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### ASSESSMENT OF MANGROVE ECOSYSTEM POTENCY AND ITS UTILIZATION IN DOMPU REGENCY COASTAL WATERS, WEST NUSA TENGGARA PROVINCE USING SATELLITE IMAGERY APPLICATION

### POTENSI EKOSISTEM MANGROVE DAN TINGKAT PEMANFAATANNYA DI WILAYAH PESISIR KABUPATEN DOMPU, PROVINSI NUSA TENGGARA BARAT

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#### ABSTRAK

Mangrove ecosystem forests are tropical coastal vegetation communities, which has the ability to grow in coastal area with tidal and muddy environment. Several functions of mangrove ecosystem forest such as ecological functions can be used for coastal protection, trapping sediment and strengthen the coastal ecosystems. Coastal waters in Dompu Regency, West Nusa Tenggara have natural mangrove ecosystem with a huge potency and advantages to the region. This study aimed to understand the condition of mangrove ecosystem based on satellite image analysis of Landsat 8 Operational Land Imager (OLI) in 2014 and assess the potency, information related to the utilization by community. Data collection in this study were combined from satellite imagery interpretation with interview and questionnaires. The results showed that the mangrove forest extent in Dompu Regency Coastal Waters were about 90,631 ha with uniformity index 0.68 (medium uniformity). Two mangrove species were found in the region namely *Rhizophora stylosa* and *Rhizophora apiculata* and used by the community for several purposes such as firewood, natural coastal protection from tidal, waves and abrasion, also for crabs and fish spawning ground.

**Keywords:** Mangrove forest ecosystem, mangrove utilization, Dompu Regency, satellite image interpretation.

#### ABSTRACT

Mangrove merupakan komunitas vegetasi pantai tropis, yang mampu tumbuh dan berkembang pada daerah pasang surut pantai berlumpur. Hutan mangrove mempunyai banyak fungsi lain, seperti fungsi ekologis yang dapat digunakan sebagai pelindung pantai, penahan lumpur dan penangkap sedimen yang diangkut oleh aliran air permukaan. Perairan Kabupaten Dompu Provinsi Nusa Tenggara Barat (NTB) merupakan kawasan yang memiliki hutan mangrove yang masih alami. Penelitian ini bertujuan untuk mengetahui kondisi ekosistem mangrove di pesisir Kabupaten Dompu, NTB berdasarkan analisis citra satelit landsat 8 tahun 2014, sehingga mampu menilai potensi dan mendapatkan informasi mengenai pemanfaatan mangrove oleh masyarakat. Teknik pengumpulan data merupakan kombinasi dari interpretasi citra satelit landsat 8 dengan metode wawancara dan kuisioner. Hasil penelitian menunjukkan bahwa terdapat luasan mangrove sekitar 90,631 Ha dengan indeks keseragaman sebesar 0.68 yang berarti keseragaman sedang dan ditemukan dua spesies mangrove yaitu *rhizophora stylosa* dan *rhizophora apiculata*. Bentuk pemanfaatan mangrove oleh masyarakat diantara adalah sebagai penghasil kayu bakar, pelindung pantai dari hampasan ombak dan abrasi dan penghasil nener dan kepiting.

**Kata kunci:** Ekosistem hutan mangrove, pemanfaatan mangrove, Kabupaten Dompu, interpretasi citra satelit.

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**INTRODUCTION**

Indonesia is the largest archipelagic country that has the potential and massive coastal marine resources, one of which is mangrove forest ecosystem. The characteristics of mangrove forest ecosystem in Indonesia is the highest diversity of species in the world. However, the condition of these mangroves forest ecosystem both qualitatively and quantitatively continuously to decline from year to year. The decline of mangrove quality is a serious concern along with the declining of the area caused by deforestation and forest degradation. Changes in canopy density are one indication to monitor both its quality and quantity. The utilization of remote sensing technology, especially using optical satellite imagery such as Landsat satellite has been used to monitor the natural resources (Purwanto *et al.*, 2014; Setyawan *et al.*, 2014). Remote sensing technology with satellites chosen based on several advantages such as efficiency, effectivity, relatively inexpensive and easily processing tool for monitoring difficult-to-reach and remote areas (Anggraini & Arief, 2015).

Dompu Regency waters located within two bays, namely Saleh Bay and Cempi Bay. This study focused on Saleh Bay, which covered an area of 1,495 km<sup>2</sup> and a length of 282 Km (Anonim, 2009). Saleh Bay waters have diverse coastal and marine natural resources, which considered as the new source of economic development in the future (Radjawane, 2006). As the center of marine-based economic activities such as fishing ground for traditional fisheries, seaweed cultivation, and fish aquaculture, Saleh Bay also known by its high marine biodiversity, and coastal ecosystem such as mangrove ecosystem forest, and coral reefs (Satria & Mujiyanto, 2011). These excellent conditions supported by the geographic of Saleh Bay which surrounded by many small islands, such as Dangar Rea Island, Liang Island, Ngali Island and Rak Island

(Ismunarti & Rochaddi, 2013).

The mangrove ecosystem forest area generally lives and grows in locations that have a tidal influence that inundates the river flow along the coast (Tarigan, 2008). Mangrove ecosystem forests consist of various organisms that also interact with each other. The physical functions of mangrove ecosystem forests include: controlling the rise of the boundary between the surface of the groundwater and the sea level towards the land (intrusion), as a buffer zone, spurring land expansion and protecting the coastline to avoid erosion or abrasion. Remote sensing technology has a vital role in mapping mangroves through its ability to see phenomena spatially (Candra & Rahmayani, 2016). The phenomenon at the surface of the earth has been carried out through analysis of data recorded with sensors both visually and digitally processed. The process of analysis and modeling often involves technology or other information that is closely related such as GIS or information on field data so that the information produced has a spatial reference and allows users to activate data as needed, analyze, and model it to reduce the new information needed (Arief *et al.*, 2017). Mangrove ecosystem forests can be identified using remote sensing technology, where the geographic location of mangrove ecosystem forests in the land and sea transitional areas provides a unique recording effect compared to other terrestrial vegetation objects (Faizal & Amran, 2005). With this technology, the spectral value of satellite images can be extracted into information on mangrove objects in the visible and near-infrared spectrum range (Suwargana, 2008).

Based on this, it is necessary to research with the aim to determine the condition of mangrove ecosystems on the coast of Dompu District, NTB based on an analysis of 2014 Landsat satellite images to be able to assess potential and obtain information about the use of mangroves by the community.

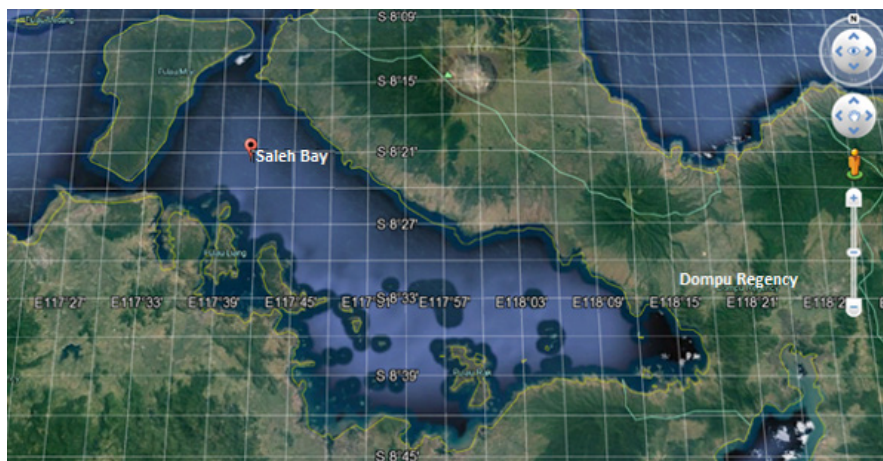


Figure 1. Research location.

**METHODOLOGY**

The study was conducted in May 2016 (transition season 1) in the waters of Dompu Regency, which is geographically located at 117°42' to 118°30' East Longitude and 8°06' 'to 9°05' South Latitude, with an area of 23,455 Ha of land and 239,296 Ha of water covering the waters of Saleh Bay (Figure 1).

Retrieval of coastal ecosystem data is carried out in 6 points (2 points of the coral reef ecosystem, two mangrove point ecosystems, and two seagrass point ecosystems). The coordinates of coral reef ecosystems are coral reefs 1 (08°38'16.41 "S and 118°12'05.04" E), coral reefs 2 (08°35'39"S and 118°11'57.99"E), the coordinates of the mangrove ecosystem are mangroves 1 (08°38'43.95"S and 118°12'09.14"E), mangrove 2 (08°39'36.58"S and 118°10'43.05"E), the coordinates of seagrass ecosystems are seagrasses 1 (08°38'46.11"S and 118°13'07.53"E), seagrass 2 (08°39'35.01"S and 118°10'43.23"E), as shown in Figure 2.

**Data Collecting of Mangrove Ecosystem**

Data collecting of mangrove ecosystems was done using transect sampling techniques. Transects are placed perpendicular to the coastline to land with a size of 10x10 m in length, depending on field conditions (the distance of mangrove ecosystem on the shore with the borders of mangrove ecosystem with land behind mangrove ecosystem) as in Figure 3. (Onrizal & Kusmana 2008). According to Onrizal & Kusmana (2008), the stand size used in the analysis of mangrove ecosystem vegetation activities is as follows: 10 x 10 m sample plots for trees (> 10 cm in diameter with height> 1.5 m), sample plots 5 x 5 m for saplings (<10 cm in diameter and <1.5 m in height), and sample plots 2 x 2 m for seedlings as shown in Table 1.

Analysis of the data used is the diversity index (H'), uniformity index (E), Dominance index (C), and type cover (Ci).

**Diversity Index (H')**

The Shannon-Wiener diversity index is used to determine the diversity of species at each growth rate (Odum, 1993 in Supriandi *et al.*, 2015) with a range of

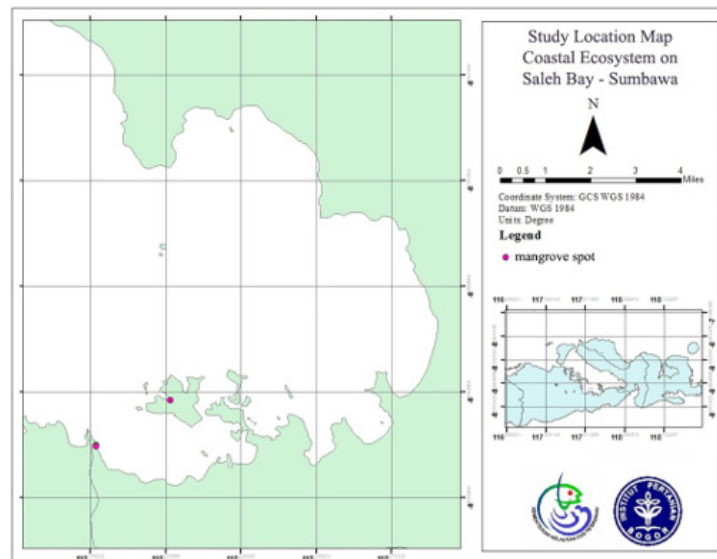


Figure 2. Observation Points.

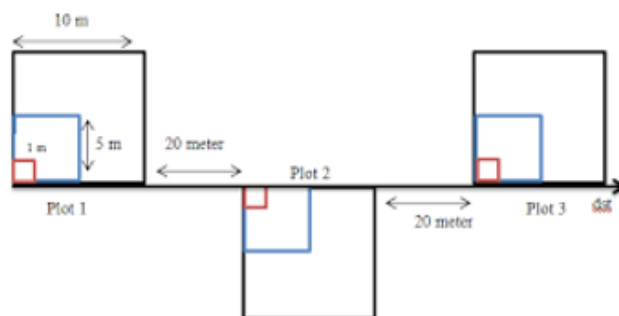


Figure 3. Mangrove data collection methods (Onrizal & Kusmana, 2008).

Table 1. Field observation results

Tools	Material
<b>Mangrove</b>	
Transect 10 x 10 m	New top
Transect 5 x 5 m	Office stationery
Transect 1 x 1 m	
Data sheet	
Roll Meter	
Camera	
Substrate	

$H' \leq 2.0$ : low diversity, high ecological pressure;  $2.0 < H' \leq 3.0$ : moderate species diversity, moderate ecological pressure; and  $H' > 3.0$ : high species diversity, low ecological pressure.

**Uniformity Index (E)**

The uniformity index (E) is used to determine the balance of the community, that is a measure of the similarity of the number of individuals between species in a community (Supriandi *et al.*, 2015). The more the number of individuals between species, the greater the degree of balance  $0 < E \leq 0.5$ : low uniformity, the ecosystem is in a depressed condition;  $0.5 < E \leq 0.75$ : medium uniformity, the ecosystem is in a less stable condition; and  $0.75 < E \leq 1.0$ : high uniformity, the ecosystem is in a stable condition.

**Dominance Index (C)**

The Simpson Dominance Index is used to determine the extent to which a group of biota dominates another group. Significant dominance will lead to labile and depressed communities with a range as follow:  $0 < C \leq 0.5$ : low dominance (there are no species that dominate the other species to the extreme), unstable conditions, and no ecological pressure on biota at that location;  $0.5 < C \leq 0.75$ : moderate dominance and relatively stable environmental conditions; and  $0.75 < C \leq 1.0$ : high dominance

**Water Quality**

Mangrove ecosystem density influence the adjacent water quality which is important for sustainability of ecological proceses such as nutrient cycle, stable environment and buffering system (Wantasen, 2013). Water chemical parameter such as salinity, degree of acidity (pH) and dissolved oxygen, while water physical parameter such as turbidity and clarity and temperature, both water quality parameter are associated with the mangrove growth rate.

**Tidal**

Tidal play an important role in the coastal region, especially in mangrove ecosystem, where it can be functioned as a media to distribute mangrove seeds as part of mangrove growth and expansion. Tidal type

mostly influenced by the atmospheric factors that might be different in every region, causing the range of tidal between low sea level and high sea level differ. This condition affect the accessibility of sea water penetration in mangrove ecosystem and suitable location for mangrove to grow and develop.

**Remote Sensing Analysis**

Analysis and interpretation of multi-band (Landsat 8 OLI) satellite images conducted to identify the mangrove distribution in the research location. The transformation process of satellite imagery used is the composite band (channel) 5, 6, and 4 with red, green, and blue (RGB) coloring. Through the transformation of color composites on three different channels, the color hue on vegetation cover associated with the tidal substrate will clearly and contrast with land cover vegetation. In this transformation, the level of mangrove damage will also be easily identified.

To identify the level of density of mangroves at the location of the study carried out through a transformation of satellite imagery and calculation of mangrove density: a. The transformation of satellite imagery used in the analysis of the density of mangrove ecosystem is an analysis of the Greenness Index (GI) through the equation:

$$GI = -0.24147B1 - 0.16263B2 - 0.40639B3 + 0.85468B4 + 0.05493B5 - 0.11749B7 \dots\dots\dots (1)$$

The Greenness Index transformation is also known as greenish index transformation, assuming that vegetation meetings will provide a high index value. GI transformation uses several channels, among others; TM 1, TM 2, TM 3, TM 4, TM 5, and TM 7 (Kauth *et al.*, 1979; Thompson 1980 in Jensen, 1998; Crist, 1984).

b. Furthermore, in the field check activity, a tree density is measured by making a plot that is placed perpendicular to the coastline, while a 10 m x 10 m observation plot was made, sampling mangroves covered by trees and saplings (Bengen, 2002). Calculation of the density of the type of mangrove measurement activities in the field is done by calculating the number of types i stands in a unit area, the calculation according to Bengen (2000):

$$Di = n/A (i/ind m^2) \dots\dots\dots (2)$$

Where, Di is density type i, this is the total number of stands of type i and A is the total area of the sampling area (class). Image classification is based on the magnitude of the vegetation index value. The vegetation index value for each transformation is classified to determine the density level as show in Table 2).



Table 2. Mangrove Density Class of the Vegetation Index Value

No.	Density Level	Transformation Index Vegetation Greenness Index (VGI)
1	Less Dense	0 - 25
2	Medium Dense	26 -30
3	High Dense	> 30

**RESULTS AND DISCUSSION**

**Mangrove Ecosystem**

The results of remote sensing analysis of Landsat 8 satellite images in 2014 were successfully determined the extent of mangrove ecosystems with an area approximately 90,631 Ha (Figure 4).

The location of the mangrove data collection was carried out in 2 different locations with each location having two substations with a distance of 50 meters between substation 1 and substation 2 (Figure 5).

The location of the mangrove data collection was carried out in 2 different locations with each location having two substations with a distance of 50 meters between substation 1 and substation 2 (Figure 5). Analysis of the data used is the diversity index ( $H'$ ), uniformity index ( $E$ ), Dominance index ( $C$ ), and type cover ( $C_i$ ).

**Diversity Index ( $H'$ )**

The Shannon-Wiener diversity index is used to determine the diversity of species at each growth rate

(Odum, 1993 in Supriandi et al., 2015) with a range of  $H' \leq 2.0$ : low diversity, high ecological pressure;  $2.0 < H' \leq 3.0$ : moderate species diversity, moderate ecological pressure; and  $H' > 3.0$ : high species diversity, low ecological pressure.

**Uniformity Index ( $E$ )**

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**Dominance Index ( $C$ )**

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At station one substation 1 (1.1), it can be seen that the mangrove diversity index is 0.47, which means that the diversity of species is low, the ecological pressure is high with the uniformity index being moderate, the ecosystem is in a less stable condition with a value of

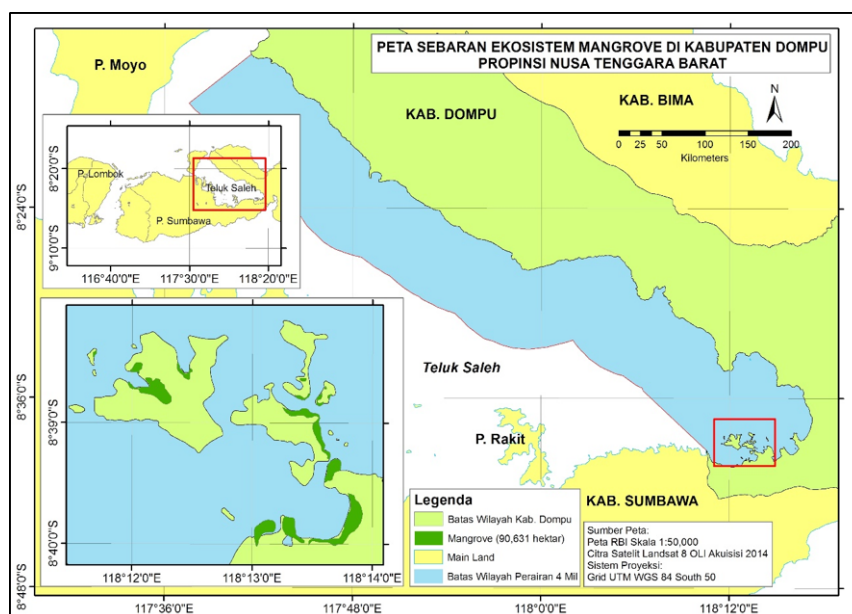


Figure 4. Mangrove distribution map in Dompu Regency, NTB Province.

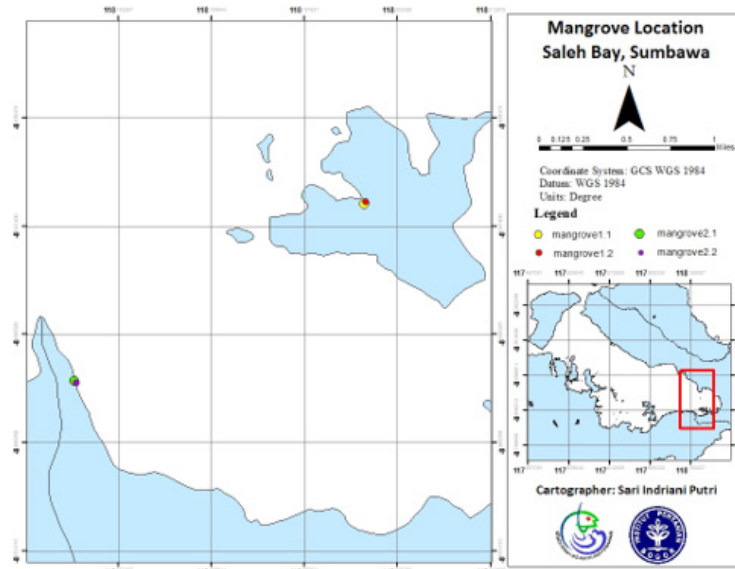


Figure 5. Mangrove ecosystem, Diversity Index, Uniformity, and Dominance Graph in Observation Points.

0.68. At station one substation 1 (1.1) two mangrove species were found, namely *Rhizophora stylosa* and *Rhizophora apiculata*. Dominance index obtained at 0.84 means high dominance (some species dominate other species), environmental conditions are unstable, and there is an ecological pressure with mangrove dominance *Rhizophora apiculata*.

species namely *Rhizophora stylosa* and *Rhizophora apiculata* (Figure 6). Mangrove species cover at 1.1 is 0.00014 for *Rhizophora stylosa* and 0.000025 for *Rhizophora apiculata*. In 1.2 capsules the type of *Rhizophora apiculata* is 0.000765, the cover type of *Rhizophora apiculata* is 0.001809 at 2.1, and the cover type of *Rhizophora apiculata* is 0.001199 in 2.2.

At station 1 substation 2 (1.2), at station 2 substation 1 (2.1) and station 2 substation 2 (2.2) have a diversity index value of 0 which means the level of species diversity is low, high ecological pressure and uniformity index value 0 because on substation 2 only found by mangrove with species of *Rhizophora apiculata*. The dominance index possessed on substation 2 is 1 which means high dominance (some species dominate other species), environmental conditions are unstable, and there is an ecological pressure. The dominating species is *Rhizophora apiculata*.

**Waters Chemical Parameter Salinity**

Salinity is one of the factors that significantly determines the development of mangroves, therefore, zoning of each mangrove habitat is always different according to local environmental conditions. Salinity in seawater salinity at two stations of the mangrove ecosystem still shows no significant difference because it is still in the ranged of around 31-34 ‰. This salinity condition caused by is because the station point of mangrove ecosystem location with no source of freshwater is not available for freshwater and is situated in an open zone, and is directly facing the high seas so that it affects salinity in these habitat areas

**Type Cover (Ci)**

Station 1 substation 1 (1.1) found two mangrove

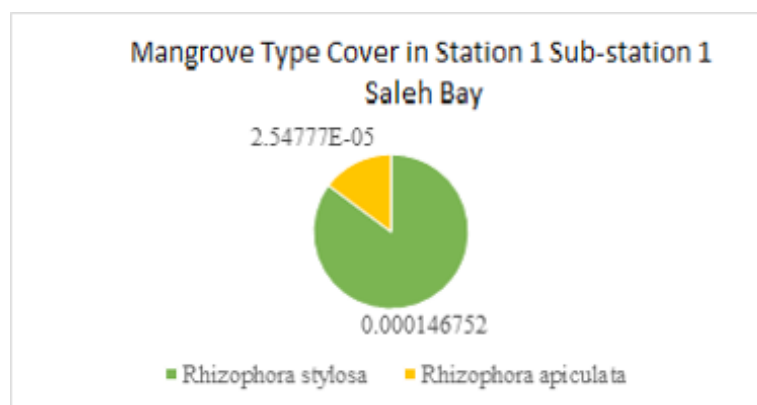


Figure 6. Mangrove species and coverage at station 1 sub-station 1 (1.1).

Table 3. Water Quality of Mangrove Ecosystem

Station	1	2
Ecosystem	Mangrove	
pH	8.07667	8.16
DO (mg/L)	5.85	7.03
Conductivity	4.63	4.64
Turbidity	2.73333	13.36667
Temperature	31.1	32
Salinity	31.0333	31.2
dT	18.3333	18.1
Dept	0.66667	0.36667
CHLO	0	0

(Jesus, 2012). The temperature at both stations is at the normal threshold of seawater temperature which is ranging at 27-32 °C.

**Degree of Acidity (pH)**

The degree of acidity (pH) of water at two stations of the mangrove ecosystem has a value of 8. According to Kaswadji (1971) in Jesus (2012) states that pH with a value of 5.5 - 6.5 and > 8.5 included less productive waters, while waters with pH 6.5 - 7.5 including included as in productive waters and pH 7.5 - 8, 5 including included as waters with high productivity. This pH variation is caused by the levels of organic matter and minerals in sedimentary soil, as well as the mineral content of seawater. From 2 stations have a with pH value of 8 which means that the waters in the area are classified as waters with high productivity.

**Water Physical Parameter**

**Turbidity and Clarity**

Brightness refers to the transparency of waters and depends on color and turbidity. Brightness values are strongly influenced by weather conditions, time of measurement, turbidity, and suspended solids. Water brightness is generally low at stations on edge or near land compared to stations in the middle of Saleh Bay waters. Brightness of the waters at the quality limit was found at stations 13 and 54 where at station 13

it was suspected to be cloudy because it was close to the non-vegetated area so that land flow from the land was still affected, while at station 54 was the area of mangrove vegetation which contributed to detritus higher than the area other. The increase in brightness value is proportional to the increase in the value of suspended solids (TSS). This tendency is common in seawater even though it does not occur in stations in the middle (Figure 7), although suspended solids correlate negatively with brightness and instead positively correlate with turbidity (Chapman, 1996; Effendi, 2003).

**Waters Temperature**

Surface temperature influenced by the geographical position of a water, seasons, time of observation, air circulation, cloud cover and depth of water (Chapman, 1996). Temperature plays a key role in the physical, chemical and biological processes of a water. The high profile of the temperature shows a decrease with increasing depth (Figure 8). This is caused by an intensive process of light absorption compared to the lower layer (deeper water column). The temperature of the waters of Saleh Bay is in the range of 30.8 - 32.3 °C, this value is still following sea water quality standards for biota, especially mangrove, but exceeds the quality standards for coral reef ecosystems. Temperature fluctuations at depths of 0 to 2 m in this measurement are relatively dynamic due to the mixed layer depth.

Temperature comparisons in measurements from 2006 to 2016 were found to have increased by 1.96°C from 2006 with temperatures of 29.61°C (Mujianto & Wasilun, 2006). The increase is feared to have an impact on the condition of coral reefs in Saleh Bay waters. Changes in varying temperatures can affect the life of coral reefs (Tambunan et al., 2013). An increase in temperature can also cause a decrease in gas solubility in water, such as O<sub>2</sub>, CO<sub>2</sub>, N<sub>2</sub>, etc. (Haslam 1995).

**Dissolved Oxygen (DO)**

Dissolved Oxygen is needed by all living bodies

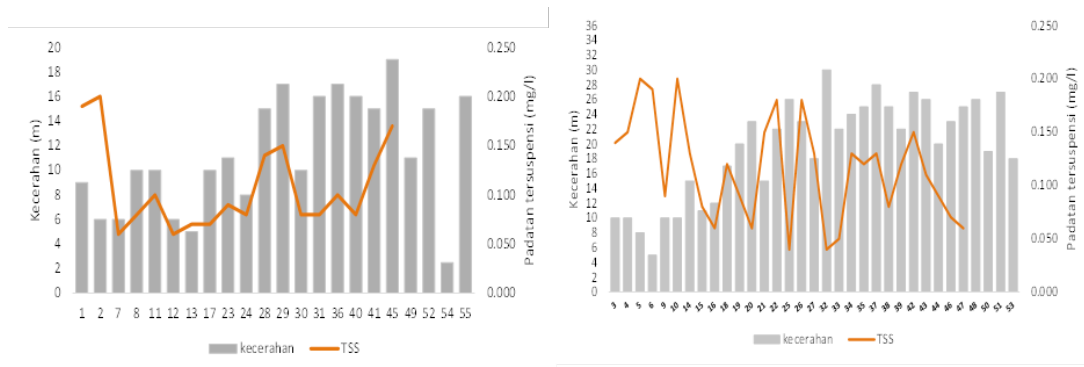


Figure 7. Water clarity and suspended solid at the station near land (a), and middle station (b).

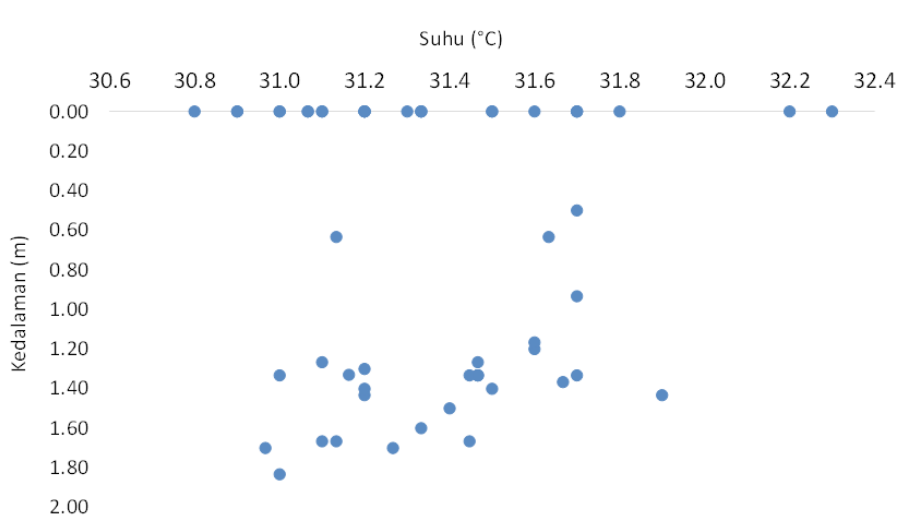


Figure 8. Temperature profile in Saleh Bay waters .

for breathing. Besides that, dissolved oxygen is also needed for the oxidation of organic and inorganic materials in aerobic processes. The main source of oxygen in a waters comes from a process of diffusion from free air and the results of photosynthesis of organisms that live in these waters (Amarullah, 2011). Dissolved oxygen in the sea is very important to carry out the process of respiration in influencing the life of living organisms including seaweed.

From the results of measurements of dissolved oxygen content in Gulf waters, the range of dissolved oxygen values was obtained between 7.13-7.49 mg/l. The average value of dissolved oxygen is 7.4 mg/l, the highest dissolved oxygen level is 8.27 mg/l, while the lowest is 7.12 mg/l. Map of dissolved oxygen distribution Figure 43 shows that the dissolved oxygen content is relatively large, but high dissolved oxygen levels are in the south of the waters because there are many ecosystems such as mangroves, seagrasses and coral reefs. Whereas the north side of the waters is low. This condition is thought to be influenced by the mixing and movement of water masses, photosynthetic activity, respiration, waste that enters the water body and the intensity of the rain. Oxygen levels in Saleh Bay waters are quite large because it is influenced by several things such as sampling time measured during the morning before noon to evening and weather conditions at the time of collection. During the day photosynthesis is higher because the intensity of sunlight is higher than morning and evening so that the oxygen produced will be more.

### Tidal

Saleh Bay waters have a mixed tidal type dominated by semi-diurnal tides. Regions with semidiurnal tidal types, if there is an input of pollution materials, the pollutants will not immediately flush out, so it is considered to have a high level of vulnerability

to the danger of pollution. Tidal phenomena also play a role in aquaculture activities. Regions with tidal types of mixed types dominated by single tides are more supportive of aquaculture activities because they have a greater ability to supply fresh water with higher oxygen levels and abundant plankton, and on the contrary there is a flushing of old water that is lacking in oxygen and full of metabolites (Marzuki *et al.*, 2013). Coastal biota in coral reef habitats, mangroves, and seagrass beds are also concerned with tides.

### CONCLUSION

The results of remote sensing analysis of Landsat 8 satellite images in 2014 were successfully determined by mangrove ecosystems with an area of about 90,631 Ha; The results of the identification of coastal ecosystem conditions including mangrove, seagrass, and coral reefs were in fairly good condition with a mangrove uniformity index of 0.68 moderate meaning uniformity and found two mangrove species namely *Rhizophora stylosa* and *Rhizophora apiculata*. Seagrass uniformity index is 0.82 which means high uniformity and the ecosystem is in a stable condition and found three seagrass species namely *Enhalus acroides*, *Cymodocea rotundata*, and *Halodule ovalis*. The coral reef uniformity index is 3.44 which means high uniformity and stable ecosystem conditions and found six lifeforms, namely coral massive coral, coral submissive coral, coral folios coral, acropora branching, encrusting coral, and coral mushroom at the research location.

This current research suggests that remote sensing application were useful to map the potency of coastal ecosystem and its utilization in providing preliminary information in the field. Therefore it will be better to conduct satellite images analysis using higher resolution imagery, combined with time series analysis



to monitor changes of potency and utilization through time.

Based on its water quality, the region of Dompu Regency considered as a high productive area with the level of water quality parameter both in chemical and physical considered as normal. This condition should be strictly maintained to protect the adjacent environment from destructive activities, which caused quality degradation. Involving the, local people and community participation might be suitable to have mutualism symbiosis among the stakeholders.

## ACKNOWLEDGEMENTS

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