastline into seaward direction also followed by the removal of mangroves area on landward margin.

On the other side, the coastline in Profile 1 also slightly shifted into landward direction, mainly on small area in western part and eastern part, adjacent with Profile 2. On the western part, the coastline shifted into landward direction with a range 2-8 m during 2009-2009. While on eastern part, adjacent with Profile 2, the changes was in range 10-35 m.

While in Profile 2, the condition also similar with condition in Profile 1. On the western part, adjacent with Profile 1, the coastline shifted into landward direction with a range 2-37 m during period 2009-2014. On the eastern part, the coastline also shifted into landward direction with the range of changes about 5-27 m. But in average, the movement of coastline into seaward direction was the dominant phenomenon in Profile 2. In average, the coastline shiftness into seaward direction about 25 m during this period.

In Profile 3, there was no much changes of coastline between period 2009-2014. In average, the coastline of outer mangroves moved into seaward direction as far as 4 m during 2009-2014. The coastline of inner edge of mangroves also shifted into seaward direction about 2 m. The man made mangroves regeneration apparently was the main contributor of this condition, mainly on the eastern part of Profile 1.

Table 5.7. Coastline changes during period 2009-2014 from Google Earth images

Profile	Changes of coastline outer mangroves (m)	Changes of coastline inner mangroves (m)
1	+26	+18
2	+25	-
3	+4	+2

+ sedimentation; - coastal erosion

According to the extracted mangrove forest and coastline year 2009 and 2014, in general it can be observed that the dominant process in both three profiles was sedimentation followed by the expansion of mangrove forest into seaward direction. In profile 1, the average of coastline changes during this period was 26 m, then followed by the expansion of mangroves area as much 1.64 ha. While in Profile 2, the changes of 25 m of coastline followed by the increases of

4.57 ha of mangrove. Then in Profile 3, a slight 4 m changes of coastline followed by 6.15 ha increases of mangroves area.

Table 5.8. The changes of mangroves and coastline extracted from Google Earth images period 2009-2014

Profile	Changes of mangroves (ha)	Changes of coastline outer mangroves (m)	Changes of coastline inner mangroves (m)
1	+1.64 ha	+26 m	+18
2	+4.57 ha	+25 m	-
3	+6.15 ha	+4 m	+2

5.2. Analysis on Community's Perception Toward the Influence of Mangrove Forest Changes due to Coastline Changes

5.2.1. Characteristics of Respondents

5.2.1.1. Age distribution

Respondents' age is ranging from 24 to 65 years old and age average is 42 years old. Most of respondents are at productive age, with the dominant age class are 31-40 years old and 41-50 years old, accounting for 27 respondents (33.3%) per each. Meanwhile, age class < 30 years old and 51-60 years old which accounted for 10 respondents (12.3%) and 13 respondents (16%), respectively. There is only 4 respondents (4.9%) whose age more than 60 years old.

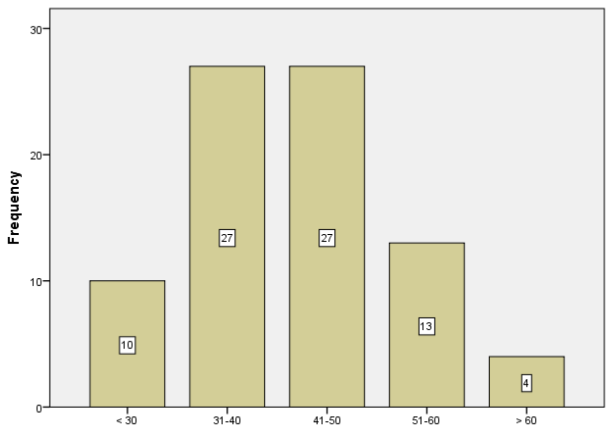


Figure 5.16. Distribution of respondents based on age

5.2.1.2. Gender

Based on field survey, the percentage of male is higher than female. Out of 81 respondents, 60 respondents (74.1%) are male and 21 respondents are female (25.9%). The distribution of respondents' gender can be observed in Figure 5.17.

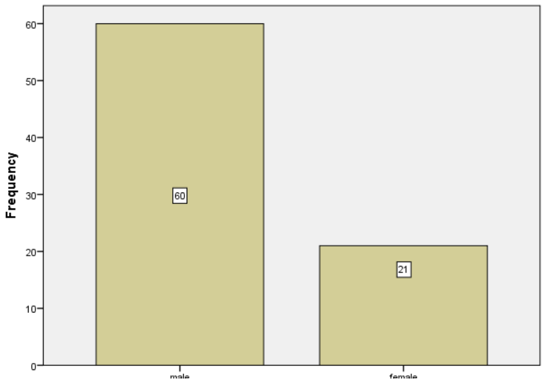


Figure 5.17. Distribution of respondents based on gender

5.2.1.3. Occupation

The bigger portion of respondents are fisherman (28 respondents or 34.6%). Most of the fishermen in sampled villages are chategorized as small fisherman. They ussually leave early in the morning and return home at day or even afternoon. The second largest of respondents' main occupation is saltpan/pond owner. They owner of pond cultivate their pond with rotary system. They cultivate their ponds as saltpan at dry season. While at rainy season, they cultivate milky fish. The other main occupation are laborer (14 respondents), trader (6 respondents), housewife (14 respondents) and farmer (1 respondent). The distribution of respondents' main occupation can be seen in Figure 5.18.

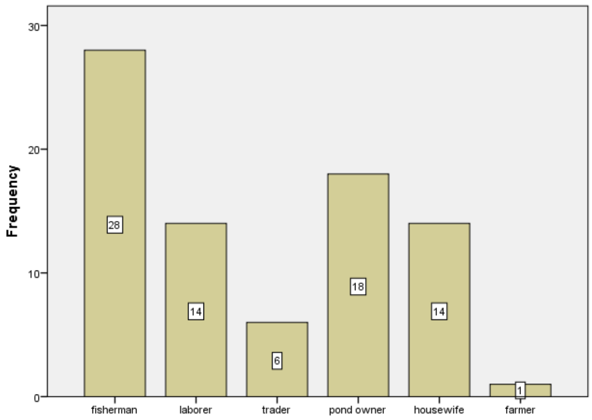


Figure 5.18. Distribution of respondents' main occupation

Some of respondents are not only have one single job. Out of 81 respondents, 59.3% or 48 respondents have side job or other occupation. While the rest do not have side job. Out of 81 respondents, 12 respondents work as collector of oyster, crab and shell. While three respondents work as collector of Avicennia fruits.

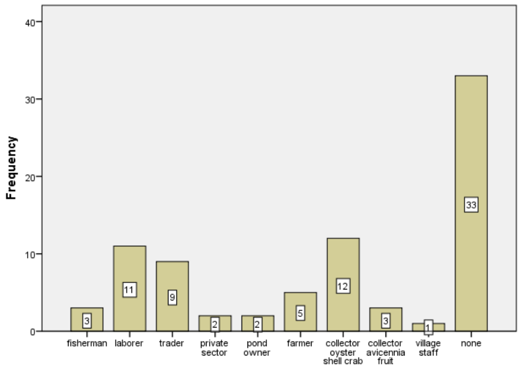


Figure 5.19. Distribution of respondents' side job

5.2.1.4. Income

Based on field survey, 19 respondents (23.5%) have income less than Rp 985,000 which is regional minimum wage (UMR) of Rembang District year 2014. Most of respondents (42 respondents or 51.9%) have monthly income in range of Rp 985,000-Rp 2,000,000. While 14 respondents (17.3%) and 6 respondents (7.4%) have monthly income in range of Rp 2,000,000-Rp 3,000,000 and more than Rp 3,000,000, respectively.

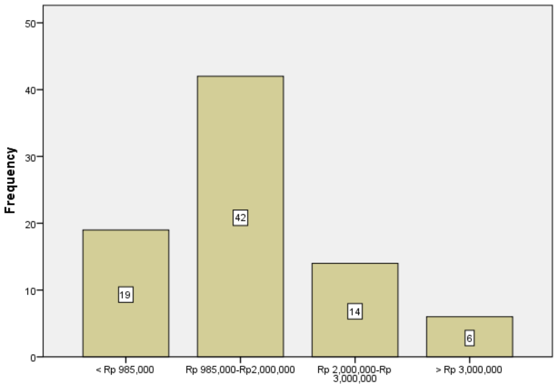


Figure 5.20. Distribution of respondents' monthly income

5.2.1.5. Education level

Education level of respondents is dominated by respondents who graduated from elementary school (32 respondents or 39.5%) and junior high school (28 respondents or 34.6%). There are only 17 respondents (21%) who graduated from senior high school. Meanwhile, only one respondent who graduated from university and three respondents who have never taken formal education.

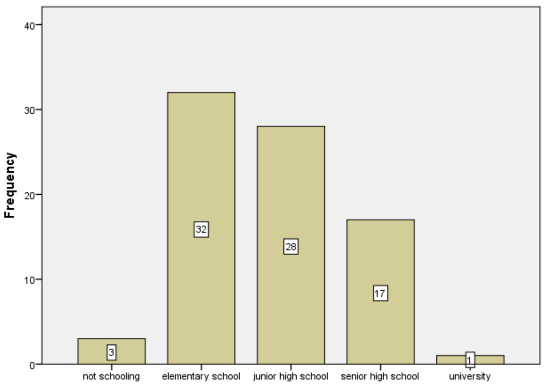


Figure 5.21. Distribution of respondents' education level

5.2.1.6. Length of stay

Most of respondent have been staying in their villages more than 10 years (76 respondents or 93.8%). Meanwhile only five respondents (6.2%) who have been staying in their villages for 5-10 years.

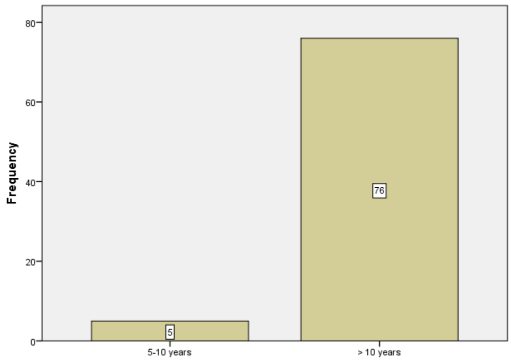


Figure 5.22. Distribution of respondents' length of stay

5.2.1.7. Household size

The household size of the interviewed respondents is dominated by 3-4 members per family (58 respondents or 71.6%). Then followed by family with more than 4 members and family with less than 3 members.

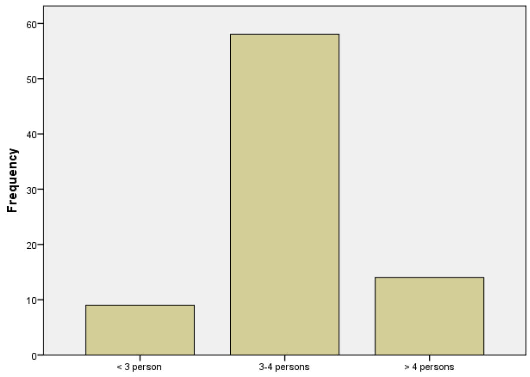


Figure 5.23. Distribution of respondents' household size

5.2.1.8. Number of income source

Most of respondents described that there is only 1-2 members in family who work as family's income source (69 respondents or 85.2%). Meanwhile, only 11 respondents (13.6%) and one respondent (1.2%) who explained that there are 3-4 members and more than 4 members in family who work for earning income.

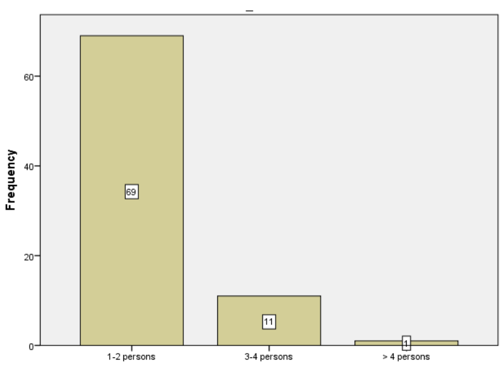


Figure 5.24. Distribution of number of income source per family

5.2.2. Community's Perception Toward Mangrove Forest Changes

In general, all respondents are familiar with the mangrove forest near their villages. All the respondents could indicated the name of mangrove species near their villages when they requested to indicate it. A total of 61 respondents could indicated less than 2 species, while the other 20 respondents could named more than two species.

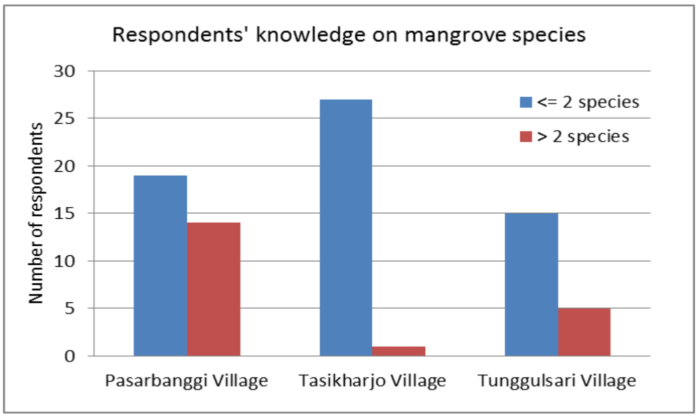


Figure 5.25. Respondents' knowledge on mangrove species in their villages

The most common species recognized by respondents were *brayo* (local name for *Avicennia marina*), *tanjang* (local name for genus *Rhizophora*) and *kedodo* (local name for *Sonneratia alba*). There were some species of mangrove identified during the field survey, such as *Avicennia marina*, *Rhizophora mucronata, R. stylosa, R. apiculata*, and *Sonneratia alba*. Out of these five species, Setyawan *et al*. (2005) also identified some other mangrove species in Rembang, such as *Avicennia alba, A. officinalis, Bruguiera cylindrica, B. gymonorrhiza, Ceriops tagal, Nypa fruticans, and Sonneratia caseolaris.*

In relation to the changes of mangrove forest extent, all respondents indicated that mangrove forest near their villages has increased compare to 10 years ago. Mangrove plantation by local people and government were assummed as a main reason duo to the increases (67 respondents), while some other respondents (14 respondents) argued that mangrove plantation and natural regeneration as the main factor of the increases.

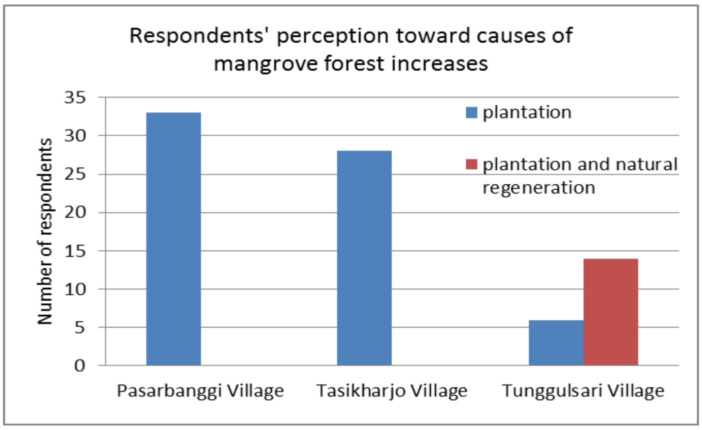


Figure 5.26. Respondents' perception toward causes of mangrove forest increases

In relation to sedimentation, the majority of respondents explained that sedimentation has taken place in their villages for the last 10 years. A number of 14 respondents and 67 respondents described that sedimentation has taken place in their village since 5-10 years and > 10 years ago, respectively. Most of the respondents (71 respondents) argued that sedimentation is not a negative condition. While some other (10 respondents) described that they have negatively affected by coastal erosion. For those whose assummed that sedimentation is not a negative condition, explained that sediments deposition resulted by this procces provide a new land which can be used for some purposes, such as area for mangrove plantation, land extension into sea direction and pond extension.

In contrary, for those who argued that sedimentation is not a good condition explained that sediment materials has hampered the fishermen boat traffic surrounding estuarine area. All of these 10 respondents are fishermen in Tunggulsari Village

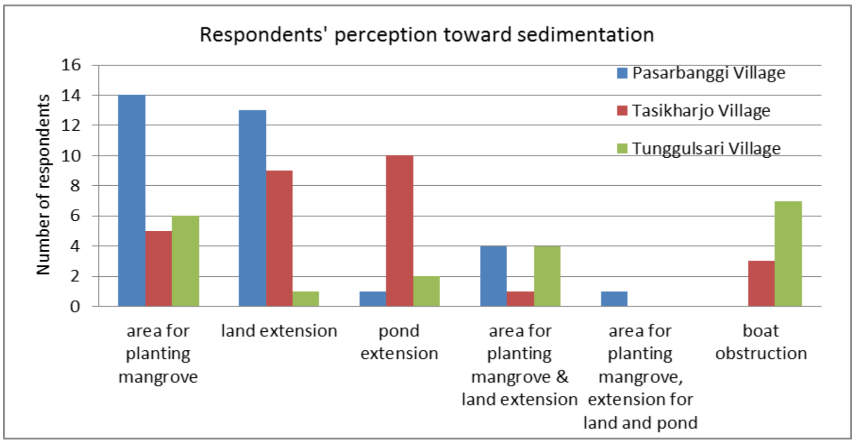


Figure 5.27. Respondents' perception toward sedimentation

Furthermore, there was 7 respondents who indicated that coastal area in their village has been affected by coastal erosion since 5-10 years ago. These 7 respondents argued that strong wave, particularly at peak season of west monsoon (locally known as *musim barat*) that ussually takes place every January-February, as the main factor of this condition. Six respondents described that coastal erosion has negatively affected pond bank and mangroves stand. While only one respondent indicated that coastal erosion has destructed mangroves stand.

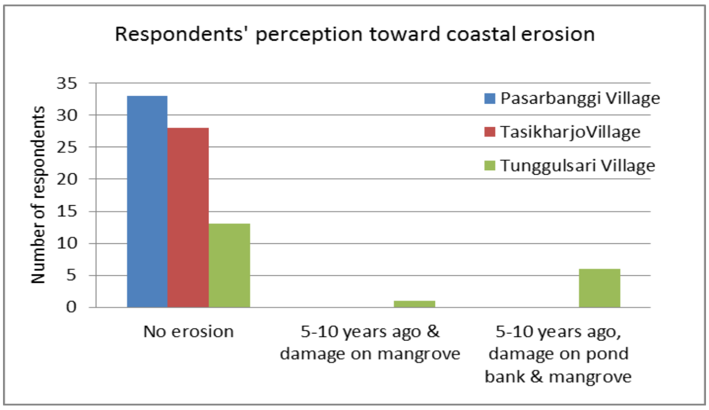


Figure 5.28. Respondents' perception toward coastal erosion

5.2.3. Community's Perception Toward the Influence of Mangrove Forest Changes

In order to observe the influence of mangrove forest changes to daily life, respondents were requested to indicate their perception if the changes could affects their daily life. A number of 34 respondents (42%) indicated their agreement when they requested to indicate their perception wheter the changes of mangrove forest extent can affects their daily life. While 47 respondents (58%) disagree if the changes can affects their daily life.

Out of 33 respondents in Pasarbanggi, 19 respondents explained that the changes of mangrove extent have influenced their daily life. The same impression also showed by 8 respondents in Tasikharjo and 7 respondents in Tunggulsari. Overall, most of the respondents (47 respondents) argued that their daily life has never affected by the changes.

Statistical analysis using chi-square test was applied in order to determine the differences of respondents' perception toward the changes of mangrove forest area in form of benefit obtained between three villages. Data validity test has been applied in order to validate the questionnarie. Based on the result, the correlation coefficient of product moment (0.871) > 0.3 and P-value (0.000) < level of confidence (0.05). Its mean that the question is valid.

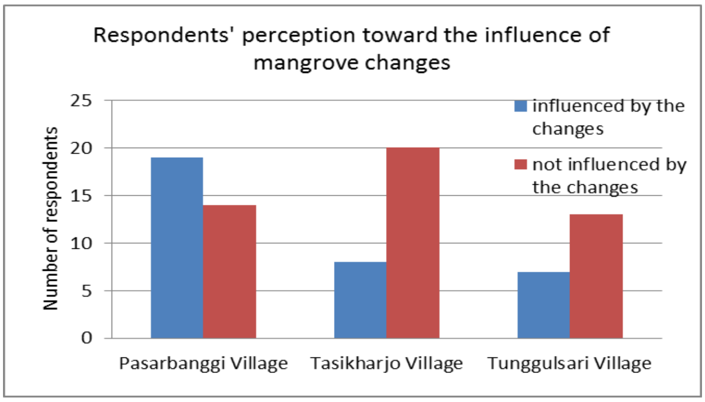


Figure 5.29. Respondents' perception toward the influence of mangrove forest changes

The null hypothesis (H0) of this test stated that respondents' perception toward the influences mangroves forest change is not significantly different between three villages. Hypothesis null will be accepted if significance probability (P-value) > 0.05 (level of confidence), and hypothesis null will be rejected if P-value < 0.05. The chi-square test resulted that P-value (0.056) is higher than 0.05. And then the decision is hypothesis null accepted. Meaning that respondents' perception toward the influences of mangrove forest change is not significantly different between the three villages.

Respondents have shown various responses when they requested to convey their reasons if the changes of mangrove could influence their life. Forty seven respondents who stated that they have never influenced by the changes of mangrove forest extent exclaimed that eventough the area of mangrove forest has increased for the last 10 years, their main occupations have never changed and their amount of income have never significantly increased.

On the other side, various answer also given by respondents who exclaimed that they have been affected by the changes of mangrove forest area. The pond owners found that the mangrove forest can protect their pond from high waves and strong currents. They stated that the maintenance cost of pond is much lower compare to 10 years ago. Some other respondents also indicated that by the changes of mangrove forest area, they found that collecting crabs, oyster, shell and Avicennia fruits are much easier.

Another respond also given by respondents who often participate in mangrove plantation which conducted by government. Some of them stated that selling the mangrove seedlings can generate additional income.

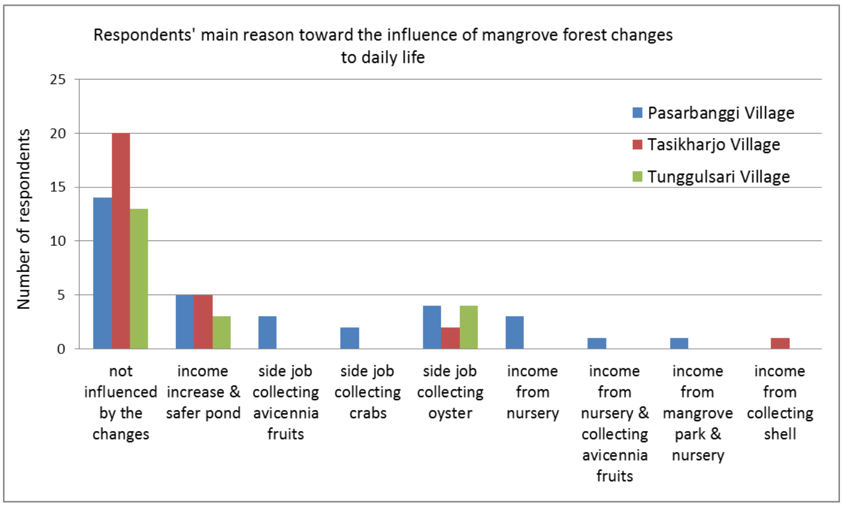


Figure 5.30. Respondents' main reason toward the influence of mangrove forest changes to daily life

Factors influencing respondents' perception toward the influence of mangrove forest changes

Multiple linear regression was applied in order to investigate the factors that might contribute to respondents' perception toward the influence of mangrove forest changes to their life. There are several factors which pre-assumed have correlation with respondents' perception toward the influences of mangrove forest changes to their life. These factors are gender, age, education, income, occupation, length of stay, distance between house-mangrove forest, and involvement in government program.

From the model summary of regression results, the R-value is 0.526 (> 0.5) which mean the correlation between dependent and independent variables is strong. While the value of adjusted R-square is 0.196, which mean 19.6% variation in dependent variable (respondents' perception) can be explained by variation in independent variables.

From the anova table, the significance probability (P-value) is 0.002 < 0.05. Its mean that jointly independent variables could influence the dependent variable (respondents' perception).

While from the coeficient table, the significant value for gender, age, education, income, occupation, length of stay, distance between house-mangrove forest, and involvement in government program as independent variables are 0.090, 0.462, 0.441, 0.059, 0.138, 0.477, 0.083 and 0.001 respectively. The independent variables will have significance influences to dependent variable if its significance value < 0.05. According to these values, only the factor of respondents' involvement or participation in government mangrove program has the significance influence to respondents' perception toward the influences of mangrove forest changes to their life.

5.2.4. Community's Adjusment/Response Toward Mangrove Forest Changes

Respondents proposed various answer when they requested to explain their adjusment in relation to the changes of mangrove forest. Amount of 48 respondents declared that they never made any particular adjusment related to the changes. While 33 respondents exclaimed that they have made adjusment toward the changes of mangrove forest.

Statistical analysis using chi-square test was applied in order to determine the differences of respondents' adjustment/response toward the changes of mangrove forest between three villages. Data validity test has been applied in order to validate the questionnarie. Based on the result, the correlation coefficient of product moment (0.874) > 0.3 and P-value (0.000) < level of confidence (0.05). Its mean that the question is valid.

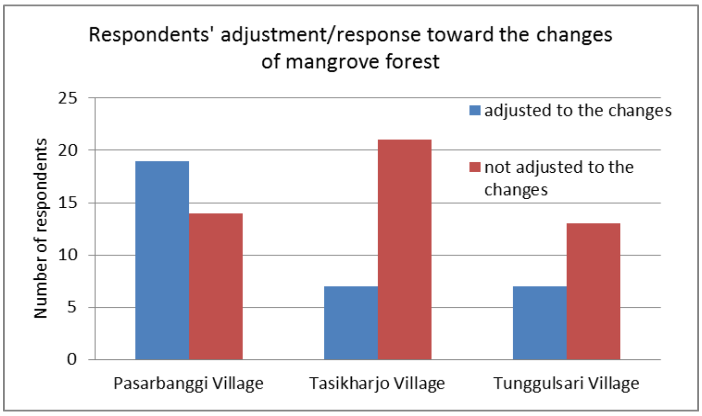


Figure 5.31. Respondents' adjustment/response toward the changes of mangrove forest

The null hypothesis (H0) of this test stated that respondents' adjustment/response toward the changes of mangroves forest change is not significantly different between three villages. Hypothesis null will be accepted if significance probability (P-value) > 0.05 (level of confidence), and hypothesis null will be rejected if P-value < 0.05. The chi-square test resulted that P-value (0.03) is less than 0.05. And then the decision is hypothesis null accepted. Meaning that respondents' adjustment/response toward the changes of mangrove forest is significantly different between the three villages.

There are two type of adjusment which made by respondents, structural and economic. Amongst 33 respondents who made adjusment, 12 of them generated structural adjusment in form of planting mangrove by their own initiative. While 21 respondents generated side job as economic adjustment to the changes of mangrove forest. There are some type of side job which owned by respondents, such as collecting and selling Avicennia fruit; collecting and selling crabs, shell and oyster; establishing own nursery and selling mangrove seedlings; and managing the parking area of mangrove park. In fact, they have never changed their main occupation. These side jobs can generate additional income for them.

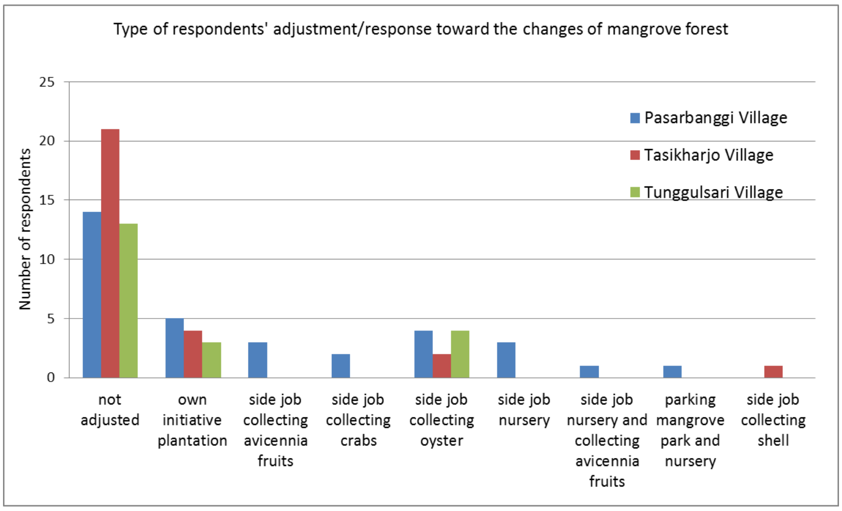


Figure 5.32. Type of respondents' adjustment/response toward the changes of mangrove forest

Factors influencing respondents' adjustment/response toward the changes of mangrove forest

Multiple linear regression was applied in order to investigate the factors that might contribute to respondents' adjustment/response toward mangrove forest changes. There are several factors which pre-assumed have correlation with respondents' response toward the changes. These factors are gender, age, education, income, occupation, length of stay, distance between house-mangrove forest, and involvement in government program.

From the model summary of regression results, the R-value is 0.532 (> 0.5) which mean the correlation between dependent and independent variables is strong. While the value of adjusted R-square is 0.203, which mean 20.3% variation in dependent variable (respondents' adjustment/response) can be explained by variation in independent variables.

From the anova table, the significance probability (P-value) is 0.002 < 0.05. Its mean that jointly independent variables could influence the dependent variable (respondents' adjustment/response).

While from the coeficient table, the significant value for gender, age, education, income, occupation, length of stay, distance between house-mangrove forest, and involvement in government program as independent variables are 0.089, 0.252, 0.298, 0.194, 0.069, 0.400, 0.101 and 0.000, respectively. The independent variables will have significance influences to dependent variable if its significance value < 0.05. According to these values, the factor of respondents' involvement in government mangrove program considered has a significant influence on respondents' adjustment toward the changes of mangrove forest.

5.2.5. Community's Perception Toward Benefit from Mangroves Non-timber Forest Products

The majority of respondents in three villages showed their agreement when they requested to convey if mangrove forest could deliver benefit in form of non-timber forest products. Respondents delivered various answer when they requested to convey the type of benefit that can be obtained from mangroves ntfp. The most familiar mangroves ntfp that recognised by respondents is the fruit of Avicennia. Most of them explained that this fruit can be used for some purposes, such as food, beverage, dyeing materials and seedlings. While only one respondent recognised the use of Sonneratia fruit for food and beverage. Some other also recognised the use of propagules of Rhizopora as seedlings materials.

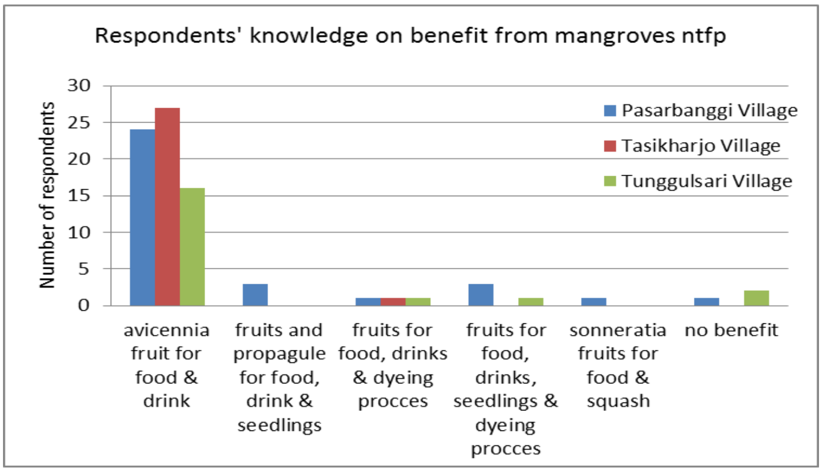


Figure 5.33. Respondents' knowledge on benefit from mangroves ntfp

Meanwhile, only 33 respondents experienced on utilising mangroves ntfp in their daily life. In line with their knowledge on mangroves ntfp, the fruits of Avicennia is the common mangroves ntfp in daily utilisation. They collected the Avicennia fruits for some purposes, such as food (snack), seedlings and side income (selling into market). Some respondents also explained that they accustomed to collect propagules of Rhizopora as materials for seedlings in nursery.

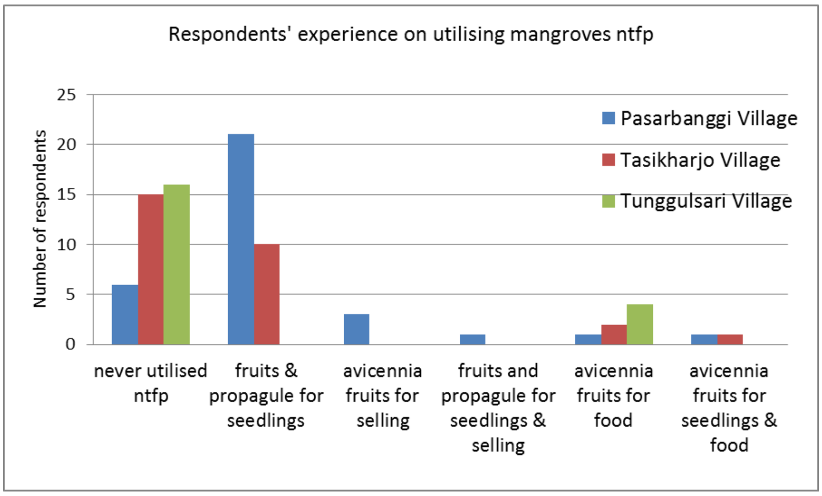


Figure 5.34. Respondents' experience on utilising mangroves ntfp

Statistical analysis using chi-square test was applied in order to determine the differences of respondents' perception toward benefit obtained from mangrove forest in form of ntfp between three villages. Data validity test has been applied in order to validate the questionnarie. Based on the result, the correlation coefficient of product moment (0.362) > 0.3 and P-value (0.001) < level of confidence (0.05). Its mean that the question is valid.

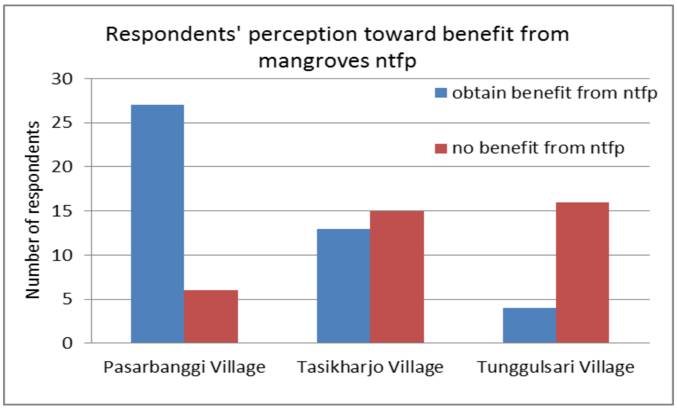


Figure 5.35. Respondents' perception toward benefit from mangroves ntfp

The null hypothesis (H0) of this test stated that respondents' perception toward benefit obtained from mangroves ntfp is not significantly different between three villages. Hypothesis null will be accepted if significance probability (P-value) > 0.05 (level of confidence), and hypothesis null will be rejected if P-value < 0.05. The chi-square test resulted that P-value (0.000) is less than 0.05. And then the decision is hypothesis null rejected. Meaning that respondents' perception toward benefit obtained from mangroves ntfp is significantly different between three villages.

5.2.6. Community's Acceptance on Government Mangroves Program

All the respondents can recognize the typical mangrove program in their villages. They could named the programs when they requested to identify what programs have been conducted in their villages. A number of 27 respondents identify that there are some type of mangrove program in their villages, such as plantation, dissemination information and training/course, and tourism. While 33 respondents named that plantation, and information dissemination and training as the government program which have been carried out in their village. In general, respondents identified that plantation as general type of mangrove program in their villages.

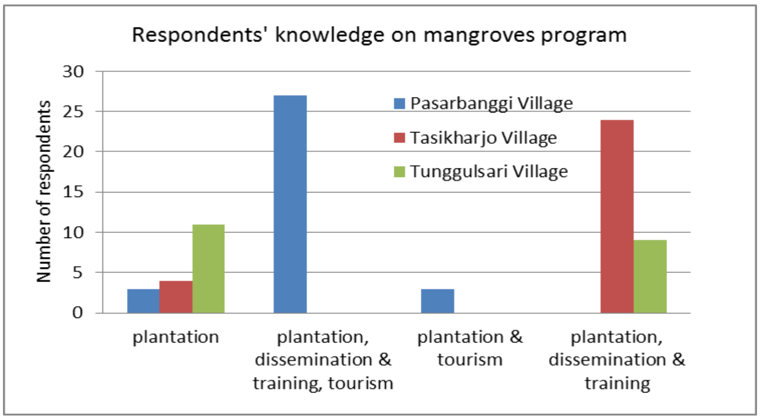


Figure 5.36. Respondents' knowledge on government mangrove program

Respondents also requested to indicate if the mangrove programs could deliver benefit for them. Cross tabulation with chi-square test has been applied to investigate respondents' perception toward benefit obtained from government program in their villages. Data validity test has been applied in order to validate the related question. Based on the result, the correlation coeficient of product moment and P-value for this question were 0.571 (> 0.3) and 0.000 (< 0.05). Its mean that the question is valid.

A number of 42 respondents recognized that mangrove programs can deliver benefit for them. While the other 39 respondents exclaimed that there is no significant advantages they can obtain from mangrove programs. Out of 33 respondents in Pasarbanggi Village, 27 of them expressed that they obtain advantages from mangrove programs. While only 13 respondents in Tasikharjo Village and 2 respondents in Tunggulsari stated the same impression.

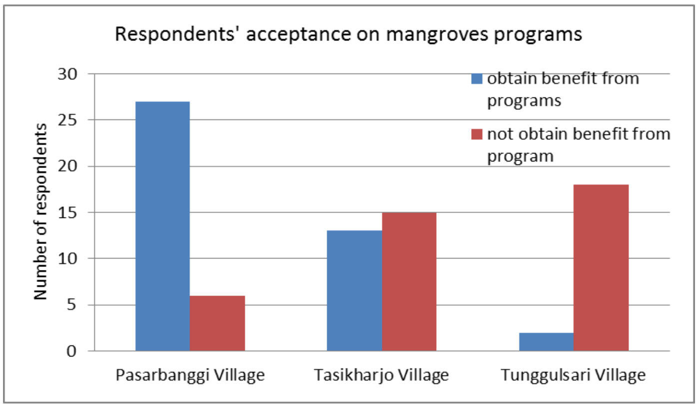


Figure 5.37. Respondents' perception toward benefit obtained from mangrove programs

Hypothesis null (H0) stated that respondents' perception toward benefit from mangrove programs is not significantly different between villages. Hypothesis null will be accepted if significance probability (P-value) > 0.05 (level of confidence), and hypothesis null will be rejected if P-value < 0.05. The chi-square results indicate that P-value (0.000) < 0.05. Meaning that respondents' perception toward advantages from mangrove programs is significantly different between villages (H0 rejected).

Respondents expressed various reasons when they requested to convey the reason if the mangrove programs could deliver advantages for them or not. Respondents who stated that they have never obtained advantages from mangrove programs, also exclaimed that mangrove programs could not deliver additional income for them. In contrary, some repondents revealed that they could obtain some advantages from the programs.

A number of 10 respondents explained that the mangrove program has delivered additional income for them. While the other 16 respondents added that beside the additional income, they assume that sense of belonging to the mangroves forest and additional knowledge as the intangible advantages from the programs.

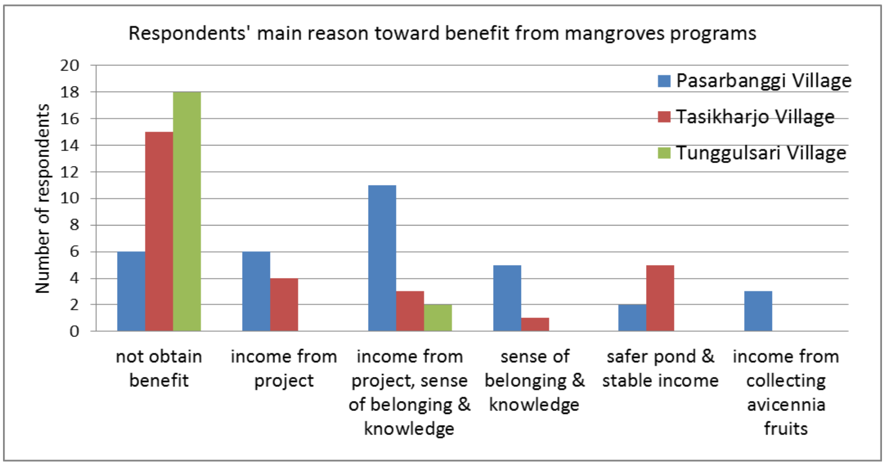


Figure 5.38. Respondents' main reason toward benefit from mangroves programs

Respondents' in the surveyed villages expressed different respons when they requested to convey if the mangroves programs need to be excecuted in their villages. All respondents in Pasarbanggi Villages exclaimed that mangroves program need to be continued in their village. The majority respondents in Tasikharjo Village and Tunggulsari Village described that their villages are still needed mangroves program. While some others exclaimed that mangroves program is not necessary to be conducted in their villages.

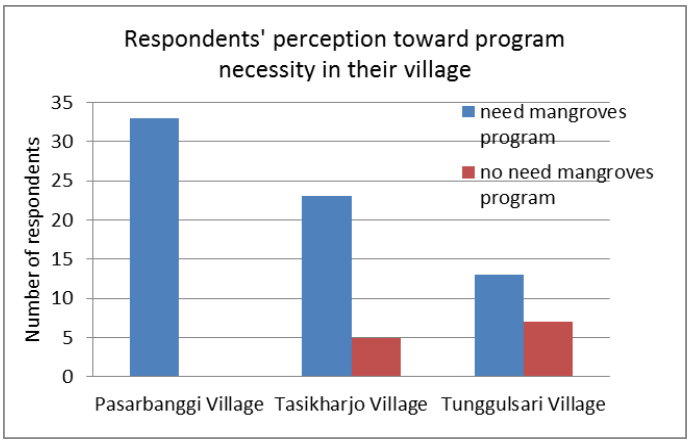


Figure 5.39. Respondents' perception toward necessity of mangroves program

Respondents' conveyed various reasons on the necessity of mangroves program in their villages. The majority respondents in Pasarbanggi Village described that they could obtain additional income from the program. While some others explained that their village could not manage the forest, particularly in mangroves plantation, by their own budget. While respondents in Tasikharjo

Village explained that their village need assistance in form of mangroves program due to lack of initiative in mangroves plantation, additional income from program and protection to pond bank. On the other hand, some respondents in Tasikharjo Village and Tunggulsari Village argued that mangroves program is not necessary to be executed in their villages due to some reasons. They argued that mangroves belt is wide enough to protect pond bank and the local pond farmers can execute mangrove plantation by their own initiative. Furthermore, the majority respondents in Tunggulsari Village emphasized that mangroves program in form of protection and pacification of the existing stand is more important that mangrove plantation.

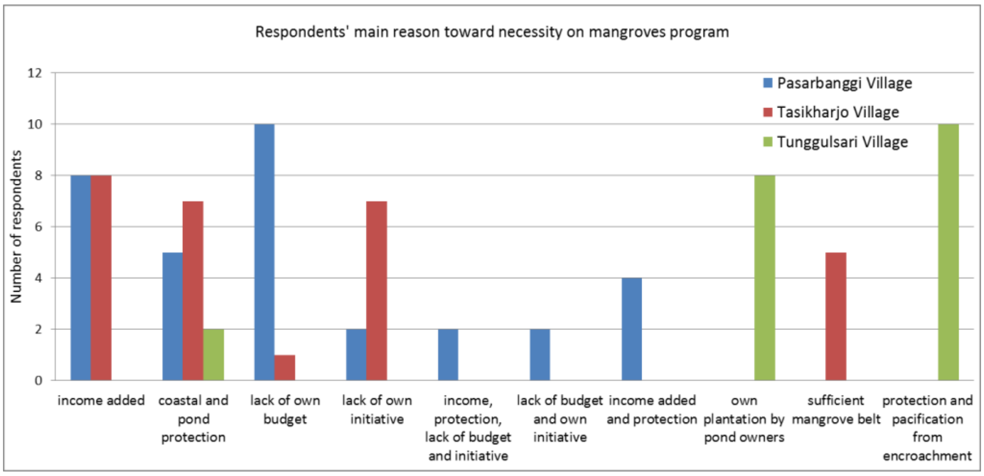


Figure 5.40. Respondents' main reason toward necessity of mangroves program

5.2.7. Correlation Between Community's Perception Toward the Influences of Mangroves Forest Changes, Adjustment/Response Toward Mangrove Forest Changes, Perception Toward Benefit from Mangroves Non-timber Forest Products, and Acceptance on Government Mangroves Program

Correlation analysis is used to determine the correlation between parameters. Contingency coeficient measurement was applied in order to determine the correlation amongs these community's perception.

5.2.7.1. Correlation between community's perception toward the influences of mangrove forest changes and adjustment/response toward mangrove forest changes

Hypothesis null (H0) stated that there is no correlation between community's perception toward the influences of mangrove forest changes and community's adjustment/response toward mangrove forest changes. Hypothesis null will be accepted if P-value > significance level (0.05).

According to the results, the P-value (0.000) < 0.05 and contingency coeficient was 0.698. Its mean that the correlation between community's perception toward the influences of mangrove forest changes and community's adjustment/response toward mangrove forest changes is directly proportional and statistically significant (H0 rejected).

5.2.7.2. Correlation between community's adjustment/response toward mangrove forest changes and perception toward benefit from mangroves non-timber forest products

Hypothesis null (H0) stated that correlation between community's adjustment/response toward mangrove forest changes and community's perception toward benefit from mangroves non-timber forest products is not significant. Hypothesis null will be accepted if P-value > significance level (0.05).

Based on the result, the P-value (0.656) > 0.05 and contingency coeficient was 0.054. Its mean that correlation between community's adjustment/response toward mangrove forest changes and community's perception toward benefit from mangroves non-timber forest products is directly proportional, but not statistically significant (H0 accepted).

5.2.7.3. Correlation between community's adjustment/response toward mangrove forest changes and acceptance on government mangroves program

Hypothesis null (H0) stated that correlation between community's adjustment/response toward mangrove forest changes and community's acceptance on government mangroves program is not significant. Hypothesis null will be accepted if P-value > significance level (0.05).

Based on the result, the P-value (0.041) < 0.05 and contingency coeficient was 0.239. Its mean that correlation between community's adjustment/response toward mangrove forest changes and community's acceptance on government mangroves program is directly proportional and statistically significant (H0 rejected).

5.3. Discussion

According to the results of extraction mangroves forest and coastline using three different dataset, in general it can be observed that sedimentation was the dominant phenomenon along the study area, in line with the increases of mangroves extent. The utilisation of historical topography map year 1881 and 1943, tough could not present the area of mangroves forest, at least the coastline extracted could show the situation of coastal area in the past, particularly to detect the phenomenon of sedimentation and coastal erosion. The utilisation of these topomaps is usefull due to the lack of homogenous data, as proposed by Marfai *et al*. (2008). During period 1881-1943, sedimentation was the dominant process in Profile 1 and Profile 2, and the western part of Profile 1. Small amount of sedimentation in western part of Profile 3 might correlated with the expansion of saltpan/fishpond into seaward direction. While the larger part of Profile 3 was affected by coastal erosion during this period.

The utilisation of multi-temporal images of Landsat data also indicated that sedimentation was the dominant process in all profiles. There was just small portion of coastal erosion in eastern part of Profile 1, adjacent with Profile 2, and in eastern part of Profile 2. This condition strengthened by the results from the utilisation of Google Earth images. The utilisation of two sets Google Earth images year 2009 and 2014 also showed that sedimentation followed by the increases of mangroves area was the dominant process in all profiles. In line with this condition, Sunarto (1999) explained that parts of study area was influenced by sedimentation process. A study by Setiady & Usman (2008) also argued that sedimentation is the dominant phenomenon along the coastal area of Kaliori Sub-District and Rembang Sub-District.

The shiftness of coastline into seaward direction in Profile 1 highly corresponds to the deposition of sediment materials from Randugunting Rivers in western part of area, which adjacent with Pati Sub-District. The accumulated sediments in estuarine, possibly eroded by the wave into east direction and deposited in the middle part of Profile 1. The high velocity of wind which blow from northwest to southeast during the peak season of west monsoon might correspond with the deposition of sediment materials. The wave that generated by this wind, will move from northwest to southeast direction, bring the sediments materials and deposit the materials in the middle of Profile 1. Due to the curve shape of beach, the deposited sediments could not reach the eastern part of area. The wave during the peak season of west monsoon seem also correspond to the eroded a small part of coastal area in eastern part of Profile 1, adjacent with Profile 2. The extracted coastline from Landsat data and Google Earth images consistently showed that this small part of area is affected by coastal erosion during 1994-2014.

While in Profile 2, the shiftness of coastline into seaward direction highly posible correlates with the deposition of sedimentation materials from Tasikharjo River. Similar with sediments movement in Profile 1, the wave during the peak season of west monsoon which blow from northwest to southeast direction, will move the materials into east direction and deposit the materials in Profile 1. The deposition of the materials could not reach the eastern part of Profile 2 due to the curve shape of beach, which consistently affected by coastal erosion during period 1994-2014.

On the other hand, a different condition might occurs in Profile 3. The coastline was not much change between period. The wave during the peak season of east monsoon which move from east to west, apparent dominantly regulate the movement of sediments in the area. The waves bring the sediments from east to west and deposit the materials in form of sandspit in some parts in front of mangroves forest. These loose sediments flow from the eroded area on the eastern part of Rembang Sub-District, mainly from Lasem Sub-District which classified as susceptible to coastal erosion (Sunarto, 1999; Setiady & Usman, 2008). The formation of this sandspit could not observed using the images used in this study (perhaps due to innundation of tidal water), but clearly observed during the field observation.

In general, the shiftness of coastline into seaward direction is positively correlate with the increases of mangroves area. It was exception in Profile 1 during 1994-2002, when the shiftness of coastline into seaward was followed by the reduction of mangroves area. The progression of mangroves area in all profiles is possibly correspond to the deposition of sedimentation materials and the customary of saltpan/fishpond owners. As explainned by Furukawa & Wolanski (1996), mangroves forest are not only passively colonize the sedimentation materials but also actively catch the materials. Furukawa & Wolanski (1996) described that mangroves forest root system maintenance the turbulence of sea water which enter the forest and promote the deposition of sedimentation materials on forest floor. In line with this statement, Kathiresan (2003) also emphasize the importance of mangrove forest to trap sediment. Mangrove forest could reduce the velocity of tidal flows and stimulate the deposition of soil particles during the low tide. Ramasubramanian *et al*. (2006) and Azlan & Othman (2009) also argued that accretion is the main factor of the increases of mangroves area.

Despite sedimentation was the dominant process in mangroves area, small scale of coastal erosion also can be identified during the field survey. The roots of mangrove vegetation which located facing to the open sea, were exposed to the air due to the erosion. The main cause of this condition might be vegetation exposure to the waves during the monsoon season.

Figure 5.41. Up rooted of mangroves vegetation due to coastal erosion (left: in Pasarbanggi Village; right: in Tunggulsari Village)

Beside the nature of mangrove forest that can promote sedimentation, the antrophogenic factor might contributes a significant role in relation to progression or decreases of mangroves area, as well as the shiftness of coastline. Mangrove plantation by local people with their own initiative and government's intervention through various programs are considered as the main contributor of the dynamic of mangroves area. Mangrove plantation is the main typical program which conducted by the government in the study area, combined with the other type of program. However, the distribution of program in the surveyed villages is rather unequal which may affects the difference on the dynamic of the forest itself and its influence to community.

Local people in Pasarbanggi Village have started to establish mangrove plantation by their own efforts around 1970s. The results of plantation then recognised as one of the good mangrove stands in regional level. The government then started to assist local people to expand the forest through plantation program. In another words it can be said that the existing stand in this village is a results of locally initiated and government-supported mangrove plantation. The Ministry of Forestry started to assist the plantation through the program of *Gerakan Nasional Rehabilitasi Hutan dan Lahan/*GNRHL (national movement on forest and land rehabilitation) in 2004. In the last five years, this ministry also has conducted two type of programs called *kebun bibit rakyat*/KBR (nursery for people) and *bantuan bibit untuk penghijauan lingkungan* (seedlings for environment greening) in this village. The plantation program also conducted by local institutions in district level which own the main responsibility to execute mangroves program. These institutions are Agriculture and Forestry Office (Distanhut), Environment Office (BLH) and Marine and Fishery Office (DKP). The Ministry of Environment also has started to run a program called *Rehabilitasi Pantai Entaskan Masyarakat Setempat*/*Rantai Emas* (coastal rehabilitation to elevate local people). This program has established at Pasarbanggi Village and colaborated with female group of Kartini I and Kartini II. The pioneering stage of tourism activity also has been started in Pasarbanggi Village by BLH Rembang District which called *rintisan taman mangrove* (pioneering program on mangrove park). This institution has started to build mangrove wooden bridge as a trigger for developing tourism activity. There is a plan to hand over the bridge to village government soon after the construction finished. At the moment when the field survey conducted, the majority of respondents explained that they could not benefited yet by the program. Visitors have started to come to the mangroves area of Pasarbanggi Village for free. There was no retribution for visitors. However, there was indirect benefit resulted by the program. The members of farmer group of Sidodadi Maju have managed the parking area. The cash obtained from this activity then considered as shared benefit for the members who in charge of duty and village office.

The succesfull of local people on establishing mangrove forest in Pasarbanggi Village apparently has attracted various parties to conduct mangroves program in this village. Mangrove plantation recently has not only conducted by the government, but also various parties such as non-governmental organisation (NGOs), students and private sectors/companies. Mangrove forest in this village then has received big portion of attention from various parties along with the incoming programs. As the direct results, protection of the existing forest is getting better. There has been an increases of forest extent between periods without significant human disturbances inform of mangrove felling. There was no much changes in coastline inner-edge of mangrove during period 2009-2014. Pasarbanggi Village is the only coastal village which already establishing formal regulation about environmental preservation through Pasarbanggi Village Regulation (*peraturan desa*) Number 03 Year 2014. This regulation consists of mangrove preservation and protection to the existing forest.

Meanwhile, government-supported mangrove plantation program is the main contributor at the initial stage of mangrove forest establishment in Tasikharjo Village. The initial stage of mangrove plantation started around year 2004 with the plantation by Ministry of Forestry through the program of GNRHL. Mangrove plantation is the main typical of government mangrove program in this village. The most responsible institutions in district level, those are Distanhut, BLH and DKP, have carried out mangrove plantation in this village. Another parties have also conducted plantation which involving local people, such as BLH of Central Java Province, DKP of Central Java Province, army, NGOs and students.

However, the intervention of local people on newly planted areas of mangroves has played an important role in mangroves dynamic in Tasikharjo Village. During 2009-2014, the newly planted areas of mangroves which resulted by government-supported program from previous period, was cleared by local people to be converted into ponds. The lack on law enforcement is considered as one contributing factors of this condition. The prohibition on mangrove felling without government approval is clearly stated in Regulation of Rembang District (*peraturan daerah*) Number 8 Year 2007 about management of coastal area, sea and small islands in Rembang District. However, local people which is represented by respondents, has showed their commitment to preserve the remaining forest. They argued that the existence of the remaining forest is important to protect their ponds. They exclaimed that the establishment of Kelompok Pelestari Mangrove (farmer group) is a prominent evidence to show their commitment to protect the forest. The village government which also supported by this group, has issued informal prohibition on mangrove disruption, includes collecting of Avicennia fruits. The village government and this group have installed announcement boards in some points related to this matter.

A different condition might occurs in Tunggulsari Village. Locally initiated of mangrove plantation by local people was the main factor of mangroves establishment in Tunggulsari Village. The pond farmers in Tunggulsari Village and surrounding area are accustomed to planting the wild seedlings of *Avicennia marina* and *Rhizophora mucronata* along the pond dyke at seaward margin to protect the earthen dykes and along the new water channel which built accross the coastline (locally known as *sungutan* or insect antenna due to its shape) to trap the sediments. They recognise that there will be a lot of sediments which come along with the waves particulary during the peak season of west monsoon (ussually hapens around December-January). Unfortunately, the establishment of new mangroves area at seaward margin often followed by mangrove felling at landward margin to be converted into new pond. Mangrove plantation program as government intervention has introduced in Tunggulsari Village and its surrounding area. The Ministry of Forestry with its KBR program, and local institutions such as Distanhut, DKP and BLH have initiated mangrove plantation program in this village.

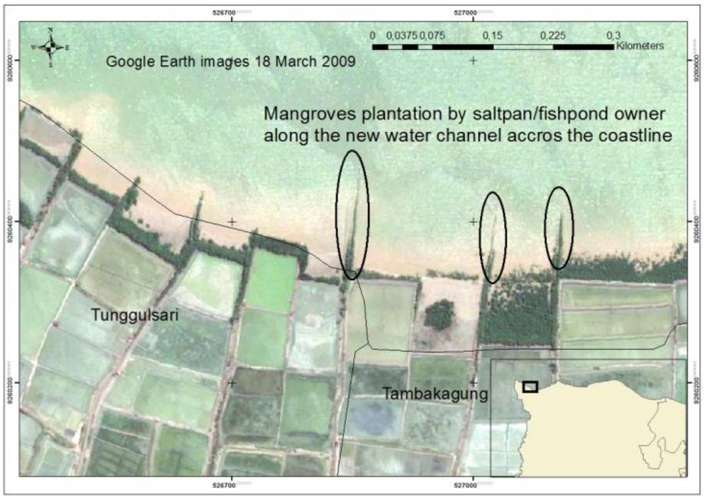
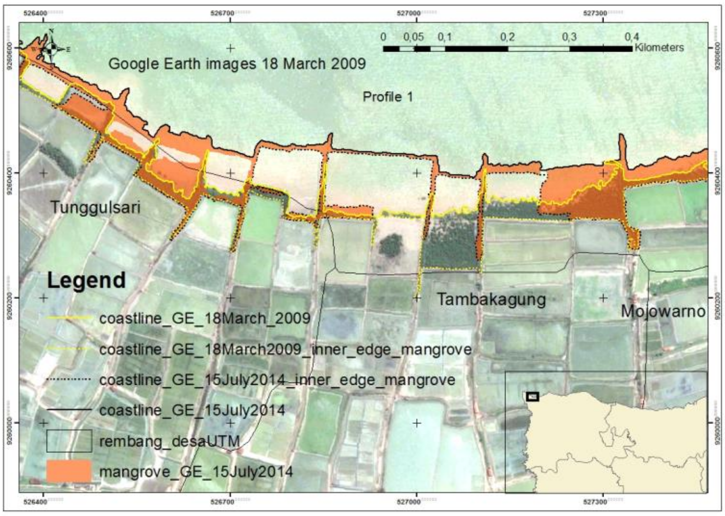


Figure 5.42. Mangroves plantation by pond farmer accross the coastline to trap sediments (Profile 1 Kaliori Sub-District)

Mangroves forest dynamic in Tunggulsari Village and its surrounding area was higher compare to another villages in the study area until period 2014 which can be observed by the fluctuation of mangroves extent and the shiftness of coastline inner-edge mangrove into seaward direction. The intervention of pond owners inform of mangroves plantation and mangrove clearing has a bigger portion in mangrove dynamic comparing to government intervention. However, the need of pond expansion is apparently more important than preserving the mangrove forest. In this context, the lack of law enforcement due to Regulation of Rembang District Number 8 Year 2007 is clearly visible. The active participation from village office is required in order to assist the government to preserve the existing forest.

The development of pond is one of the main factors which contributes to the changes of mangroves area in the study area. In Kaliori Sub-District and Rembang Sub-District, the anthropogenic factor in form of the construction of pond together with natural condition in form of deposition of sedimentation materials are the main factor which contribute to the changes of mangroves area, as well as coastline changes. Ramasubramanian *et al*. (2006), Thampanya *et al*. (2006), Nguyen *et al.* (2013), and Muryani (2010) also argued that the increases of aquaculture farm is correspond to the changes of mangrove forest extent.



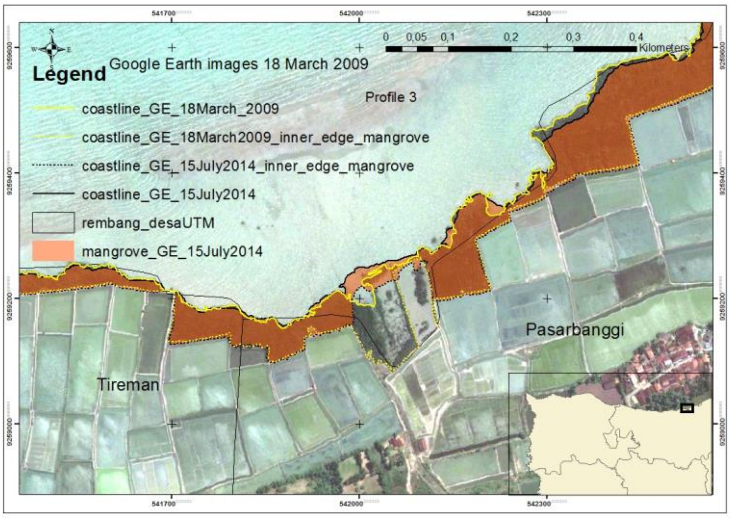


Figure 5.43. The changes of coastline followed by the changes of mangroves area period 2009-2014 using Google Earth images(upper: Profile 1 Kaliori Sub-District; bottom: Profile 3 Rembang Sub-District)

The majority of respondents in Pasarbanggi Village exclaimed that they have been affected by the increases of mangrove forest. In contrary, the majority respondents in Tasikharjo Village and Tunggulsari Village argued that the increases of mangrove forest does not influence their daily life. For those who have have never affected by the changes described that they never change their main job and never obtained direct benefit in form of cash from the mangrove forest. While for those who have been affected by the changes of mangrove forest explained that they have obtained some advantages from the forest. The advantages obtained by respondents are classified into two type: (1) Regulated function and related ecosystem services. The respondents argued that mangroves belt provide physical protection to their pond toward sea wave (2) Production function and related ecosystem goods and services. Some respondents explained that the increases of mangrove forest contribute to sided-income generation through collecting and selling goods from the forest, such as the fruits of Avicennia, propagules of Rhizophora, and fauna (crabs, oysters, shells).

Furthermore, respondents perception toward the influence of mangrove forest changes is highly correspond to their adjustment toward the changes of mangrove forest. Respondents who explained that they have been affected by the changes of mangrove forest, also explained that they have made certain adjustments to the changes of the forest. In line with the previous statement, the majority respondents in Pasarbanggi Village explained that they have created certain adjustments toward the changes of mangrove forest. On the other hand, the majority respondents in Tasikharjo Village and Tunggulsari Village explained that generating adjustment is not necessary to respon with mangrove forest changes. Respondents' adjustment can be grouped into two type. First, structural adjustment in form of own initiative mangrove plantation. This response mainly executed by the pond farmer to strengthen the pond dyke. Second, economic adjustment in form of sided-income generation. Collecting and selling goods from mangrove forest such as the fuits of Avicennia, crabs and oyster is often conducted by fisherman, laborer and housewive in their unoccupied time. Gamayanti (2013) explained that local people have developed some adjustment toward post activity of mangrove rehabilitation. According to the author, the adjustment encompassed some type, such as (1) economic, for instance by changing the main occupation (2) fishpond management (3) participation in mangrove rehabilitation, (4) mangrove forest protection, and (5) collective adaptation.

Meanwhile, respondents' adjustment toward the changes of mangrove forest corresponds to their participation or involvement in government mangroves program. The adjustment their made is highly corresponds to their perception toward the benefit obtained form mangrove government program, but on the other side less correlate with their perception toward benefit from mangroves ntfp. Their participation in mangrove government program in form of affiliation in farmer group of mangrove is considered could provide certain advantages for them.

Respondents from the three villages conveyed different reason if the government mangrove program could deliver benefit for them. Respondents from Pasarbanggi Village explained that they could obtain direct benefit in form of cash from the mangrove plantation program conducted by government and other parties. While some other explained that newly planted mangrove provide a better protection for their pond. In contrary, majority respondents in Tasikharjo Village and Tunggulsari Village assumed that direct benefit in form of cash from the program is not essential for them as sided-income generation.

The respondents from the surveyed villages also conveyed different reason if their villages require government program. In fact, the majority of respondents argued that government mangroves program is still need to be conducted in their villages. The majority respondents of Pasarbanggi Village who have received various programs explained that additional income from program, lack of own budget and environment protection are the main reasons due to this situation. On the other hand, respondents in Tunggulsari Village exclaimed that mangrove plantation is no need to be conducted in their village because the local people can do the plantation by their own iniative. They emphasized that protection and preservation the existing forest is more important.

As a counter measure toward government mangrove plantation, the members of farmer group in Pasarbanggi Village have initiated to conduct own initiative plantation by group. They ussually conduct direct planting using propagules of Rhizophora twice a year. The farmer group in Pasarbanggi Village also often sell the seedlings of mangrove to the other parties which intended to planting mangroves. The cash obtained from this selling then distributed to all member as collective benefit. The involvement the farmer group in mangrove plantation is not only when the program occurs, but they also do plantation by their own initiative. This situation could not be founded in Tasikharjo Village and Tunggulsasri Village. The member of farmer group just only work when the government or other parties which intended to do mangrove plantation appoint them as a partner to conduct the program. Amri (2005) described that on this situation, local people join and support the program due to subsidies from the program owner, and they get income in form of wages.

During the field survey, some respondents argued that there are two type of benefit due to the changes of mangrove forest. First, physical protection of fishpond/saltpan toward sea wave. Second, sided-income generation through collecting and selling goods such as oyster, crab and Avicennia fruits. In general, respondents explained that mangrove forest in their area could not provide direct benefit for them. Amongs the three villages, direct utilisation of mangroves ntfp only founded in Pasarbanggi Village in form of collecting Avicennia fruits and propagules of Rhizophora. In Tasikharjo Village, there is a prohibition of collecting Avicennia fruits which issued by village office. This is the reason why local people never utilised the fruits in daily life. While in Tunggulsari Village, some respondents argued that due to the distance from their house to mangrove area, they feel reluctant to obtain the fruits of Avicennia. The majority of respondents in three villages also described that they feel reluctant to enter the mangrove habitat due to the muddy substrate and the dense aerial root system of vegetation. They argued that it had better to seek another job for earning cash, such as work as laborer at saltpan and agriculture land, than entering the forest to collect goods.

The existence of government intervention and local community's participation in establishing mangrove forest has showed different effects on the dynamic of the forest itself, as well as their influence to community. Various programs in Pasarbanggi Village and active participation of local people in mangrove plantation have delivered the stable increases of mangrove forest and benefit from the forest for local people. This condition might has not been observed in Tasikharjo Village and Tunggulsari Village.

Government-supported mangrove program which combining with active participation of local people are required in order to manage the mangrove forest in sustainable manner. Allowing local people to participate in mangrove forest management, as well as sharing responsibilities and obtaining benefit, will promote ecological and economical sustainaibility (Takama & Iftekhar, 2008).

Local people participation in managing mangrove forest is one of the most efective ways to preserve and conserve the forest itself (Nguyen *et al*., 2013).

Meanwhile, program diversification is also required to assist local people in managing the forest. Government-supported mangrove program is still needed due to the lack of budget of village office and local people. Establishing of demonstration area in mangrove management with active participation of local people is one option that can be considered by government. Initial stage of tourism activity in Pasarbanggi Village is a good model that can be implemented in another areas. The development of tourism activity might promote livelihood diversification in one side, also preserve the forest on the another side (Nfotabong-atheull *et al.*, 2011). Combining between aquaculture and mangrove vegetation is another effort that can be introduced to meet the need of preserving the forest and generating additional income for local people. Generation of short-term and long-term benefit are should be taken into account on formulating mangroves program (Amri, 2005). Mangrove plantation program might creates job opportunity for local people right after the program established. However, the plantation program should also deliver sustainable benefit for local people after certain years of establishment. For instance, the plantation can use certain species which can deliver ntfp, such as *Avicennia spp, Bruguiera gymnorrhyza* and *Sonneratia caseolaris.*

The government should also consider the need of local people before formulating the mangroves program. For instance, some respondents in Tunggulsari Village described that the pond owners could establish mangrove plantation by their own budget and initiative without government assistance. They recognise that preserving and protecting the remaining forest is more important than planting mangrove for avoiding the forest from conversion activity. In this case, there is a need to determine the clear border between the pond farmers' land and the forest. The law enforcement to protect the forest from conversion activity which combining with income added generation for local people are need to be considered for future management options (Traynor & Hill, 2008; Nfotabong-atheull *et al*., 2011). However, government assistance in mangrove establishment is still required in the study area. The majority of respondents in the surveyed villages recognised that conducting mangrove plantation requires certain amount of budget. They also argued that government program is still needed as trigger factor for local people to do their own plantation. Some respondents admited that there is still lack of own initiative to conduct mangove plantation.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

8.1. Conclusion

The present study has utilised different datasets to investigate the dynamic of mangrove forest due to coastline changes. The findings have provided usefull information on the dynamic of mangroves extent between periods and its influencing factors. Though historical topography maps could not show the existence of mangroves area, at least the result can be used to explain the past condition in study area. The utilisation of Landsat images to map mangroves area which grow in very narrow strip along the dike or with the width area far below the pixel size, then leave a limitation for the present research. There was also a limitation on determining the exact boundary between land and water to map the coastline. Errors may occurs due to mixed information in one single pixel and researcher subjectivity. The utilisation of free downloaded images of Google Earth year 2009-2014 is considered provide a good visualization of mangroves area and coastline. But still errors may occur when executing visual interpreation and delineation on mangroves and coastline due some factors, such as the different level of water and water innundation on young mangroves vegetation.

In general, the dynamic of mangroves area is influenced by both natural and antrophogenic factors. Profile 1 and Profile 2 in Kaliori Sub-District have faced sedimentation between periods due to wave action which caused sediment displacement and deposited along the coastline during the peak season of west monsoon. The deposited materials keep remain in the area due to the curve shape of coastline and provide new environment for establishing mangroves. Human intervention through constructing new pond dyke and new water channel accross the coastline at seaward margin reduces the exposure of waves action. Combining with tending activity on newly planted mangrove seedlings, the intervention supports the planted mangroves to keep settle along seaward margin. Unfortunately, the establishment of mangroves at seaward margin often followed by the removal of mangrove vegetation at landward margin to be converted into fishpond/saltpan.

While the dynamic of mangroves and coastline in Profile 3 at Rembang Sub-District was not so high compared to the dynamic of mangroves and coastline in Profile 1 and Profile 2. The deposited materials due to waves action which bring the loose sediments from eastern part of Rembang Sub-District during the peak season of east monsoon have provided new land to planting mangroves, mainly in the eastern part of area. The continuous mangrove planting and tending activity on newly planted mangrove seedlings have also contributed to the increases of mangroves extent between periods. In addition, there is minimal disturbances on mangroves due to conversion to fishpond/saltpan compared to the disruption on mangroves in Kaliori Sub-District.

The dynamic of mangrove forest also highly corresponds to the government intervention through mangroves programs and local community's participation in establishing mangrove forest. Pasarbanggi Village which received various program, both from government and other parties, combined with active participation of local people in planting mangrove, has a stable increases of mangroves area between periods without significant disruption in form of mangroves felling compared to the dynamic of mangroves area in Tasikharjo Village and Tunggulsari Village. On the other hand, government intervention through mangrove plantation is apparently not sufficient to meet with local people needs in Tunggulsari Village and Tasikharjo Village which can be observed through the fluctuation of mangroves area between periods due to conversion to fishpond/saltpan.

In line with this situation, respondents have shown different responses due to the dynamic of mangrove forest in their area. Their response toward the changes of mangrove forest is mainly corresponds to their participation in government mangroves program. Respondents in Pasarbanggi Village are apparently more benefited by the changes of mangroves forest including direct and indirect benefit from the forest, as well as from mangroves program, compared to another respondents in Tasikharjo Village and Tunggulsari Village. Respondents adjustment can be grouped into two category. First, structural adjustment in form of mangrove plantation, and second, economic adjustment in form of sided-income generation. Collecting and selling goods from forest such as oyster, crab and Avicennia's fruits, obtaining additional income from mangrove plantation program, and selling mangrove seedlings are considered as the main advantages for respondents.

8.2. Recommendation

According to the results of the present study, the following are recommended:

1. The further study about sediment transport is need to be carried out. Some aspects need to be addressed such as sedimentation rate during rainy and dry season, and sediment transport during peak season of west monsoon and east monsoon as well as during the interchange season
2. The utilisation of various data set is advisable to investigate the history of mangrove forest changes and coastline changes, such as high resolution imageries and aerial photographs
3. The ownership of mangrove forest and pond farmers' land is need to be clarified in order to preserve the protection function of the forest and to eliminate the disturbance by humans
4. Mangroves plantation activity through the government program is still need to be continued along with own initiative plantation by local people
5. Program diversification is required to meet the needs the local people and preservation option, and reduce disturbances on the existing forest. Various activities that can be conducted such as establishing of demonstration site on integrated management of aquaculture and mangrove forest, facilitating on utilisation of ntfp and its marketing, protecting and preserving the existing forest with local people as the main stakeholder along with law enforcement, and educating local people to increase their awareness through continuous dissemination of information.

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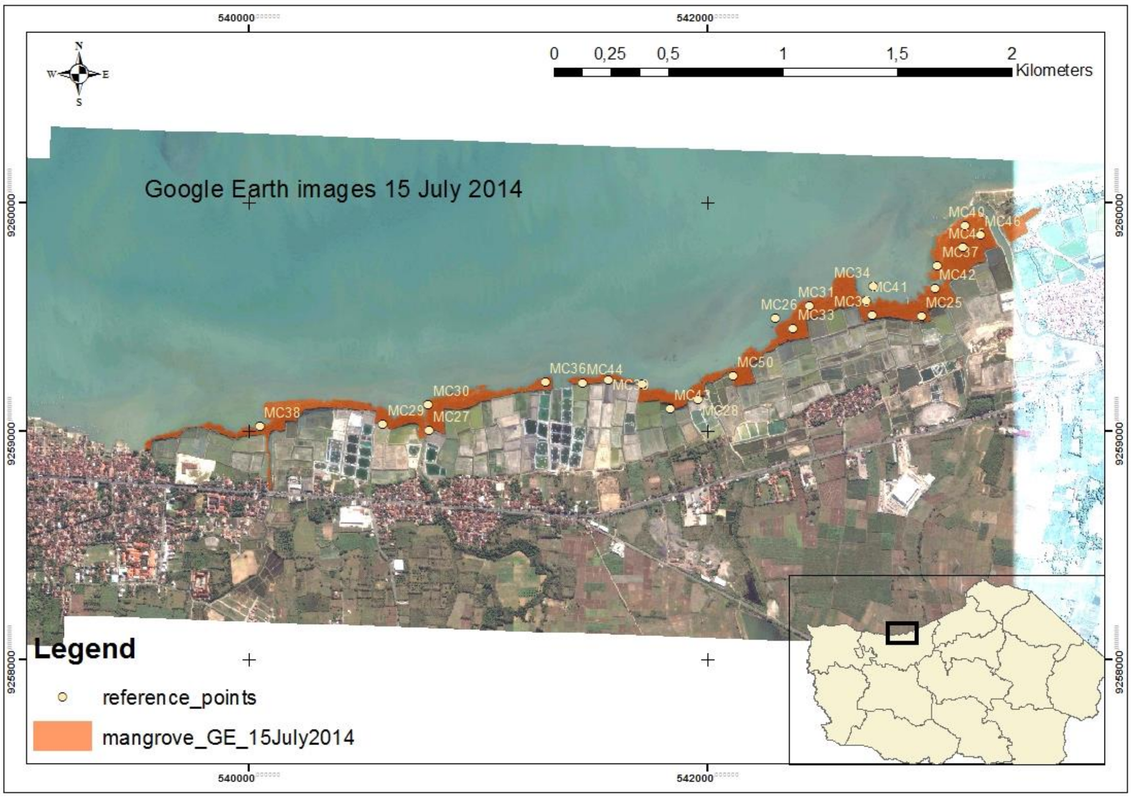
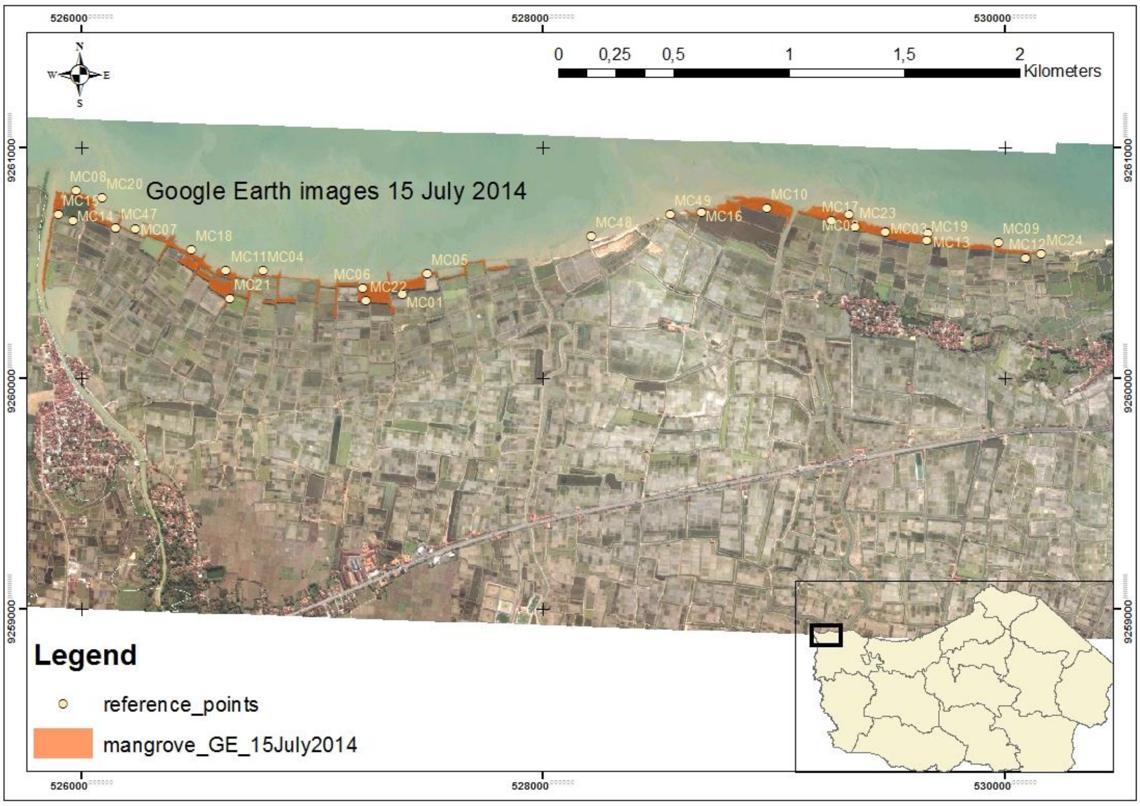
Appendix 1. Distribution of ground reference points





Appendix 2. Visual observation on ground reference points

Points	Coordinat		Actual condition
	X	Y	
MC01	527392	9260366	Non-mangrove (saltpan/pond)
MC02	529326	9260713	Mangroves (A. marina; h: 1-2 m; ṝ : 1 m x 0.5 m)
MC03	529486	9260633	Mangroves (A. marina; h: 1-2 m; ṝ : 1 m x 0.5 m)
MC04	526788	9260468	Non-mangroves (mudflat/water/sea)
MC05	527498	9260456	Mangroves (A. marina; h: 1-2 m; ṝ : 0.5 m x 0.5 m); along pond dyke
MC06	527222	9260391	Mangroves (A. marina; h: 1-2 m; ṝ : 0.5 m x 0.5 m)
MC07	526236	9260649	Non-mangrove (saltpan/pond)
MC08	525978	9260815	Non-mangroves (mudflat/water/sea)
MC09	529973	9260591	Non-mangroves (mudflat/water/sea)
MC10	5 8969	9260740	Mangroves (A. marina; h: 2-3 m; ṝ : 1 m x 0.5 m)
MC11	526626	9260466	Mangroves (A. marina mixed R. stylosa; h: 2-3 m; not dense)
MC12	530092	9260524	Non-mangrove (saltpan/pond)
MC13	529671	9260631	Non-mangroves (mudflat/water/sea)
MC14	525963	9260683	Non-mangrove (saltpan/pond)
MC15	525901	9260712	Mangroves (A. marina mixed R. stylosa; h: 6-8 m)
MC16	528688	9260719	Mangroves (A. marina; h: 2-3 m; ṝ : 1 m x 0.5 m)
MC17	529252	9260686	Mangroves (A. marina; h: 2-3 m; ṝ : 1 m x 0.5 m)
MC18	526477	9260559	Non-mangroves (mudflat/water/sea)
MC19	529664	9260597	Mangroves (A. marina; h: 2-3 m; ṝ : 1 m x 0.5 m)
MC20	526091	9260784	Non-mangroves (mudflat/water/sea)
MC21	526645	9260347	Mangroves (A. marina mixed R. stylosa; h: 6-8 m)
MC22	527234	9260337	Mangroves (A. marina mixed R. stylosa; h: 6-8 m)
MC23	529352	9260658	Mangroves (A. marina; h: 2-3 m; ṝ : 1 m x 0.5 m)
MC24	530161	9260542	Mangroves (A. marina; h: 1-2 m; ṝ : 1 m x 0.5 m)
MC25	542937	9259503	Mangroves (R. mucronata dominated; h: 8-10 m)
MC26	542297	9259497	Non-mangroves (mudflat/water/sea)
MC27	540785	9259007	Mangroves (R. mucronata dominated; h: 8-10 m)
MC28	541961	9259138	Non-mangrove (saltpan/pond)
MC29	40585	9259031	Mangroves (R. mucronata dominated; h: 6-8 m)
MC30	540784	9259116	Non-mangroves (mudflat/water/sea)
MC31	542448	9259551	Mangroves (R. mucronata dominated; h: 8-10 m)
MC32	541718	9259206	Mangroves (R. mucronata dominated; h: 6-8 m)
MC33	542377	9259449	Mangroves (R. mucronata dominated; h: 8-10 m)
MC34	542725	9259637	Non-mangroves (mudflat/water/sea)
MC35	542720	9259507	Mangroves (R. mucronata dominated; h: 8-10 m)
MC36	541295	9259218	Mangroves (R. mucronata dominated; h: 8-10 m)
MC37	543007	9259724	Mangroves (R. mucronata; h: 1-2 m; ṝ : 1 m x 1 m)
MC38	540048	9259023	Mangroves (R. mucronata dominated; h: 6-8 m)
MC39	541569	9259224	Mangroves (R. mucronata dominated; h: 6-8 m)

MC40	54312	9259900	Mangroves (A. marina dominated; h: 1-2 m; r̄ : 1 m x 1 m)
MC41	542697	9259571	Mangroves (R. mucronata dominated; h: 6-8 m)
MC42	542995	9259627	Mangroves (R. mucronata dominated; h: 4-6 m)
MC43	541839	9259101	Non-mangrove (saltpan/pond)
MC44	541457	9259212	Mangroves (R. mucronata dominated; h: 6-8 m)
MC45	543120	9259805	Mangroves (R. mucronata dominated; h: 6-8 m)
MC46	543194	9259859	Mangroves (A. marina mixed R. stylosa; h: 4-6 m)
MC47	526151	9260651	Mangroves (A. marina mixed R. stylosa; h: 4-6 m)
MC48	528211	9260616	Non-mangroves (mudflat/water/sea)
MC49	528553	9260710	Non-mangrove (saltpan/pond)
MC50	542115	9259242	Mangroves (R. mucronata dominated; h: 8-10 m)

Remark

h: estimation on average height; r̄: estimation on average space between individu

Appendix 3. Frequency and procentage of maximum wind during 2013

Frequency and procentage of maximum wind during west monsoon (January-February and December) year 2013

Wind Direction	0-5 knot		6-10 knot		11-15 knot		16-20 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-
SE	7	7.8	-	-	-	-	-	-	7	7.8
S	8	8.9	-	-	-	-	-	-	8	8.9
SW	24	26.7	5	5.5	-	-	-	-	29	32.2
W	4	4.4	19	13.3	5	5.5	1	1.1	29	32.2
NW	3	3.3	12	13.3	2	2.2	-	-	17	18.8
Total	46	51.1	36	40	7	7.8	1	1.1	90	100

Frequency and procentage of maximum wind during interchange season I (March-April-May) year 2013

Wind Direction	0-5 knot		6-10 knot		11-15 knot		16-20 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	1	1.1	-	-	-	-	-	-	1	1.1
NE	1	1.1	-	-	-	-	-	-	1	1.1
E	-	-	-	-	-	-	-	-	-	-
SE	33	35.9	14	15.2	-	-	-	-	47	51.1
S	4	4.3	-	-	-	-	-	-	4	4.3
SW	27	29.3	1	1.1	-	-	-	-	28	30.4
W	3	3.3	2	2.2	1	1.1	-	-	6	6.5
NW	4	4.3	1	1.1	-	-	-	-	5	5.4
Total	73	79.3	18	19.6	1	1.1	-	-	92	100

Frequency and procentage of maximum wind during east monsoon (Juni-July-August) year 2013

Wind Direction	0-5 knot		6-10 knot		11-15 knot		16-20 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-
NE	1	1.1	-	-	-	-	-	-	1	1.1
E	-	-	-	-	-	-	-	-	-	-
SE	41	44.6	35	38.0	2	2.2	-	-	61	84.8
S	6	6.8	-	-	-	-	-	-	6	6.5
SW	4	4.3	-	-	-	-	-	-	4	4.3
W	1	1.1	-	-	-	-	-	-	1	1.1
NW	2	2.2	-	-	-	-	-	-	2	2.2
Total	55	59.8	35	38.0	2	2.2	-	-	92	100

Frequency and procentage of maximum wind during interchange season II (September-October-November) year 2013

Wind Direction	0-5 knot		6-10 knot		11-15 knot		16-20 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	1	1.1	-	-	1	1.1
SE	36	39.6	18	19.8	1	1.1	-	-	55	60.4
S	22	24.2	4	4.4	-	-	-	-	26	28.6
SW	5	5.5	-	-	-	-	-	-	5	5.5
W	1	1.1	1	1.1	-	-	-	-	2	2.2
NW	1	1.1	1	1.1	-	-	-	-	2	2.2
Total	65	71.4	24	26.4	2	2.2	-	-	91	100

Appendix 4. Frequency and procentage of maximum wave during 2013

Frequency and procentage of maximum wave during west monsoon (January-February and December) year 2013

Wave Direction	0-0.5 m		0.6-1.0 m		1.1-1.5 m		1.6-2.0 m		> 2 m		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	1	1.1	-	-	-	-	-	-	1	1.1
NW	39	43.3	-	-	29	32.2	9	10.0	12	13.3	89	98.9
Total	39	43.3	1	1.1	29	32.2	9	10.0	12	13.3	90	100

Frequency and procentage of maximum wave during interchange season I (March-April_May) year 2013

Wave Direction	0-0.5 m		0.6-1.0 m		1.1-1.5 m		1.6-2.0 m		> 2 m		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	19	20.6	6	6.5	6	6.5	-	-	1	1.1	32	34.8
NE	5	5.4	-	-	-	-	-	-	-	-	5	5.4
E	28	30.4	15	16.3	10	10.9	-	-	-	-	53	57.6
SE	-	-	1	1.1	-	-	-	-	-	-	1	1.1
S	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-
W	1	1.1	-	-	-	-	-	-	-	-	1	1.1
NW	-	-	-	-	-	-	-	-	-	-	-	-
Total	53	57.6	22	23.9	16	17.4	-	-	1	1.1	92	100

Frequency and procentage of maximum wave during east monsoon (Juni-July-August) year 2013

Wave Direction	0-0.5 m		0.6-1.0 m		1.1-1.5 m		1.6-2.0 m		> 2 m		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	1	1.1	-	-	-	-	-	-	-	-	1	1.1
E	-	-	-	-	-	-	-	-	-	-		
SE	41	44.6	35	38.0	2	2.2	-	-	-	-	61	84.8
S	6	6.5	-	-	-	-	-	-	-	-	6	6.5
SW	4	4.3	-	-	-	-	-	-	-	-	4	4.3
W	1	1.1	-	-	-	-	-	-	-	-	1	1.1
NW	2	2.2	-	-	-	-	-	-	-	-	2	2.2
Total	55	59.8	35	38.0	2	2.2	-	-	-	-	92	100

Frequency and procentage of maximum wave during interchange season II (September-October-November) year 2013

Wave Direction	0-0.5 m		0.6-1.0 m		1.1-1.5 m		1.6-2.0 m		> 2 m		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	1	1.1	3	3.3	3	3.3	2	2.2	-	-	9	9.9
E	39	42.8	15	16.5	11	12.1	4	4.4	-	-	69	75.8
SE	-	-	-	-	-	-	-	-	-	-	-	-
S	-	-	1	1.1	-	-	-	-	-	-	1	1.1
SW	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-
NW	7	7.7	1	1.1	4	4.4	-	-	-	-	12	13.2
Total	47	51.6	20	21.9	18	19.8	6	6.6	-	-	91	100

Appendix 5. Frequency and procentage of maximum currents during 2013

Frequency and procentage of maximum currents during west monsoon (January-February and December) year 2013

Wave Direction	0-10 knot		11-20 knot		21-30 knot		31-40 knot		> 40 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	9	10.0	1	1.1	-	-	1	1.1	2	2.2	13	14.4
E	6	6.7	5	5.5	8	8.9	2	2.2	8	8.9	29	32.2
SE	10	11.1	4	4.4	-	-	2	2.2	1	1.1	17	18.9
S	2	2.2	-	-	-	-	-	-	-	-	2	2.2
SW	7	7.8	4	4.4	-	-	-	-	-	-	11	12.2
W	1	1.1	6	6.7	3	3.3	1	1.1	-	-	11	12.2
NW	5	5.5	1	1.1	1	1.1	-	-	-	-	7	7.8
Total	40	44.4	21	23.3	12	13.3	6	6.7	11	12.2	90	100

Frequency and procentage of maximum currents during interchange season I (March-April-May) year 2013

Wave Direction	0-10 knot		11-20 knot		21-30 knot		31-40 knot		> 40 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	12	13.0	4	4.3	-	-	-	-	-	-	16	17.4
E	13	14.1	9	9.8	-	-	1	1.1	-	-	23	25.0
SE	20	21.7	4	4.3	-	-	-	-	-	-	24	26.1
S	1	1.1	-	-	-	-	-	-	-	-	1	3.3
SW	8	8.7	3	3.3	2	2.2	-	-	-	-	13	14.1
W	6	6.5	6	6.5	-	-	-	-	-	-	12	13
NW	2	3.3	-	-	-	-	-	-	-	-	3	3.3
Total	63	68.5	26	28.3	2	2.2	1	1.1	-	-	92	100

Frequency and procentage of maximum currents during east monsoon (Juni-July-August) year 2013

Wave Direction	0-10 knot		11-20 knot		21-30 knot		31-40 knot		> 40 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	4	4.3	-	-	-	-	-	-	-	-	4	4.3
E	2	2.2	3	3.3	-	-	1	1.1	-	-	6	6.5
SE	7	7.6	6	6.5	3	3.3	-	-	-	-	16	17.4
S	-	-	1	1.1	-	-	-	-	-	-	1	1.1
SW	5	5.4	6	6.5	4	4.3	-	-	1	1.1	16	17.4
W	4	4.3	6	6.5	24	26.1	9	9.8	2	2.2	45	48.9
NW	2	2.2	-	-	1	1.1	1	1.1	-	-	4	4.3
Total	24	26.1	22	23.9	32	34.8	11	11.9	3	3.3	92	100

Frequency and procentage of maximum currents during interchange season II (September-October-November) year 2013

Wave Direction	0-10 knot		11-20 knot		21-30 knot		31-40 knot		> 40 knot		Total	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	3	3.3	-	-	1	1.1	1	1.1	-	-	5	5.5
E	2	2.2	3	3.3	-	-	-	-	-	-	5	5.5
SE	12	13.2	1	1.1	-	-	-	-	-	-	13	14.3
S	1	1.1	-	-	-	-	-	-	-	-	1	1.1
SW	5	5.5	4	4.4	2	2.2					11	12.1
W	5	5.5	19	20.9	16	17.6	7	7.7	5	5.5	52	57.1
NW	3	3.3	1	1.1	-	-	-	-	-	-	4	4.4
Total	31	34.1	28	30.8	19	20.9	8	8.8	5	5.5	91	100

Appendix 6. Results of statistic test

1. Results of cross tabulation with chi-square test to investigate the differences respondents' perception toward the influences of mangrove forest changes between villages

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
mangrove_changes_influenced * village	81	100.0%	0	0.0%	81	100.0%

mangrove_changes_influenced * village Crosstabulation

Count

		village			Total
		pasarbanggi	tasikharjo	tunggulsari	
mangrove_changes_influenced	yes	19	8	7	34
	no	14	20	13	47
Total		33	28	20	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.762[a]	2	.056
Likelihood Ratio	5.806	2	.055
Linear-by-Linear Association	3.410	1	.065
N of Valid Cases	81		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.40.

2. Results of multiple linear regression to investigate factors influencing respondents' perception toward the influences of mangrove forest changes

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	program_involvement, income_class, distance, length_stay, education, occupation, age_class, gender[b]	.	Enter

a. Dependent Variable: mangrove_changes_influenced

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.526[a]	.276	.196	.445	.276	3.436	8	72	.002

a. Predictors: (Constant), program_involvement, income_class, distance, length_stay, education, occupation, age_class, gender
b. Dependent Variable: mangrove_changes_influenced

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.451	8	.681	3.436	.002[b]
	Residual	14.278	72	.198		
	Total	19.728	80			

a. Dependent Variable: mangrove_changes_influenced
b. Predictors: (Constant), program_involvement, income_class, distance, length_stay, education, occupation, age_class, gender

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.217	.709		3.128	.003
	gender	-.282	.164	-.250	-1.720	.090
	age_class	-.048	.065	-.101	-.740	.462
	education	-.059	.076	-.103	-.775	.441
	income_class	-.140	.073	-.237	-1.920	.059
	occupation	.062	.041	.200	1.501	.138
	length_stay	.155	.217	.076	.715	.477
	distance	.202	.115	.193	1.760	.083
	program_involvement	-.462	.127	-.422	-3.627	.001

a. Dependent Variable: mangrove_changes_influenced

3. Results of cross tabulation with chi-square test to investigate the differences respondents' adjustment/response toward the changes of mangrove forest between villages

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
mangrove_changes_adjusment * village	81	100.0%	0	0.0%	81	100.0%

mangrove_changes_adjusment * village Crosstabulation

Count

		village			Total
		pasarbanggi	tasikharjo	tunggulsari	
mangrove_changes_adjusment	yes	19	7	7	33
	no	14	21	13	48
Total		33	28	20	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.021[a]	2	.030
Likelihood Ratio	7.120	2	.028
Linear-by-Linear Association	3.611	1	.057
N of Valid Cases	81		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 8,15.

4. Results of multiple linear regression to investigate factors influencing respondents' adjustment/response toward the changes of mangrove forest

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	program_involvement, income_class, distance, length_stay, education, occupation, age_class, gender[b]	.	Enter

a. Dependent Variable: mangrove_changes_adjusment
b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.532[a]	.283	.203	.441	.283	3.549	8	72	.002

a. Predictors: (Constant), program_involvement, income_class, distance, length_stay, education, occupation, age_class, gender
b. Dependent Variable: mangrove_changes_adjusment

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.531	8	.691	3.549	.002[b]
	Residual	14.025	72	.195		
	Total	19.556	80			

a. Dependent Variable: mangrove_changes_adjusment
b. Predictors: (Constant), program_involvement, income_class, distance, length_stay, education, occupation, age_class, gender

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.195	.702		3.125	.003
	gender	-.279	.162	-.249	-1.721	.089
	age_class	-.074	.064	-.156	-1.154	.252
	education	-.079	.075	-.139	-1.048	.298
	income_class	-.095	.072	-.161	-1.311	.194
	occupation	.076	.041	.245	1.847	.069
	length_stay	.182	.215	.089	.846	.400
	distance	.189	.114	.181	1.663	.101
	program_involvement	-.490	.126	-.450	-3.886	.000

a. Dependent Variable: mangrove_changes_adjusment

5. Results of cross tabulation with chi-square test to investigate the differences respondents' perception benefit from mangroves ntfp between villages

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
ntfp_benefit_31a * village	81	100.0%	0	0.0%	81	100.0%

ntfp_benefit_31a * village Crosstabulation

Count

		village			Total
		pasarbanggi	tasikharjo	tunggulsari	
ntfp_benefit_31a	yes	27	13	4	44
	no	6	15	16	37
Total		33	28	20	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.253[a]	2	.000
Likelihood Ratio	21.702	2	.000
Linear-by-Linear Association	19.860	1	.000
N of Valid Cases	81		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.14.

6. Results of cross tabulation with chi-square test to investigate the differences respondents' acceptance on government mangroves program between villages

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
program_benefit_40a * village	81	100.0%	0	0.0%	81	100.0%

program_benefit_40a * village Crosstabulation

Count

		village			Total
		pasarbanggi	tasikharjo	tunggulsari	
program_benefit_40a	yes	27	13	2	42
	no	6	15	18	39
Total		33	28	20	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	26.231[a]	2	.000
Likelihood Ratio	29.209	2	.000
Linear-by-Linear Association	25.906	1	.000
N of Valid Cases	81		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.63.

7. Results of contigency test to investigate correlation between community's perception toward the influences of mangrove forest changes and community's adjustment/response toward mangrove forest changes

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
mangrove_changes_influenced * mangrove_changes_adjusment	81	100.0%	0	0.0%	81	100.0%

mangrove_changes_influenced * mangrove_changes_adjusment Crosstabulation

Count

		mangrove_changes_adjusment		Total
		yes	no	
mangrove_changes_influenced	yes	33	1	34
	no	0	47	47
Total		33	48	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	76.980[a]	1	.000		
Continuity Correction[b]	73.012	1	.000		
Likelihood Ratio	100.473	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	76.029	1	.000		
N of Valid Cases	81				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.85.
b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	.698	.000
N of Valid Cases		81	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

8. Results of contigency test to investigate correlation between community's adjustment/response toward mangrove forest changes and community's perception toward benefit from mangroves non-timber forest products

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
mangrove_changes_adjusment * ntfp_benefit_31a	81	100.0%	0	0.0%	81	100.0%

mangrove_changes_adjusment * ntfp_benefit_31a Crosstabulation

Count

		ntfp_benefit_31a		Total
		yes	no	
mangrove_changes_adjusment	yes	19	14	33
	no	25	23	48
Total		44	37	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.238[a]	1	.626		
Continuity Correction[b]	.068	1	.794		
Likelihood Ratio	.238	1	.626		
Fisher's Exact Test				.656	.398
Linear-by-Linear Association	.235	1	.628		
N of Valid Cases	81				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.07.
b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	.054	.626
N of Valid Cases		81	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

9. Results of contigency test to investigate correlation between community's adjustment/response toward mangrove forest changes and community's acceptance on government mangroves program

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
mangrove_changes_adjusment * program_benefit_40a	81	100.0%	0	0.0%	81	100.0%

mangrove_changes_adjusment * program_benefit_40a Crosstabulation
Count

		program_benefit_40a		Total
		yes	no	
mangrove_changes_adjusment	yes	22	11	33
	no	20	28	48
Total		42	39	81

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.896[a]	1	.027		
Continuity Correction[b]	3.945	1	.047		
Likelihood Ratio	4.966	1	.026		
Fisher's Exact Test				.041	.023
Linear-by-Linear Association	4.835	1	.028		
N of Valid Cases	81				

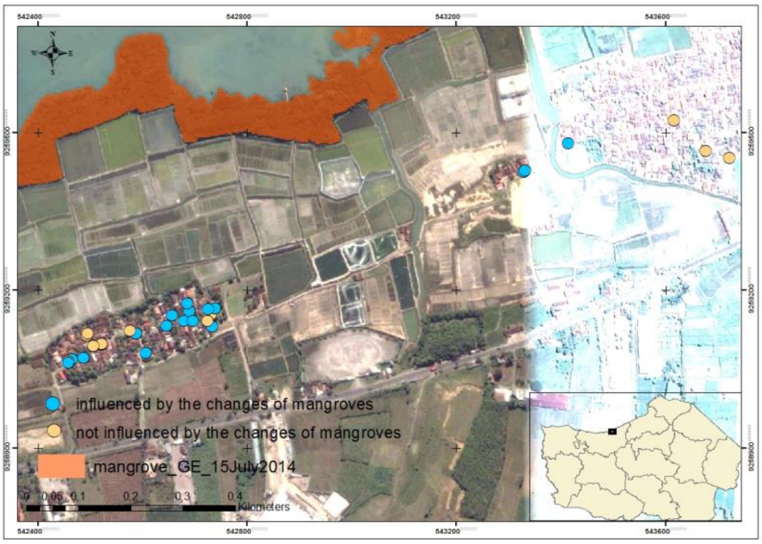
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.89.
b. Computed only for a 2x2 table

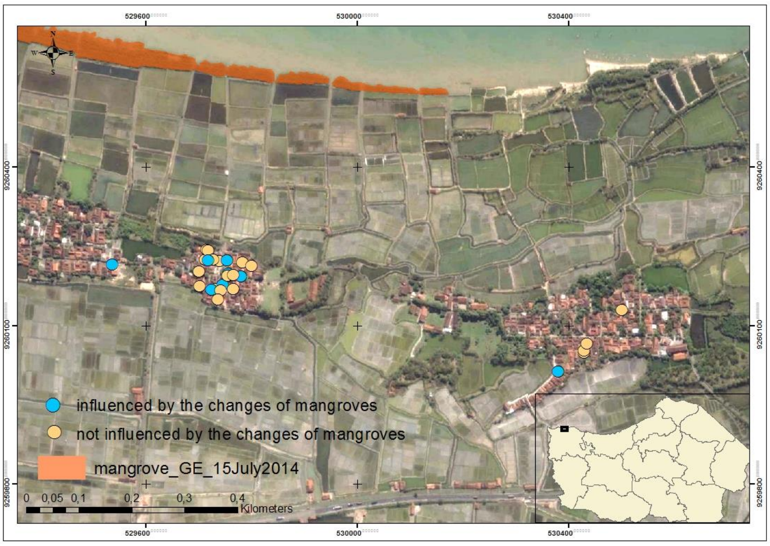
Symmetric Measures

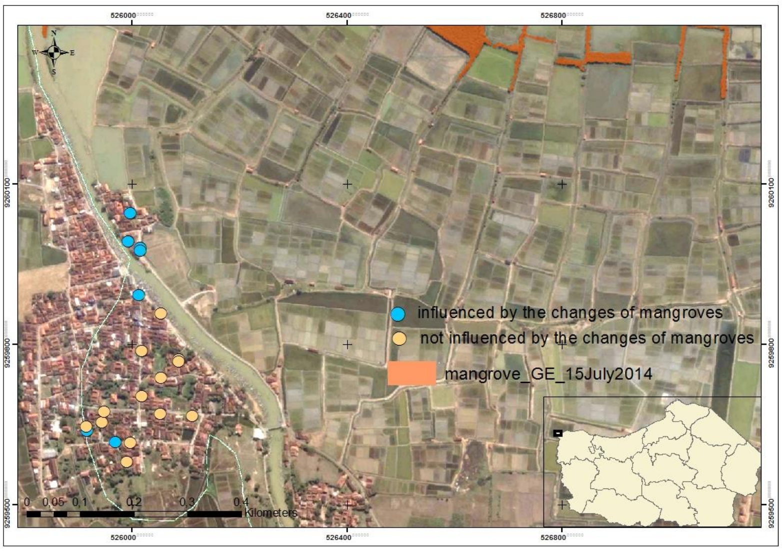
		Value	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	.239	.027
N of Valid Cases		81	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

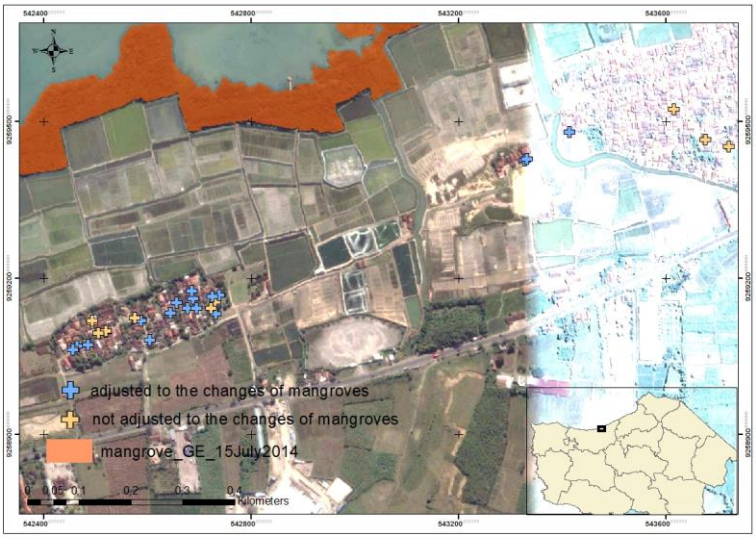
Appendix 7. Spatial distribution of respondents' perception toward the influence of mangrove forest changes in the surveyed villages (upper: Pasarbanggi; centre: Tasikharjo; bottom: Tunggulsari)

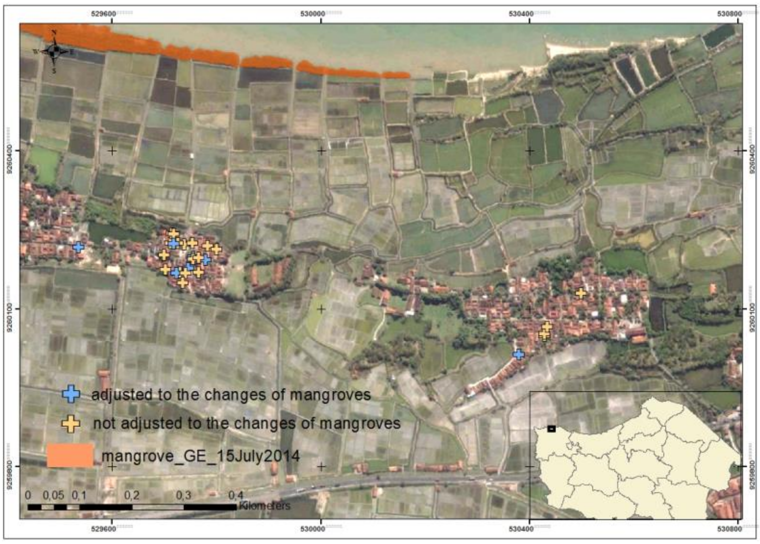


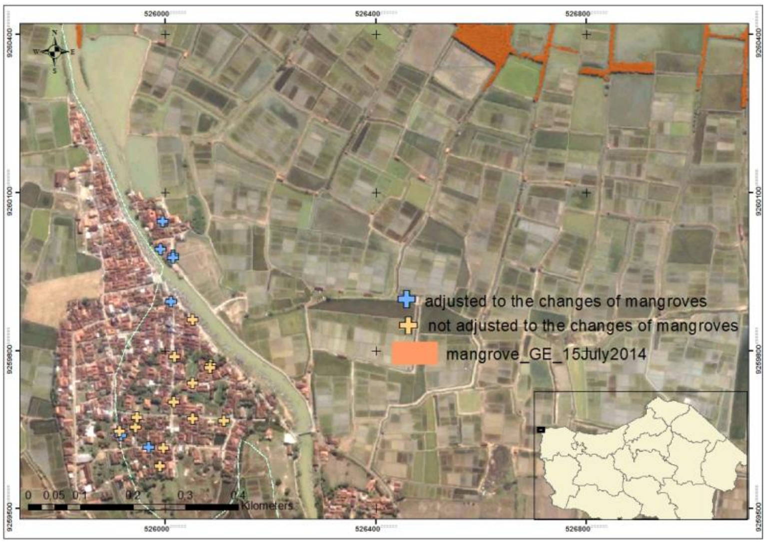




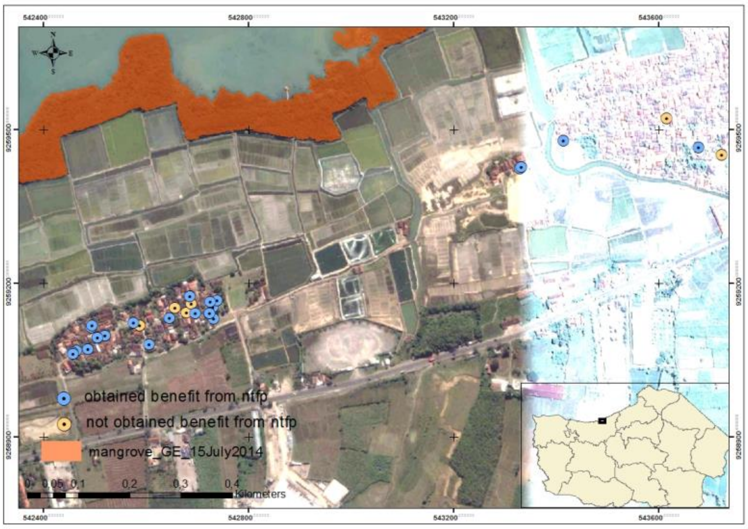
Appendix 8. Spatial distribution of respondents' adjustment/response toward mangrove forest changes in the surveyed villages (upper: Pasarbanggi; centre: Tasikharjo; bottom: Tunggulsari)

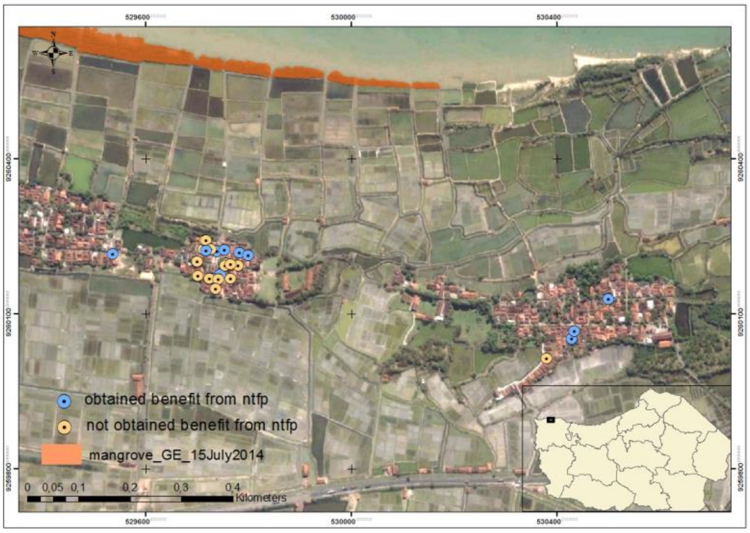


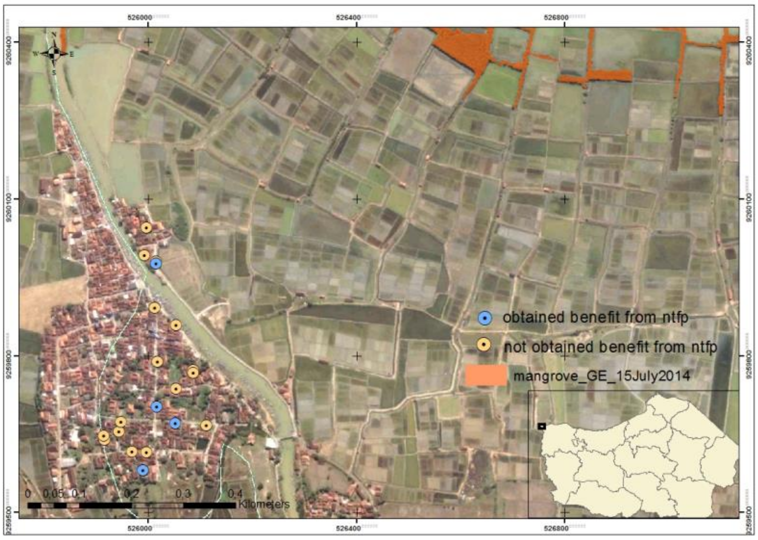




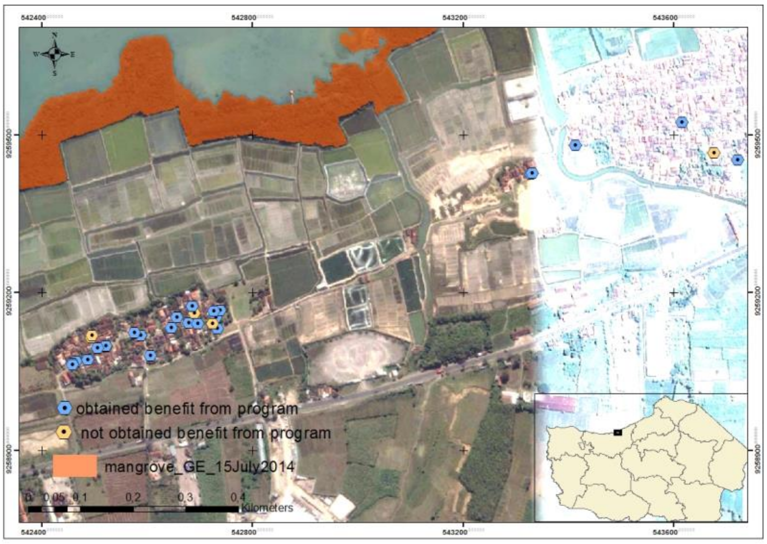
Appendix 9. Spatial distribution of respondents' perception toward benefit from mangroves ntfp in the surveyed villages (upper: Pasarbanggi; centre: Tasikharjo; bottom: Tunggulsari)

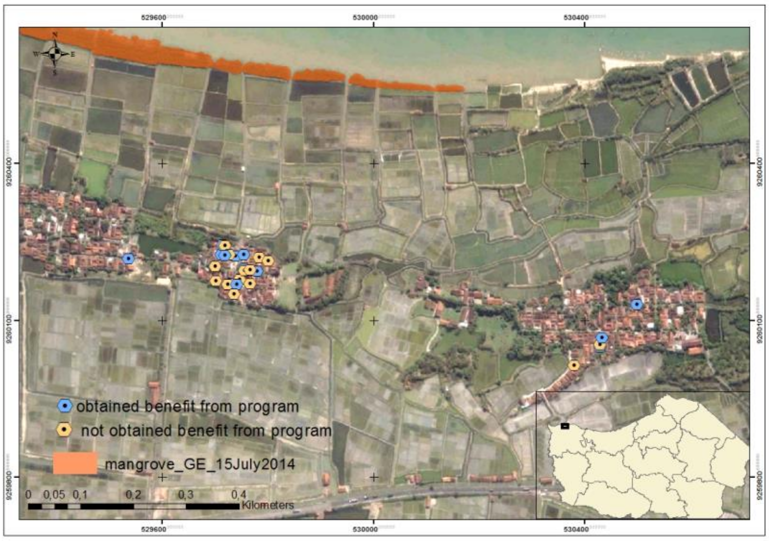


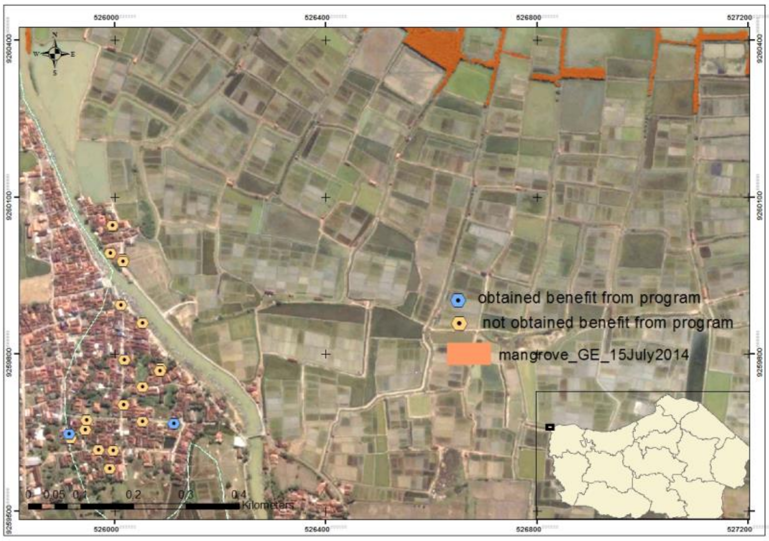




Appendix 10. Spatial distribution of respondents' perception toward benefit from government mangrove program in the surveyed villages (upper: Pasarbanggi; centre: Tasikharjo; bottom: Tunggulsari)







Appendix 11. Questionnaire for respondents

Researcher	:	Mochamad Budi Purnomo
Contact	:	m.b.purnomo@student.utwente.nl
Research Title	:	Analysis on Mangrove Forest Changes in Relation to Coastline Changes, and Its Influence to Community in Rembang District, Central Java Province, Indonesia
University	:	Geo-Information for Spatial Planning and Disaster Risk Management, Post Graduate School of Gadjah Mada University – Faculty of Geo-Information Science and Earth Observation, University of Twente

This information will only be used for scientific research

Questionaire No. :
Date of interview :
Time of interview :
Respondent's name :
House coordinate : a. Latitude :
b. Longitude :
Village :

A. Information on Respondent's Profile

1. Age : years old
2. Sex : (a) Male (b) Female
3. Marital status : (a) Married (b) Single (c) Widow/Widower
4. Position in household : (a) Head of family (b) Member
5. Main occupation : (a) Fisherman (b) Laborer (c) Trader (d) Private sector (e) Civil servant (f) Saltpan/fishpond owner (g) Teacher (h) Student (i) Housewife (j) Others
6. Side job:
7. Income per month : Rp
8. Expenses per month: Rp
9. Education : (a) Not schooling (b) Elementary school (b) Junior high school (c) Senior high school (d) University
10. How long have you been stayed at this village : (a) < 5 years (b) 5 – 10 years (c) > 10 years
11. Household size : (a) < 2 person (b) 3 – 4 persons (c) > 4 persons
12. Number of income source in family : (a) 1 – 2 (b) 3 – 4 (c) > 5
13. Status of house ownership : (a) Own property (b) Rent (b) Borrow (d) Others...........

B. General Information on Mangrove Forest, Sedimentation and Coastal Erosion

14. Do you know the mangrove forest?
    (a) Yes (b) No
    If yes, could you please indicate one or more mangrove species in your neighboring area
    ....

....

15. Do you consider that the area/extension of mangrove forest in your village has changed?
    (a) Yes (b) No
    If yes, could you please indicate wheter it is increased or decreased
    (a) Increased (b) Decreased
16. If the mangrove forest has changed, could you please indicate the main reason of this condition
    ....
    ....
17. Does coastal area in your village impacted by coastal erosion?
    (a) Yes (b) No
    If yes, could you recognize since when your village has impacted by coastal erosion and
    what damage resulted by coastal erosion?
    ....
    ....
18. Reffering to question number 4 above, if your village has impacted by coastal erosion, could you please indicate the main causes of coastal erosion in your village
    ....
    ....
19. Do you negatively affected by coastal erosion?
    (a) Yes (b) No
    If yes, what measures you have been taken to deal with?
    ....
    ....
20. Do you consider if sedimentation process has taken place in your village?
    (a) Yes (b) No
    If yes, could you please indicate since when sedimentation process has taken place in your village
    ....
    ....
21. Reffering question number 20 above, if sedimentation process has taken place in your village, do you negatively affected by this condition?
    (a) Yes (b) No
    Could you please indicate your reason why
    ....
    ....

C. Information on How Mangrove Changes Influence the Community and How They Perceive the Changes

22. In case of mangrove forest in your village has changed, does this condition affects your daily activities, let say compare to 10 years ago?
    (a) Yes (b) No
    Could you please indicate your reason
    ....
    ....

23. Reffering to question number 22 above, do you consider that you get the benefit from this condition?
    (a) Yes (b) No
    Could you please indicate your reason
    ....
    ....
24. Reffering to question number 22 above, have you taken any adjusment or adaptation to deal with this situation?
    (a) Yes (b) No
    Could you please indicate your reason
    ....
    ....

D. Information on Respondent's Perception Toward the Importance of Mangrove

25. Do you think that mangrove forest important for marine biota as spawning ground, nursery ground and feeding ground?
    (a) Yes (b) No
26. Could you please compare the availability of marine biota (fish, crab, pond) around mangrove forest in your village, let say 10 years ago to the recent times. Does the availability much more abundant?
    (a) Yes (b) No
    Could you please indicate your reason
    ....
    ....
27. Do you think that mangrove forest can protect coastal area from coastal erosion, and another physical processes such as strong wind and high wave?
    (a) Yes (b) No
    Could you please indicate your reason
    ....
    ....
28. Could you please indicate the differences on the capability of mangrove forest in relation to protect your village from coastal processess such as coastal erosion, high wave, strong wind, let say 10 years ago with the recent times. Does the current situation has a better protection?
    a) Yes (b) No
    Could you please indicate your reason
    ....
    ....
29. Do you think that mangrove can be used as sources of non-timber forest product, such as food and medicine?
    (a) Yes (b) No
    If yes, could you please mention the example of this
    ....
    ....
30. Have you ever utilised non-timber forest products from mangrove forest?
    (a) Yes (b) No
    If yes, could you please indicate your purpose

....
....

31. Could you please indicate the differences on the capability of mangrove forest to deliver benefit, such as non-wood forest products, let say 10 years ago with the recent times. Does the current mangrove forest provide a better service?
    (a) Yes (b) No
    Could you please indicate your reason
    ....
    ....

E. Information on Respondent's Acceptance Toward Government Program in Relation to Mangrove

32. Do you know typical government program in relation to mangrove?
    (a) Yes (b) No
    If yes, could you please indicate the type of program
    ....
33. Are there any government program in relation to mangrove in your neighboring area?
    (a) Yes (b) No
    If yes, could you please indicate the type of program
    ....
34. Reffering to question number 2 above, if the government program related to mangrove ever conducted in your village, does the program give the positive influence in your daily life compare to, let say 10 years ago?
    (a) Yes (b) No
    Could you please indicate the reason
    ....
    ....
35. Do you think your village need government program in relation to mangrove?
    (a) Yes (b) No
    Could you please indicate the reason
    ....
    ....

Appendix 12. Photographs during the field survey


Rhizophora mucronata stand in Pasarbanggi Village


Newly planted area of *Avicennia marina* in Pasarbanggi Village


Mangrove wooden bridge in Pasarbanggi Village


The up-rooted of *Rhizopora mucronata* trees at seaward margin in Pasarbanggi Village


The monostand of *Avicennia marina* in Tasikharjo Village


Avicennia marina stand at seaward margin in Tasikharjo Village

Announcement on prohibition to collect Avicennia's fruits in Tasikharjo Village

Harvesting of coarse salt in Tasikharjo Village

Avicennia marina stand at seaward margin in Tunggulsari Village

The up-rooted of *Avicennia marina* trees at seaward margin in Tunggulsari Village

A very narrow strip of *Avicennia marina* belt in Tunggulsari Village

Tree stumps of mangrove vegetation inside pond in Tunggulsari Village

A woman collecting oyster inside *Rhizophora mucronata* stand in Pasarbanggi Village

A woman collecting the fruits of Avicennia in Pasarbanggi Village

Interview with respondent

Interview with respondent