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ANALYSIS OF CHANGES IN MANGROVE AREA IN THE NORTH COAST OF CENTRAL JAVA PROVINCE INDONESIA

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ABSTRACT

Mangrove is one of the coastal ecosystems which has an important role as the main ecosystem to support life activities in coastal areas and plays an important role in maintaining the balance of the biological cycle in the environment. However, on the other hand, mangrove forests are very vulnerable to environmental influences, both from nature and from humans. In relation to mangrove forest management, information is very much needed regarding the wide area cover from time to time. The research objectives were to analyze the condition of mangrove forests, to analyze changes in mangrove area, and to provide input on mangrove ecosystem management. The mangrove forest in Pemalang Regency had a degradation of 26.89 ha, Semarang City had a gradation of 42.97 ha, and in Demak District there was a gradation of 58.55 ha. Mangrove density was in the range of 503-726 ind/ha. Mangrove sediment texture was dominated by sandy loam. Temperature was 29-31°C. Water salinity was 29-30 ‰ and sediment salinity was 27-28‰. Water pH was 8 and sediment pH was 6. The PCA analysis results showed that the supporting variables for mangrove forests consisted of four groups. The first group is mangrove density, temperature and water pH. The second group is soil salinity, clay form, and water salinity. The third group is the dust and sand fraction. The fourth group is soil pH. Based on the results of PCA analysis, mangrove forest density has a positive correlation with water temperature and negatively correlated with water pH.

***Keywords**:* Mangrove Area; North Coast; Central Java

INTRODUCTION

Indonesia as an archipelagic country has more water areas than land areas. The confluence of water and land areas is known as a coastal area. Being in an area where water and land meet makes the coastal area an unstable area. This instability is caused by the influence of the two bordering areas, both physical and non-physical. However, fortunately the coastal area is equipped with several supporting ecosystems. This ecosystem plays a role in supporting the coastal area so that it can become stable. The three ecosystems are coral reef ecosystems, seagrass and mangrove forests. This is confirmed by Motoku et al. (2014), Indonesia is known as a country with high diversity. This high diversity is reflected in the coastal areas. The coastal area of Indonesia as an archipelago has the largest biological wealth in the world. The coastal area is composed of three ecosystems, namely coral reef ecosystems, seagrass beds, and mangrove forests. The three of them are interconnected and support each other in maintaining regional stability.

Mangrove forests are the main ecosystem that supports life activities in coastal areas and plays an important role in maintaining the balance of the biological cycle in the environment. Indonesia has vast mangrove forest resources that are scattered in coastal areas in various provinces. The potential of natural wealth needs to be managed and utilized optimally to support the implementation of national development and to improve the welfare of the community.

According to Noor et al., (2013) Central Java Province has a mangrove area of 76,929.14 hectares. Almost all of the northern coastal areas in Central Java Province have mangrove planting activities. Some areas that have large mangrove forest areas include Pemalang Regency, Semarang City, and Demak Regency. The mangrove area in the coastal area of Semarang City is 84.47 ha with the largest area in the Tugu District which has a mangrove area of 52.4 ha. This situation tends to decrease in the area of mangrove areas due to land conversion for industrial use and coastal abrasion due to sea level rise (Semarang Marine and Fisheries Office, 2010).

This is also reinforced by the results of research from Muskananfola et al., (2020) which show that most of the Sayung coastline has suffered from severe erosion. The rate of erosion ranges from −4 m to −65 m with a mean of −25 m / year and the movement of the net erosion coastline ranges from −90 m to −1558 m with an average of −592 m. The trend of annual shoreline recession in most of the study area with limited increase indicates that sediment was carried consistently from the coastal waters of the Sayung system to the offshore.

The importance of the existence of mangrove forest ecosystems for the community and the environment, especially the northern coastal area of Central Java is an area that cannot be separated from environmental threats because it is directly adjacent to a densely populated area, encouraging the author to conduct research on Changes in Mangrove Forest Area in the North Coastal Zone of the Province. Central Java. This research is expected to be a reference in decision making when managing mangrove forests on the north coast of Central Java province.

RESEARCH METHODS

Study Area

The research was conducted in the mangrove forest area of the north coast of Central Java province, namely in the mangrove forest area of Mojo Village, Pemalang Regency; Bedono Village, Demak Regency; and Tugu District, Semarang City. The research location is directly adjacent to the Java Sea. To reach the research location, you can go by land and some have to use a boat. The mangroves in the research location have the purpose of being a conservation area, besides that they are also to withstand the onslaught of waves and beach abrasion so as not to damage the ponds belonging to the people who are behind the mangrove forests. Over time, some of these areas were redeveloped as tourist areas.

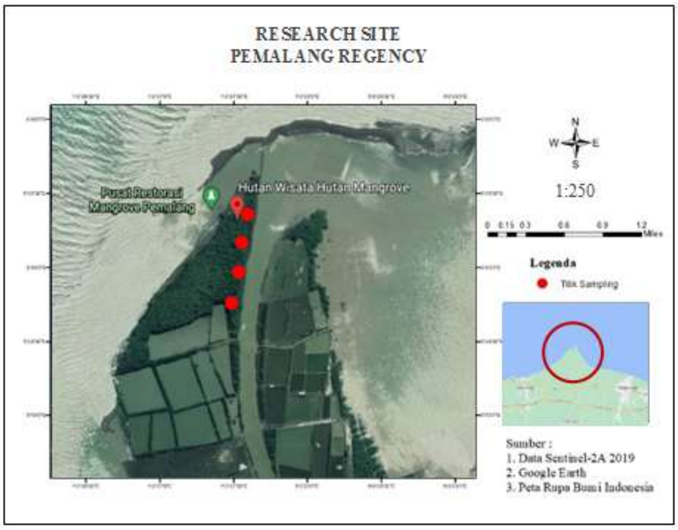

Figure 1. Research Site at Pemalang Regency

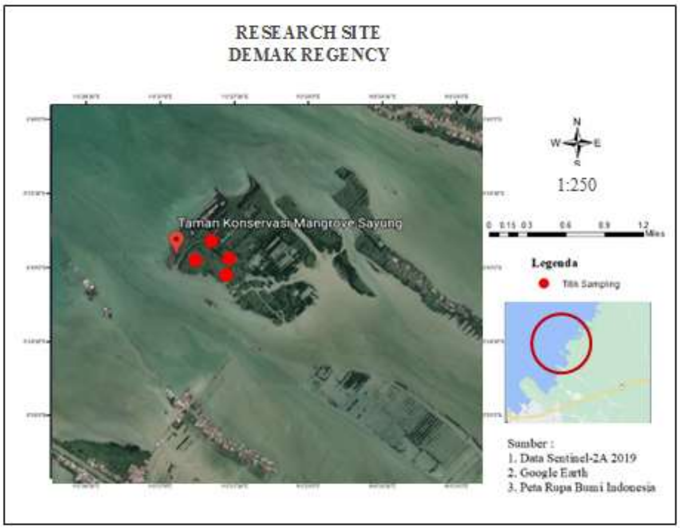

Figure 2. Research Site at Demak Regency

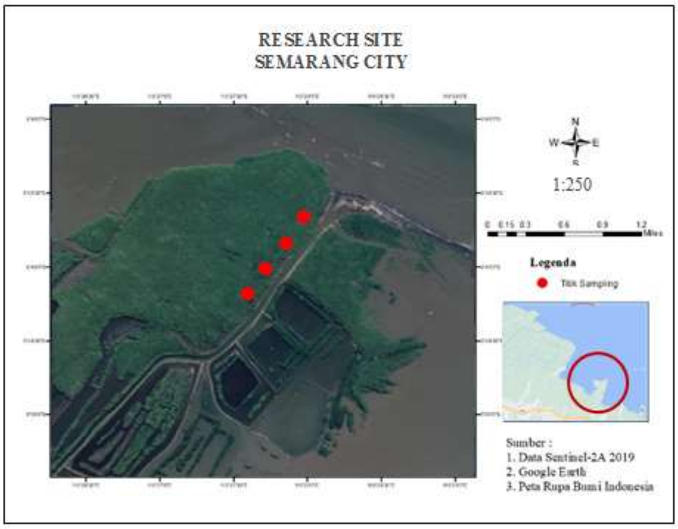

Figure 3. Research Site at Semarang City

The dominant mangrove species in each study location consisted of *Rhizopora mucronata* and *Avicennia marina*. In the mangrove forest area of Sayung, Demak and Tugu Subdistricts, Semarang is more dominated by *A. marina* species, while in the mangrove forest area of Mojo District, Pemalang is more dominated by *R. mucronata* species.

Sampling

Analysis of spatial data will use Landsat-8 satellite imagery. Where the processing and classification of data will be carried out using the help of digital data obtained. The stages taken include downloading the map on the web, cutting the image to be used, creating an algorithm that will compare the field data obtained with satellite data, image sharpening, overlaying, and making map layouts as the final result which will show an overview of the spatial data from the research results.

Measurement of mangrove vegetation was carried out using the Point Quarter Method. In this method, the measurement of the distance between individual plants or the distance from randomly selected trees to the closest individual plants is carried out. At the sampling point, two virtual lines will be made that make this point the center so that four quadrants will be obtained. In each quadrant one tree closest to the center will be selected, then the distance will be measured. For the four nearby trees, species and circumference of the tree trunk will also be recorded. This method is also used by Susiana (2011), when using the Point Centered Quarter Method it will make it easier to calculate the number of all mangrove stands. Other supporting variables were measured directly at the research location or in-situ in July-October 2020.

RESULTS AND DISCUSSION

Changes in Mangrove Area

Pemalang Regency

The result pf area mapping in the mangrove fprest area of pemalang Regency in 2014-2017 and 2017-2020 are presented in Figure 4. And Figure 5.

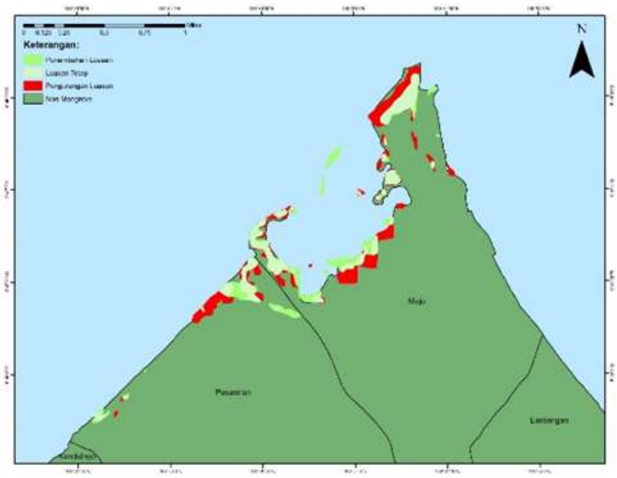

Figure 4. Map of Pemalang Regency Mangrove Area Changes in 2014-2017

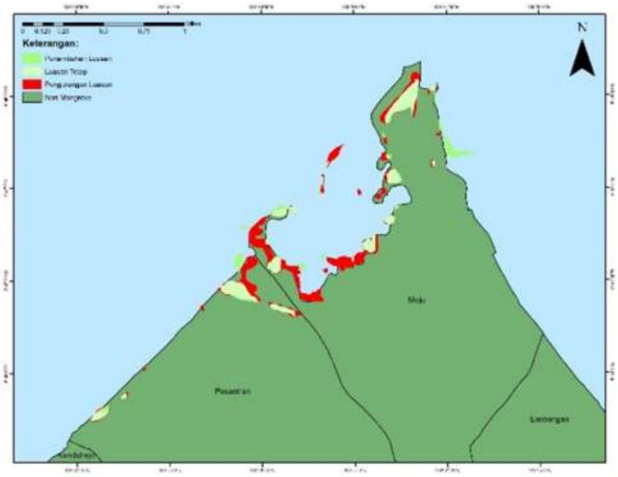

Figure 5. Map of Pemalang Regency Mangrove Area Changes in 2017-2020

Table 1. Change in Mangrove Forest Area of Pemalang Regency 2014-2020

Location	Area (ha)			
	2014	2017	2020	Change
Mojo	40,36	31,61	18,16	-22,2
Pesantren	12,89	11,20	8,20	-4,69
Total				**-26,89**

Based on the measurement results of changes in the area of mangrove forest in Mojo and Pesantren Village, Ulujami District, Pemalang Regency in Table 1. it can be seen that there has been degradation of the mangrove forest area of 26.89 ha from 2014 to 2020. In 2014-2017 there was degradation. The mangrove forest area is 8.75 ha in Mojo Village and 1.69 ha in Pesantren Village. In 2017-2020 there was degradation of the mangrove forest area of 13.45 ha in Mojo Village and 3.00 ha in Pesantren Village.

Semarang City

The results of area mapping in the mangrove forest area of Semarang City in 2014-2017 and 2017-2020 are presented in Figure 6. and Figure 7.

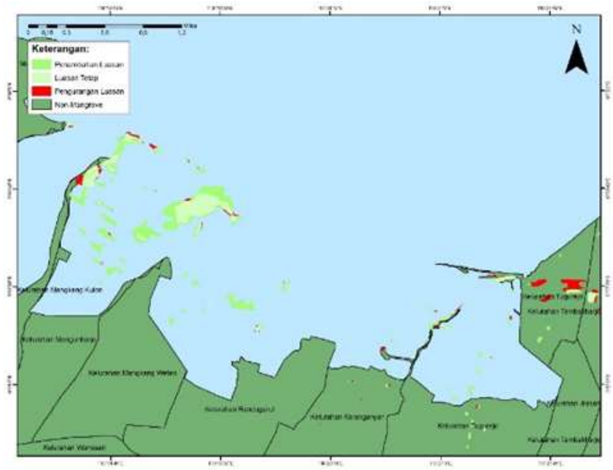

Figure 6. Map of Semarang City Mangrove Area Changes in 2014-2017

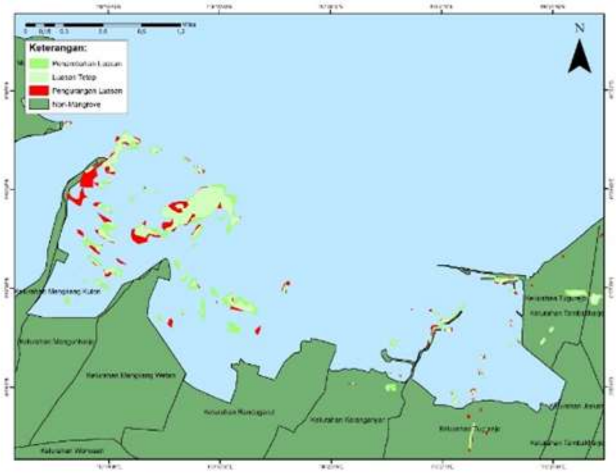

Figure 7. Map of Semarang City Mangrove Area Changes in 2017-2020

Table 2. Change in Mangrove Forest Area of Semarang City 2014-2020

Location	Area (ha)			
	2014	2017	2020	Changes
Mangkang Wetan	2,56	5,95	12,62	10,06
Mangkang Kulon	5,51	7,29	7,34	1,83
Mangunharjo	18,13	42,09	39,12	20,99
Randugarut	0,58	4,35	7,55	6,97
Tugurejo	7,75	6,30	10,25	1,50
Karanganyar	0,52	0,54	2,15	1,62
Total				**42,97**

Based on measurement results of change in the area of mangrove forests in Tugu District, Semarang City in Table 4. it can be seen that there has been a gradation of the mangrove forest area of 42,97 from 2014 to 2020. In 2014-2017 there was a gradation of mangrove areas, which are 39 ha in Mangkang Wetan Village; 1,78 ha in Mangkang Kulon Village; 23,96 ha in Mangunharjo Village; 3,77 ha in Randugarut Village; 0,02 ha in Karanganyar Village; and 1,45 ha of degradation in Tugurejo Village. In 2017-2020, there was a gradation of mangrove areas, which are 6,67 ha in Mangkang Wetan Village, 0,05 ha in Mangkang Kulon Village; 3,2 ha in

Randugarut Village; 3,95 ha in Tugurejo Village; 1,61 ha in Karanganyar Village; and 2,97 ha of degradation in Mangunharjo Village.

Demak Regency

The results of area mapping in the mangrove forest area of Demak Regency in 2014-2017 and 2017-2020 are presented in Figure 8. and Figure 9.

Figure 8. Map of Demak Regency Mangrove Area Changes in 2014-2017

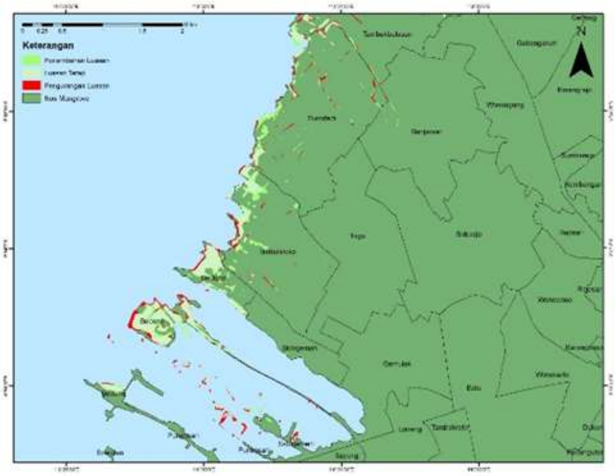

Figure 9. Map of Demak Regency Mangrove Area Changes in 2017-2020

Table 3. Change in Mangrove Forest Area of Demak Regency 2014-2020

Location	Area (ha)			
	2014	2017	2020	Change
Bedono	75,06	93,35	92,76	17,70
Purwosari	0,08	0,97	0,85	0,77
Sidogemah	4,33	10,45	6,58	2,25
Timbulsloko	11,47	27,58	36,92	25,45
Surodadi	16,31	23,72	28,69	12,38
Total				**58,55**

Based on the measurement results of changes in the area of mangrove forest in Sayung District, Demak Regency in Table 5. it can be seen that there has been a gradation of the mangrove forest area of 58.55 ha from 2014 to 2020. In 2014-2017 there was a gradation of mangrove forest areas. 18,29 ha in Bedono Village; 0.89 ha in the village of Purwosari; 6.12 ha in Sidogemah Village; 16.11 ha in Timbulsloko Village; and 7.41 ha in Surodadi Village. In 2017-2020, there was a gradation of mangrove forest area of 9.34 ha in Timbulsloko Village; 4.97 ha in Surodadi Village; and there was degradation of 0.59 in Bedono Village; 0.12 ha in the village of Purwosari; and 3.87 ha in Surodadi Village.

There is an increase or increase in mangrove forest area and a decrease or decrease in mangrove forest area can be caused by various things. According to Hamuna and Rosye (2018), changes in mangrove cover occur when there is an increase in mangrove area due to the growth of mangrove forests or the distribution of mangrove seeds which then grow in areas where there are no mangroves, or a reduction in mangrove area occurs if an area has mangroves then the mangroves dead or lost replaced by other land cover. The increase in the area of mangrove forests can be caused by efforts to manage and protect the mangrove forest ecosystem. The mangrove forest ecosystem is part of the coastal area ecosystem, so that the impacts of each coastal ecosystem will interact with each other. According to Haryani (2013), to increase the area of mangrove forests, there are efforts to rehabilitate and revitalize mangrove forests which are already damaged. In order to support the rehabilitation and revitalization of mangrove forests, mangrove nurseries and nurseries were carried out, which were then carried out by planting mangroves in coastal areas where the environmental quality had decreased. Meanwhile, the decrease in mangrove forest area can be caused by the activities of the community and local government to convert the mangrove forest. This is reinforced by (Puryono and Suryanti, 2019a) who state that the conversion of mangrove areas to brackish water ponds contributes to the most dominant cause of mangrove degradation in most areas in Indonesia, even in the world. Mangroves provide a suitable environment to support cultivation activities because of their carrying capacity. Unfortunately, the extensive conversion of mangroves to ponds has resulted in a significant decline in mangrove forests. Fitriana et al., (2017) also added that several factors have caused the reduction of mangrove forest land, one of which is the conversion of mangrove forests to land forms. Although this can be interpreted as a good effort, on the other hand, if it is not considered carefully, it can cause degradation of mangrove forests in coastal areas.

The rapid degradation of mangrove forests will also trigger coastal erosion which in turn will damage the natural habitat of biota in coastal areas such as fish and shrimp. This is reinforced by Puryono et al., (2018) who stated that the mangrove ecosystem plays an important role in the fish restocking process. Any disturbance that is active in the mangrove ecosystem can affect the ability of mangroves to support fish resources and subsequently have an impact on the abundance of biodiversity and fish stocks in coastal areas. Puryono et al., (2019) added that mangroves provide various services for coastal ecosystems, including protection against floods and storms, control of sediment flow and transport, maintaining water quality, providing nutrient sources, habitats and nursery areas for plants and animals, sources of diversity biodiversity, and others, thereby increasing mangrove cover. means that the services provided will be emphasized.

Mangrove Importance Value Index (IVI) and Density

One of the ways to determine the ecology of mangrove forests is by calculating it Importance Value Index. The data is obtained by calculating density, frequency, and relative dominance. The Importance Value Index of each species at each station presented in Table 4.

Table 4. Mangrove Importance Value Index (IVI) at Research Site

Site		IVI (%)		
		R. mucronata	*A. marina*	Total
Pemalang	1	179,17	120,83	300
	2	205	95	300
	3	160	140	300
	4	192,5	107,5	300
Semarang	5	167,86	132,14	300
	6	192,5	107,5	300
	7	180	120	300
	8	204,17	95,83	300
Demak	9	107,5	192,5	300
	10	108,33	191,67	300
	11	70	230	300
	12	117,86	182,14	300

Based on the results obtained, it can be seen that at stations 1–8 or in the mangrove forest area of Mojo Village, the index of importance value is dominated by *R. mucronata* species, while at stations 9-12 or mangrove forest areas in Tugu Village and Bedono Village, the highest index of importance value is dominated by the species *A. marina*. The IVI value can be used to indicate the level of control of the species in its habitat. This is in accordance with the research of (Puryono and Suryanti, 2019b) mangroves in the village of Mojo Pemalang dominated by *R. mucronata*.

Based on the calculation of mangrove species density at all stations, it can be seen that the highest density is at station 8 with 730 ind / ha and the lowest density is at station 1 with 526 trees / ha. Density and dominance calculation data can be seen in the appendix. Data on mangrove tree density, seedlings and logging activity are presented in Table 5.

The results of the calculation of the Importance Value Index (IVI) obtained show differences in each research location. The mangrove species *R. mucronata* had a higher and more dominant IVI compared to *A. marina* species at the research locations in the mangrove forest areas of Pemalang Regency and Semarang City. Whereas in the mangrove forest area of Demak Regency, the IVI type of A. marina was higher and more dominant than that of *R. mucronata*. The difference in the IVI value can be used to show the level of tenure between species in one habitat and another. Parmadi et al., (2016), argue that differences in important values can be caused by competition between species. Competition can be in terms of how much sunlight is obtained and how to process the nutrients obtained. Other influencing factors are the ebb and flow of the substrate.

Table 5. Density, Presence of Seeds, and Logging of Mangrove at The Research Site

Site	Density (ind/ha)	Seed Presence	Logging
1	526	Yes	Nothing
2	530	Yes	Nothing
3	553	Yes	Nothing
4	580	Yes	Nothing
5	657	Yes	Nothing
6	650	Yes	Nothing
7	692	Yes	Nothing
8	730	Yes	Nothing
9	692	Yes	Nothing
10	711	Yes	Nothing
11	650	Yes	Nothing
12	681	Yes	Nothing

The results of the calculation of mangrove density at the research location showed that the density in the mangrove forest area in Semarang City was higher than in other locations. The difference in mangrove density can be caused by several factors. These factors can come from the species itself or the habitat of the species. This is confirmed by Hotden et al., (2014), who state that the assumption of differences in mangrove density that occurs in their research is due to differences in environmental factors, including pH and salinity of sediments. This is also reinforced by Buwono (2017) who states that environmental factors in the form of nutrients such as leaf litter also affect the growth and development of mangrove ecosystems, resulting in differences in density.

Environmental Factors

The environmental factors of mangrove forests in the study were seen in the water and sediment conditions. Environmental factors of mangrove forests include water temperature, water salinity, water pH, soil salinity, soil pH and soil texture. The measurement of environmental factor variables was carried out in situ, while the soil texture in the field was only carried out by sampling, then further analysis was carried out in the laboratory. The data from the measurement of environmental factors are presented in Table 6.

Table 6. Environmental Factors Measurement Result

Site	Environmental Factors				
	Water			Soil	
	Temperature (°C)	Salinity (ppt)	pH	Salinity	ph
1	29	30	8	28	6
2	30	29	8	28	6
3	29	29	8	27	6
4	29	29	8	28	6
5	31	30	8	28	6
6	30	30	8	27	6
7	31	30	8	28	6
8	31	30	8	28	6
9	30	30	8	28	6
10	31	30	8	28	6
11	30	30	8	28	6
12	30	30	8	28	6

The results of water temperature measurements for all stations range from 29-31 ° C. This is because the measurements were made at the same time range, which is around 10.00-12.00 WIB. The results of measurements of water salinity, soil salinity, water pH, and soil pH also have the same range because each station is directly adjacent and not too far from the shoreline.

Based on the results of measurements of environmental factors, the water temperature at all research stations fluctuated very little with values ranging from 29 - 31 ºC. This is because almost the entire surface of the land and waters below is shaded by mature and tall mangroves so that incoming solar radiation decreases and causes a uniform range of water temperatures at the research location. This is confirmed by Setyawan et al., (2002) that the high and low temperatures in mangrove habitats are caused by the intensity of sunlight received by water bodies, the large or small amount of water volume inundated in mangrove habitats, weather conditions and the presence or absence of shade (closure) by plant.

The salinity of water and sediment obtained based on observations at all stations also fluctuates very little with values ranging from 29-30 ppt and 27-28 ppt. Based on the research location which is directly adjacent to the coastal area, it is possible that the entry of sea water is more dominant than fresh water so that the salinity value in the area is high and tends to be uniform. This is reinforced by Kushartono (2010) that the increase in salinity concentration is influenced by water entering the ground from seawater intrusion that comes at tides where the sea water is Aini et al., (2016), the salinity of sediments can vary greatly depending on at its location. The high and low concentration of sediment salinity is also influenced by the amount of sea water that enters the mangrove forest area during tidal waves.

The results of sediment pH measurements at all research locations were around 6. This pH value range indicates the normal sediment pH range for the mangrove forest ecosystem. This is confirmed by English et al., (1997) *in* Rachmawati (2012) that most of the soil pH in mangrove forests is in the range of 6-7, although there are some that have soil pH values below 5. While for the water pH is also quite stable, which is around 8. This water pH range also shows that the research location has a water pH range that is still suitable for the water pH range in the mangrove ecosystem. This is confirmed by Juwita et al., (2015) that the optimum pH in the mangrove area is 7.5 - 8.5.

The results of measuring the soil texture of the research location at the research location are presented in Table 7.

Based on the calculation of the sediment texture in the research location, it can be seen that the texture of the sandy clay is dominated. The sand fraction dominates almost all stations with the highest percentage, namely 82% being at station 13 and the lowest percentage of sand fraction at station 6 with a percentage of 50%.

The results of measurements of sediment texture analysis that have been carried out at a depth of 30 cm at the study site, found that the content of sand (sand) is higher than the other 2 types of sediment and the content of silt (dust / mud) is higher than clay (clay). The existing sand sediment texture can be caused by high waves from the sea due to its location near the coast, while the existing mud sediment texture is usually caused by the mangrove root system. This was also stated by Mahmud et al., (2014) who stated that the type of soil that dominates the mangrove area is usually the dusty clay fraction as a result of the existing mangrove root density. In addition, according to the results of research by Setiawan (2013), it is stated that the binding of dust and clay particles by the roots of mangrove vegetation, over time these particles will settle and form mud.

Table 7. Soil Texture Measurement Results

Site	Soil Fraction (%)			Soil Texture
	Sand	Silt	Clay	
1	61	32	7	Sandy Loam
2	74	13	13	Sandy Loam
3	68	12	20	Sandy Loam
4	71	12	17	Sandy Loam
5	80	14	6	Clay Sand
6	50	30	20	Clay
7	80	6	14	Sandy Loam
8	82	7	11	Clay Sand
9	60	31	9	Sandy Loam
10	54	34	12	Sandy Loam
11	62	21	17	Sandy Loam
12	67	23	10	Sandy Loam

Observation of sediment texture at the research location was dominated by sand fraction at almost all stations. The high sand fraction makes the sediment classified as sandy clay clay. The substrate type can be influenced by the location of the observation station. This is confirmed by Yulma et al., (2019), the dominance of this type of substrate is assumed because of the location around the riverbank where the location tends to be open.

Environmental Factor Correlation of Mangrove Forest

The results obtained were then analyzed the data. Data analysis was performed using Principal Component Analyze (PCA). PCA analysis is used to see the relationship between the calculated variables. The results of PCA analysis, the relationship between variables that affect mangrove density, can be seen in Table 8.

Table 8. Rotation Component Matrix of PCA Result

Variables	Component			
	1	2	3	4
Water_Temperature	.861	.220	-.152	.258
Mangrove_Density	.822	-.016	.429	.101
Water_pH	-.693	.190	-.100	.465
Soil_Salinity	-.205	.899	.204	.169
Clay_Fraction	-.134	-.869	.018	.254
Water_Salinity	.469	.628	-.159	-.335
Silt_Fraction	-.040	.135	-.976	-.007
Sand_Fraction	.100	.262	.948	-.108
Soil_pH	.124	-.189	-.061	.941

Mapping of PCA analysis of the relationship between variables in the study location from the data Table 10. Rotated Component Matrix is presented in Figure 10.

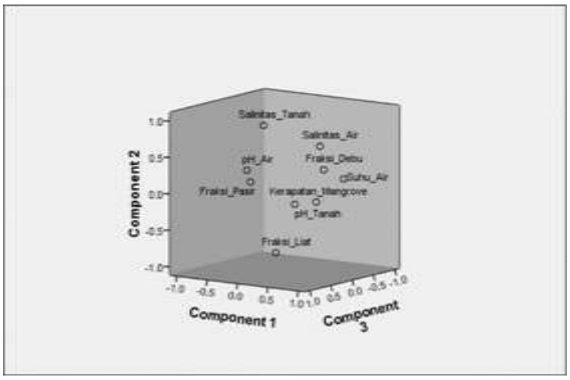

Fig 10. Rotated Component Matrix Mapping

Based on the picture above, mangrove density is related to water temperature and pH. Mangrove density has a positive correlation with water temperature but has a negative correlation with water pH. This can be interpreted that if the mangrove density has decreased, then the water temperature has decreased as well as for the opposite condition. Meanwhile, if the mangrove density has decreased, the pH of the water will increase as well as for the opposite condition. Other environmental factors, namely clay fraction, soil salinity, and water salinity are related but not with mangrove density. Likewise, dust and sand fractions have a relationship with one another but have no relationship with mangrove density at the research location.

Based on the analysis using Principal Component Analysis (PCA), it was found that mangrove density had a negative correlation with water pH but positively correlated with water temperature. Each type of organism, including plants, has a different tolerance range for environmental factors. Plants that have a wide tolerance range are resistant to unfavorable environmental conditions, which under certain conditions are referred to as environmental stress. These conditions include drought stress, water humidity, high temperature, low temperature, and high salinity. Ramayani et al., (2012) added that stress is all environmental conditions that allow it to reduce and harm plant growth or development in its normal function. As stated above, one of the environmental stresses that occur in plants is that it can be caused by pH and temperature.

In general, pH plays an important role in the life of mangrove vegetation. pH can affect the growth of mangrove seedlings. This is in accordance with the results of research from Andarani et al., (2016), namely that pH has a negative effect on the growth of *R. mucronata* seedlings. Judging from the results of the study that showed a comparison of mangrove growth at high and low pH levels, where with a high pH content the growth of mangrove seedlings was shorter than mangrove seedlings with a lower pH or it could be said to inhibit growth.

Not much different from salinity, water temperature is also an important environmental factor for mangrove growth. Based on the research results obtained water temperature can still be said to be good. This was confirmed by Kusmana et al., (2010), who stated that good mangrove growth requires an average temperature of> 20 ° C and the difference in seasonal temperatures does not exceed 50 ° C. This temperature range is good for mangrove growth. Alongi (2009) states that the maximum stomata conductance and assimilation rate in mangrove leaves ranges from 25-30 ° C and will experience a rapid decline at temperatures above 35 ° C. For the *Rhizophora* species, photosynthesis is the fastest at 25 ° C and will decline sharply at temperatures above 35 ° C. Apart from affecting the physiological processes of mangrove plants, water temperature can also affect the activities of aquatic animals such as migration, predation, swimming speed, embryo development, and the speed of metabolic processes.

There are several things that affect the high temperature, including the intensity of direct sunlight if the mangrove area is slightly open because the distance between trees is rather large. Apart from having an effect on water temperature, this can also affect the substrate temperature which also plays an important role in mangrove growth. This was confirmed by Hambran et al., (2014) which stated that in addition to air temperature, substrate temperature is also a factor that affects the types and levels of mangrove diversity. Substrate temperature is very helpful in the process of mineral decomposition in mangrove habitat, which is used by mangrove plants to meet their energy needs during growth. Temperature and humidity greatly affect species diversity in a habitat. The ideal substrate temperature for mangrove growing conditions ranges from 27 -31 ° C.

SWOT Analysis

Sustainable mangrove ecosystem management is carried out by collecting a number of data or information which is then analyzed using a SWOT analysis. The initial stage in compiling sustainable mangrove management is to know the internal and external factors.

a. Identification of Internal and External Factors

Internal factors which are the strengths and weaknesses as well as external factors that become opportunities and threats in containing sustainable mangrove management in the three research locations representing the north coast of Central Java were obtained from direct interviews with the community and field observations. The strength factors that exist in the three mangrove forest areas on the north coast of Central Java are quite attractive and good locations, the existence of an institution that manages the mangrove forest area and the support of local residents.

The weakness factors found in the three locations are facilities and infrastructure such as poor road access and lack of transportation to the location, lack of warning boards to prohibit damage to mangrove forests, insufficient availability of trash bins for tourists and lack of community supervision of mangrove forests. The results of the analysis of internal and external factors can be seen in the Table 9. and Table 10.

b. Compilation of Internal and External Factors Matrix

Determination of the weight and value assigned to each factor is adjusted to the scale of importance of sustainable mangrove management in the north coast of Central Java. The weight of each internal and external factor is determined by the Paired Comparison method, in order to obtain the weight of each variable along with the rating value for each factor. Discussion of internal strategic factors for sustainable mangrove management can be seen in the Table. 11 and Table. 12 below.

Based on the table above, the total internal factor score is 2.748, this shows that the internal conditions of the area have strength in sustainable mangrove management. The strengths of the three mangrove ecosystem locations on the north coast of Central Java are able to cover existing weaknesses. While the external factors obtained by the total external factors are 2.605, so a study using a SWOT analysis of mangrove forest areas is needed in order to get better management.

Table 9. Results of Analysis of Internal Factors and Level of Interest in Sustainable Mangrove Management

Symbol	Strenght Factor	Importance Level
S1	Location has interesting views	Moderate
S2	Attract tourists	Moderate
S3	Get support from community	High
S4	There is an institution that manages mangrove	High
Symbol	**Weakness Factor**	**Importance Level**
W1	Inadequate facilities and infrastructure	Moderate
W2	Lack of supervision	Significant low
W3	Far from settlement	Meaningless
W4	Lack of community participation in mangrove ecosystem management	Low

Table 10. Results of Analysis of External Factors and Level of Interest in Sustainable Mangrove Management

Symbol	Opportunities Factor	Importance Level
O1	The area is suitable for mangrove planting	Medium odds, average response
O2	Many visits from academia and government conduct research	Medium odds, average response
O3	There is positive support from the government	High odds, superior response
O4	The existence of conservation activities carried out by local NGOs	High odds, superior response
Symbol	**Threats Factor**	**Importance Level**
T1	Covid-19 Pandemic	High threat
T2	Abrasion	High threat
T3	Over Exploitation	Moderate threat
T4	Pollution	Low threat

c. Compilation of Internal and External Factors Matrix

The SWOT matrix is made to determine alternative priorities that will be used as policies in sustainable management, then the total score of the related SWOT factors is carried out, so that the priority ranking is obtained. The first priority is the strategy with the highest total score first, the second priority is the strategy with the second highest total score and so on. The SWOT matrix obtained several formulations for sustainable management in mangrove forest areas in the North Coastal Mangrove Ecosystem of Central Java as follows (Table 13).

Table 11. Matrix of Analysis of Internal Factors for Sustainable Mangrove Management

Internal Factor	Quality	Rating	Score
Strength			
1.Location has interesting views	0,112	2	0,224
2.Attract tourists	0,114	2	0,228
3.Get support from community	0,136	3	0,408
4.There is an institution that manages mangrove	0,150	4	0,6
Weakness			
1. Inadequate facilities and infrastructure	0,120	2	0,24
2. Lack of supervision	0,143	4	0,572
3. Far from settlement	0,098	1	0,098
4. Lack of community participation in mangrove ecosystem management	0,127	3	0,381
Total Score	**1**		**2,748**

Table 12. Matrix of Analysis of External Factors for Sustainable Mangrove Management

External Factor	Quality	Rating	Score
Opportunity			
1. The area is suitable for mangrove planting	0,116	2	0,232
2. Many visits from academia and government conduct research	0,129	2	0,258
3. There is positive support from the government	0,164	4	0,656
4. The existence of conservation activities carried out by local NGOs	0,134	3	0,402
Threats			
1. Covid-19 Pandemic	0,120	3	0,366
2. Abrasion	0,143	2	0,23
3. Over Exploitation	0,098	1	0,098
4. Pollution	0,127	3	0,363
Total Score	**1**		**2,605**

Based on the results of the SWOT matrix analysis, recommendations for finding sustainable mangrove management can be made:

- Strength-Opportunities Strategy

1. Developing mangrove areas as a means of education: The aim is to introduce and foster a sense of care for the environment, especially the mangrove ecosystem.
2. Conducting education to local communities regarding the benefits and functions of the mangrove ecosystem: This activity is carried out because it can change the mindset of the surrounding community towards mangroves, even though the community has known mangroves from an early age, many of them still lack knowledge about the benefits and importance of the mangrove ecosystem. Enriching public knowledge about the importance of

mangroves, is expected to influence community participation in mangrove management.

3. Improve relationships with parties who care about the mangrove ecosystem: Increased relations are carried out to improve the socio-economic welfare factor of farmer groups and communities around the mangrove ecosystem. These activities can be in the form of providing mangrove seeds, developing processed mangrove products and various activities that can support activities around the mangrove area.

- Weakness-Opportunities Strategy

1. Repair and add facilities and infrastructure: Facilities and infrastructure are one of the important factors in supporting sustainable mangrove management activities. This includes accessibility such as road conditions, transportation advice and road signs, lodging, and various other things that can make it easier for tourists to get to the location of the mangrove area.
2. There is a need for more intensive management and monitoring: The problem that needs to be resolved in this case is related to the location of the mangrove area which is quite far from residential areas and in some locations requires a boat as a means of transportation to reach the location. There are still hunting activities for endemic species that are protected by mangrove areas, as well as excessive use of mangroves. In addition, the expensive transportation to the mangrove area is also a problem in itself, because it can reduce the number of visitors.
3. Provide community participation in mangrove ecosystem management: Giving the community participation in all activities related to mangrove area management is very necessary, this will lighten the performance of the government and existing NGOs, because the local community better understands the condition of the mangrove area. The management activities in question start from planning, implementing mangrove planting to protecting mangrove areas.

Internal Factor / **External Factor**	**Strength**	**Weakness**
	1. Location has interesting views 2. Attract tourists 3. Get support from community 4. There is an institution that manages mangrove	1. Inadequate facilities and infrastructure 2. Lack of supervision 3. Far from settlement 4. Lack of community participation in mangrove ecosystem management
Opportunities (O)	**SO Strategy**	**WO Strategy**
1. The area is suitable for mangrove planting 2. Many visits from academia and government conduct research 3. There is positive support from the government 4. The existence of conservation activities carried out by local NGOs	1.Floating location as a means of education. 2.Conducting education to local communities regarding the benefits and functions of the mangrove ecosystem. 3.Improve relationships with parties who care about the mangrove ecosystem.	1.Repair and add facilities and infrastructure. 2.There needs to be more intensive management and supervision. 3.Provide community participation in mangrove ecosystem management.
Threats (T)	**ST Strategy**	**WT Strategy**
1. Covid-19 Pandemic 2. Abrasion 3. Over Exploitation 4. Pollution	1. Provide guidance regarding proper and correct waste management for pond entrepreneurs. 2. Confirmation of land ownership in mangrove areas.	1. Increase awareness to the public regarding balanced use and management. 2. Develop more products from mangrove base materials that have been managed by the surrounding community.

- Strength-Threats Strategy

1. Provide guidance regarding proper and correct waste management for pond entrepreneurs: Poor waste management in the area around mangroves can have a negative impact on the survival of living creatures in the mangrove area, therefore guidance to the community and pond cultivators must be done to restore a good mangrove ecosystem.
2. Confirmation of land ownership in mangrove areas: This needs to be done in connection with the conversion of land functions from mangrove areas to ponds. Land ownership must be proven by a land certificate

- Weakness-Threats Strategy

1. Increase public awareness regarding the use and management must be balanced: Excessive use will reduce the existing mangrove ecosystem, therefore the community needs to be nurtured to participate in planting good mangroves in aquaculture areas and river estuaries so that the mangrove population is maintained.
2. Develop more products from mangrove base materials that have been managed by the surrounding community: Increase the role of the existing mangrove working group to provide guidance and training to the community to make various processed mangrove products so that they

can improve the welfare of the surrounding community.

CONCLUSION

Throughout 2014-2020 the mangrove forests of Pemalang Regency experienced extensive degradation of 26.89 ha, Semarang City experienced an extensive gradation of 42.97 ha, and Demak Regency experienced an area gradation of 58.55 ha.

The range of values for environmental factors of mangrove forest at the research location, namely mangrove density ranges from 503-726 ind / ha, sediment texture is dominated by sandy loam, water temperature ranges from 29-31 ° C, water salinity ranges from 29-30 ‰, salinity sediment ranges from 27-28 ‰, water pH ranges from 8, and sediment pH ranges from 6.

The PCA analysis results show that the mangrove forest supporting variables consist of four groups. The first group is mangrove density, temperature and water pH. The second group is soil salinity, clay form, and water salinity. The third group is the dust and sand fraction. The fourth group is soil pH. Based on the results of PCA analysis, mangrove forest density has a positive correlation with water temperature and a negative correlation with water pH.

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