THE UTILIZATION OF LANDSAT 8 FOR MAPPING THE SURFACE WATERS TEMPERATURE OF GRUPUK BAY - WEST NUSA TENGGARA: WITH IMPLICATIONS FOR SEAWEEDS CULTIVATION

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Abstract Locating a suitable site is the key to success in cultivating seaweed, as it is becomes one of the coastal and marine prospects for improving the national economy. Numerous factors such as water movement, substratum, depth, salinity, light intensity, surface water temperature, influence the growth of this aquatic plant, and should be considered while choosing a farming area. One of key parameters on studying sea water conditions is surface temperature distribution, as changes on temperature effecting physical, chemical, and biological condition of the sea water. Surface waters temperature is affected by radiation, and sun position, geographic, seasons, overcast, interaction process between air and waters, evaporation level, and wind blowing. It's rarely easy job to measure surface waters temperature, because often, researcher has to deal with strong winds and high waves. The objectives of this research is to do surface waters temperature mapping of Grupuk Bay – West Nusa Tenggara, using thermal infrared channel of Landsat 8 data, which is supported by field observation data. Surface temperature measurement is conducted through field survey in conjunction with Landsat 8 orbit. Surface temperature calculation is carried out by using certain method issued by United States Geological Survey (USGS, 2013). Calculation result on Grupuk Bay's water surface temperature shows that it ranges from 28.00 to 30.00^{o}C, while field survey result shows that it ranges from 28.27 to 29.69^{o}C. This research shows that sea surface temperature measurement result based on Landsat 8 data has nearly identical range with field survey result.

Keywords: *surface water temperature, Grupuk Bay, Landsat 8, infrared thermal imaging*

1 INTRODUCTION

Indonesia is an archipelagic country extending 5,120 kilometers (3,181 mi) from east to west and 1,760 kilometers (1,094 mi) from north to south. Included in Indonesia's total territory is another 93,000 square kilometers (35,908 sq mi) of inland seas (straits, bays, and other bodies of water). Indonesia, with 17.508 islands and 81.000 Kilometers of shoreline, is the biggest archipelagic state with immense marine natural resources which have not been optimally and sustainably utilized (KKP, 2011). As Indonesia is located in the tropical areas, therefore coastal and marine region are very dynamic, with immense natural resources and great amount of problems which arises during the extraction activities. These problems, particularly to safeguard the marine resources of the Coral Triangle for food security, should be address immediately and decisively for the sake of sustainable and responsible utilization of coastal and marine natural resources.

Indonesia, as a maritime country having the world's second longest coastal line after Canada, thus the potential for aquaculture in Indonesia was very high.

Wikipedia stated aquaculture "is understood to mean the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. As a maritime country with large areas od thus, Indonesia has very big potential in the production of seaweed, which is relatively easy to cultivate as it takes only 45 days to fully grow. Cultivation of seaweed as a major source of income for tens of thousands of Indonesian farmers is being intensified to improve their economy. Locating a suitable site is the key to success in cultivating seaweed. Numerous factors influence the growth of seaweed and should be considered while choosing a farming area. Ecological parameters are the most important factor that determine the success of the farming operation. Ecological parameters that should be assessed are availability of seed, shelter, water movement, indicator species, substratum, depth, salinity, light intensity temperature and pollution.

To provide accurate and detailed information on water temperature has been a long-standing critical need in marine water resources management in Indonesia, particularly in the Nusa Tenggara. The scientific community has long been researching the use of dependable satellite information to fulfill this quantification need, and now image processing programs designed to utilize the long record of Landsat imagery are finally in place for application to extensive areas of the Indonesia. These processing programs locate and quantify the consumption of diverted water resources that occurs via the process of evapotranspiration (ET)3. These programs require and have taken strong advantage of the thermal imager of the Landsat system.

As explained earlier, one of the important parameters to influence the living conditions and plant organisms in the sea is water temperature. To determine the distribution and changes in water temperature, mapping the profile of the sea surface temperature (SST) is really required. However, it is not easy to observe water temperature, as its dynamic nature on the high sea, therefore, the broad coverage and high frequency observations are deemed necessary.

SST is also one of the parameters that affect the metabolism and proliferation of marine organisms, so it can be used to determine the location of marine aquaculture. One example of the waters which requires the study of the SPL for marine aquaculture businesses are the waters of Lombok in West Nusa Tenggara Province, as Lombok Island is one of the region defined by the government as a business center for minapolitan mariculture (Pijar, 2012).

In addition to the scope and high frequency of observation, the SST distribution of temporally and spatially observations are also required, to investigate the correlation between the distribution SST oceanographic processes such as monsoon and ENSO phenomenon can affect water conditions. SST is also one of the parameters that affect the metabolism and proliferation of marine organisms, so it can be used for determining the location of marine aquaculture. One example of the waters which requires the study of the SST for marine aquaculture businesses are the waters of Lombok in West Nusa Tenggara Province, due to Lombok Island is one of the region defined by the government as a business area minapolitan mariculture (Pijar, 2012).

Sea surface temperature is an important geophysical parameter, providing the boundary condition used in the estimation of heat flux at the air-sea interface. SST can be obtained by direct measurement (in situ) or using satellite remote sensing imagery (Rao *et al.*, 1972; Maurer, 2002). Satellite remote sensing

sensors detect electromagnetic radiation emitted by the sea surface in the form of far infrared radiation or thermal infrared with a wavelength between 8-15 μm. This thermal infrared radiation can pass through the atmosphere without being absorbed by the gas and the water molecules in the atmosphere, because at wavelengths between 8-14 μm. Therefore, the sensor works at thermal infrared wavelengths used to detect the emission of sea surface temperature (Emiyati, 2013).

On the other hand, Bintoro (2005) stated in his study that the Madura Strait is in the closely related with Bali Sea, the Strait of Bali, and the Java Sea in the eastern part. Accordingly, the physical and biological characteristics of its waters is strongly influenced by the said sea waters. Madura Strait is grouped into the category of shallow waters and semi-enclosed so that the temperature difference either horizontally on a rather wide area and vertically up to a certain depth of even basic water is not too large.

The measurement results showed that the surface temperature in the Madura Strait in the range of 26.5–30 ºC. The objectives of this study were to analyze the distribution of SST of Grupuk Bay, Central Lombok, West Nusa Tenggara, by utilizing LDCM Landsat 8 data and field observations. The results of this study can be used as one of the important inputs to the analysis of the suitability of the location of fish farming, especially the cultivation of seaweed. Therefore, objectives of study was to assess sea water temperature to find out the suitable areas for seaweed farming. A basic requisite in the selection of a site for the cultivation of seaweed is an understanding of the ecological factors required and culture method chosen.

2 MATERIALS AND METHODOLOGY

The study utilized data of LDCM-Landsat 8 as acquired on 28 July 2013, which were coincided with the implementation of the field survey. The study area was the Grupuk Bay waters - East Lombok, Nusa Tenggara, data are presented in Figure 2-1. The satellite remote sensing data method of Samad (2011) was utilized on-site investigation to determine site suitability for a new seaweed farm, as follows (Figure 2-2).

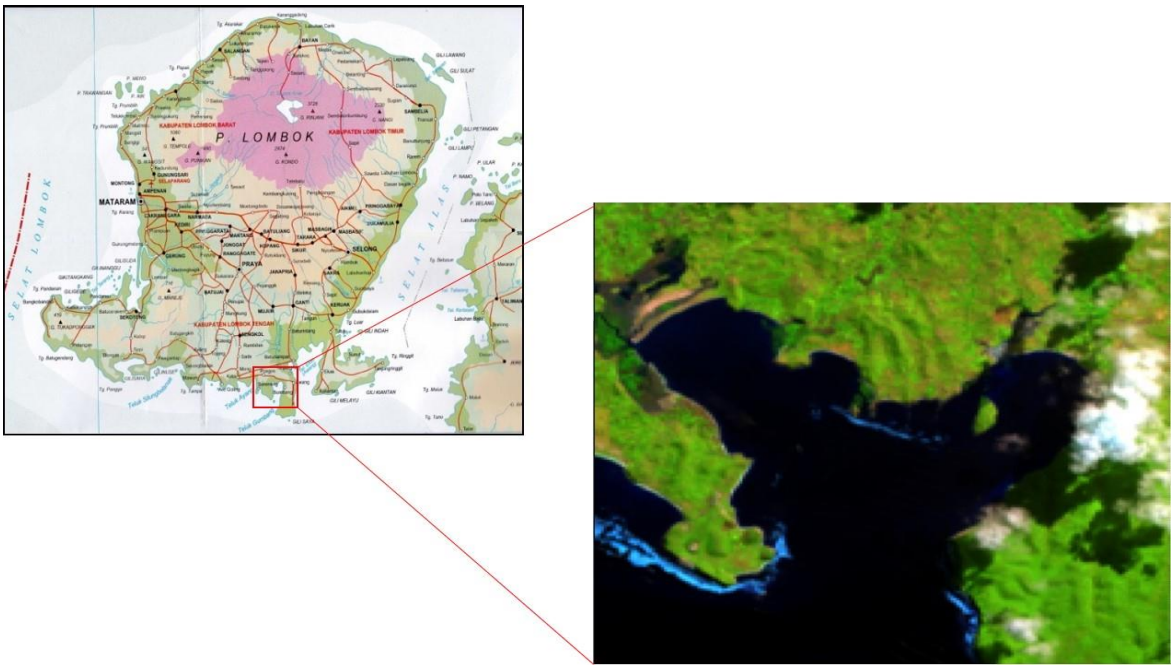

Figure 2-1: Study area, the Gulf Grupuk - NTT Lombok Island, as taken by Landsat 8 on 28 June 2013

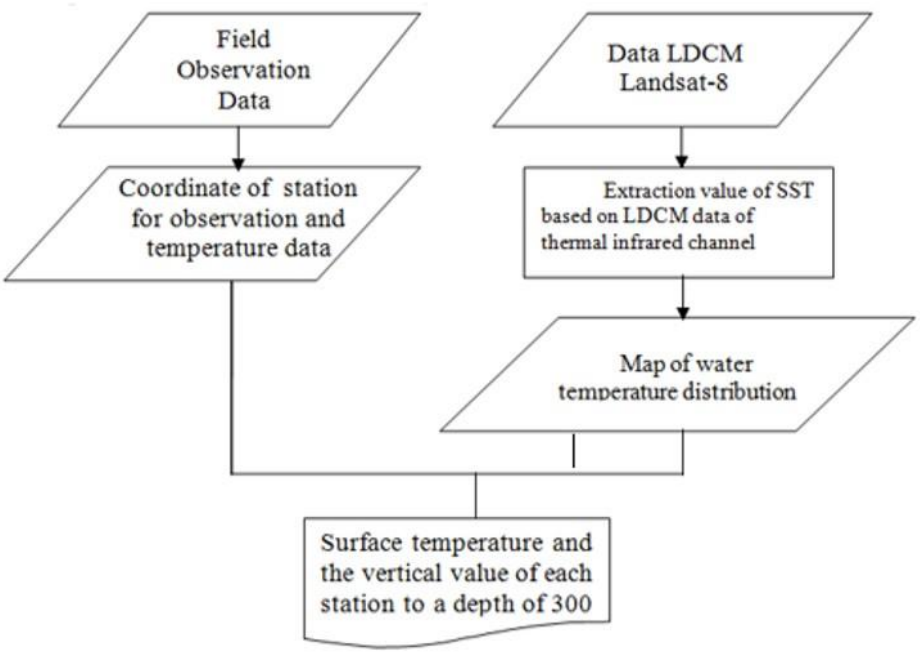

Figure 2-2: Flowchart of extraction process of surface temperature based on LDCM Landsat 8 data and vertical temperature of Grupuk Bay waters based on the field observations

Similar with other aquaculture systems, selection of a suitable site is critically important for a new seaweed farm. For the purpose of this this study the criteria of temperature issued by ISO (2010) will be utilized. According to ISO the criteria of sea water temperature suitability for seaweed is divided into three categories: (1) does not correspond to the lower temperature range of 20 oC and above 32 oC; (2) according to the temperature range between 20-26 oC; and (3) The optimum temperature ranges from 26°C to 32°C.

SST extraction was carried out using the Landsat-5 channels 6. The calculation of the SST was based on the equation of Landsat handbook as follows:

$$T = K2 / \ln((K1 / L_\lambda) + 1) \quad (2\text{-}1)$$

where:
T =Efective temperture;
K2=Constanta Calibration Value 2;
K1=Constanta Calibration Value 1;
Lλ =Radiant, watt/(m2*ster*µm).

The constanta values 1 dan 2 are presented at Table 2-1.

Table 2-1: The Value of Constant Calibration of Band Thermal ETM+ dan TM

Satellite	Constant 1 - K1 watts/ (meter squared * ster * µm)	Constant 2 - K2 Kelvin
Landsat 5	607,76	1.260,56
Landsat 7	666,09	1.282,71

3 RESULTS AND DISCUSSION

The measurements of water surface temperature were carried out on 28 June 2013, at 9 stations with periodic observations, the different coordinates of the location positions, and the current speed, they are presented at Table 3-1.

The vertical distribution of temperature in Indonesian waters basically can be divided into three layers, namely: (1). A warm layer (homogeneous layer) in the upper layer, a layer which has a warm temperature (is about at 28 °C) are homogeneous on the top layer to a depth of 50-70 meters; (2). Thermocline (discontinuity layer) in the middle layer, located at the depth of 100-200 meters in which temperature changes more rapidly with depth than it does in the layers above or below. In the ocean, the thermocline may be thought of as an invisible blanket which separates the upper mixed layer from the calm deep water below. Depending largely on season, latitude and turbulent mixing by wind, thermoclines may be a semi-permanent feature of the body of water in which they occur or they may form temporarily in response to phenomena such as the radiative heating/cooling of surface water during the day/night. Factors that affect the depth and thickness of a thermocline include seasonal weather variations, latitude and local environmental conditions, such as tides and currents. And (3). The deep-water layer is the bottom layer of water, which in the middle latitudes exists below 1,000 meters. This layer is characterized by fairly constant cold temperatures, generally less than 5 °C. (Nontji, 1993).

The profile temperature of the surface waters of the station-1 based on data acquired from LDCM Landsat 8 was at 29,03 ºC, while the temperature based on the results of the field at a depth penguuran 0.10 m and 0. 25 m are 29,04 ºC, which means that the temperature of the sea water from the surface to a depth of 0.25 m relatively the same. The temperature of sea water at a depth of 0.5 m decreased compared to the depth of 0.25 m which was from 29,04 ºC to be 28,91 ºC, while the temperature at a depth of 1 m was at 28.85 ºC, which experienced a slight decrease compared to the depth of 0.5 m. The temperature of sea water at a depth of 2 m decreased significantly compared to the depth of 1m i.e. from 28.85 ºC to be 28.27 ºC. On the other hands, an anomaly has been applied at a depth of 3 m as the temperature rose compared to the depth of 2 m which was at 28.82 ºC. It was almost similar to the temperature at a depth of 1 m. With reference to the vertical temperature profile at station -1 (presented at the Figure 3-1), we may conclude that temperature is relatively stable to a depth up to 0.25 m.

Table 3-1: Time of observation, the coordinates of the location, and the current speed at each observation stations

Stations	Time	Locations		Current Speed (cm/sec)	Temperature LDCM
		South	East		
1	9:50-10:05	8⁰55’15.9”	116⁰21’19.2”	9.52	29.03
2	10:10-10:15	8⁰55’10.8”	116⁰21’24.3”	20	29.05
3	10:20-10:30	8⁰55’59.5”	116⁰21’22.4”	9.52	29.08
4	10:35-10:40	8⁰54’52.6”	116⁰21’16.7”	25	29.12
5	10:45-10:50	8⁰54’52.2”	116⁰21’09.6”	11.76	29.14
6	10:55-11:05	8⁰54’54.1”	116⁰21’01.5”	13.33	29.2
7	11:10-11:20	8⁰54’41.9”	116⁰20’56.8”	18.18	29.29
8	13:10-13:20	8⁰54’27.7”	116⁰21’07.7”	10.53	29.11
9	13:30-13:35	8⁰54’22.2”	116⁰21’26.9”	10	29.15

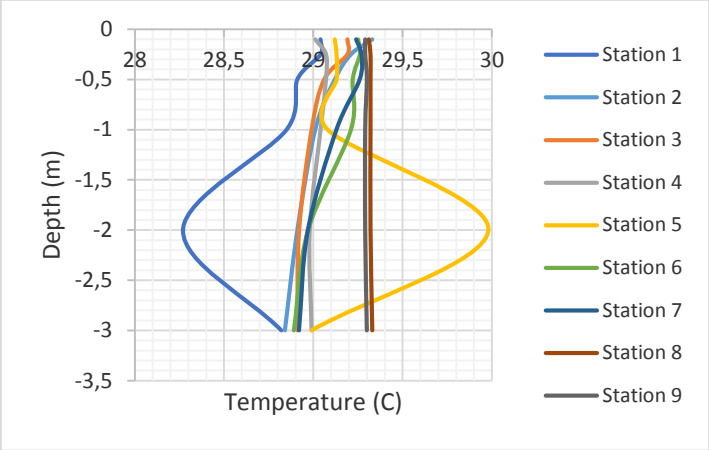

Figure 3-1: Vertical temperature profile of Grupuk Bay waters at the observation station 1 to 9

The profile temperature of the surface waters of the Grupuk Bay at station 2 based on LDCM Landsat 8 data was 29,05 ºC, 0.28 ºC lower compare to the temperature of field observations as obtained at a depth of 0.10 m depth which was at 29,33 ºC. With reference to the vertical temperature profile of station 2 as presented at Figure 3-1, it appears that the temperature of the sea waters has decreased regularly. The temperature of the surface to a depth of 0.5 m has decreased to 0,21 ºC, from a depth of 0.5 m to 1 m has decreased to 0,11ºC, whereas at a depth of 1 m to 2 m has decreased by 0,10 ºC. Finally, from a depth at 2 m to 3 m the temperature of the surface waters decreased by 0,07 ºC.

The profile temperature of the surface waters of the Grupuk Bay at station 3 based on LDCM Landsat 8 data was at 29.08 ºC, while according to the field observations at a depth of 0.1 m and 0.25 m the temperature was similar at 29,19 ºC. The temperature of the sea waters at a depth of 0.5 m has decreased to 29,06 ºC. At the depth of 0.5 m up to 1 m the temperature has slightly dropped by 0,07 ºC, and finally at the depth of 2 m to 3 m it has decreased by 0,01 ºC. Graph vertical temperature profile from surface waters to a depths of 3 m at station 3, are presented at Figure 3-1.

The profile temperature of waters of the Grupuk Bay at station 4 show differences with those presented at the station 3. The temperature profile of surface waters at station 3 based on LDCM Landsat 8 data was at 29.12 ºC, while the profile temperature at a depth of 10 cm based on field observations was at 29,19 ºC, it means 0,07 ºC higher than those at the surface of the waters. The temperature at a depth of 0.25 m and 0.5 m is higher than the temperatures at a depth of 0.1 m was at 29,07 ºC. The temperature of sea water at a depth of 1 m has decreased to 29,04 ºC. Water temperature at a depth of 2 m and 3 m decreased by 0,06 ºC and 0,05 ºC, compare to the temperature of waters at a depth of 1 m, thus they mean that the temperature at a depth of 2 m and 3 m are relatively equal. The Graph of the vertical temperature profile of waters at station 4 at a depth of 3 m, are presented at Figure 3-1.

The profile temperature of waters of the Grupuk Bay at station 5 indicated that temperature condition was unstable. Based on Landsat 8 LDCM data the profile temperature of surface waters temperature at station 5 was at 29.14 ºC, while the temperature of field observations at a depth of 10 cm was at 29.12 ºC, it means it is 0.02 ºC lower compared to the temperature on the surface of the waters. The temperature at a depth of 0.25 m and 0.5 m is relatively flat at around 29,13 ºC, while at a depth of 1 m slightly decreased to 29,08 ºC or decreased to 0,05 ºC. Water temperature at a depth of 2 m experienced

changes due to increase by 0.9 ºC compared to temperature at a depth of 1 m, on the contrary to the depth of 3 m the temperature decreased by 0.99 ºC compared to the temperature at a depth of 2 m. Graph vertical temperature profiles of waters at 5 from surface waters to depths of 3 m as shown in Figure 3-1, has indicated that the water temperature conditions were unstable, it is less suitable for seaweed farming.

The profile temperature of waters of the Grupuk Bay at station 6 which were acquired by LDCM Landsat 8 was at 29,20 ºC, while temperature based on the field observations at a depth of 0.1 m below the surface was at 29,25 ºC it means that was 0.05 ºC higher compared to the temperature at the surface waters acquired by LDCM Landsat 8. Temperature profiles at station 6 of Grupuk Bay waters has indicated relatively stable conditions. While the temperature at a depth of 0.1 m up to 1 m were relatively similar in the range of 29,25 ºC - 29,21 ºC, at a depth of 2 m slightly decreased to 28,97 ºC or 0,25 ºC lower. Water temperature at a depth of 3 m is 28,89 ºC experienced a slight decrease by 0.08 ºC compared to the temperature at a depth of 2 m. Graph of vertical temperature profiles at station 6 from surface waters to a depths of 3 m are presented at Figure 3-1, and it has indicated stable conditions temperature of waters, thus it is quite appropriate to be used as the location of seaweed cultivation.

The profile temperature of waters of the Grupuk Bay at station 7 which were acquired by LDCM Landsat 8 was at 29.29 ºC, while temperature based on the field observations at a depth of 0.1 m below the surface was at 29,24 ºC, it was 0.05 ºC higher compared to the temperature at the surface waters acquired by LDCM Landsat 8. Temperature profiles at station 7 in Grupuk Bay waters are presented at Figure 3-1. Further, the Figure showed that the temperature at a depth of 0.25 m and 0.5 m has slightly increased compared to the temperature at a depth of 0.1 m that was at the range 29,27 ºC. Vertical temperature profile at a depth of 1 m, 2 m, and 3 m indicated good condition, namely it was 29,13 ºC at depth of 1 m, then slightly increased to 28,97 ºC at a depth of 2 m, and went down again to 28,92 ºC at a depth of 3 m. Vertical temperature profiles at station 7 from surface waters to depths, showing the condition of stable conditions, so it is quite appropriate to be used as the location of seaweed cultivation.

The profile temperature of waters of the Grupuk Bay at station 8 based on LDCM Landsat 8 data was at 29.11 ^{o}C, while the results of field observations at a depth of 0.1 m below the surface was at 29,31 ºC, it means 0.20 ºC higher compared to the temperature at the surface waters obtained from the LDCM data. Temperature profiles of Grupuk Bay waters at station 7 are presented at Figure 3-1, which shows that the temperature at a depth of 0.1 m – 3 m relatively the similar, namely at the range from 29,31 ºC to 29,31 ºC. Based on the vertical profile temperature at station 8, it gives the impression that the site is suitable to be used as the location of seaweed cultivation.

The profile temperature of waters of the Grupuk Bay at station 9 based on data acquired by LDCM Landsat 8 was at 29.15 ºC, while the results of field observations at a depth of 0.1 m below the surface was at 29.29 ºC which means it was 0.14 ºC compared to the temperature of the surface waters acquired by LDCM Landsat 8. The field observation of temperature at station 9 of Grupuk Bay waters are presented at Figure 3-1. Data of this Figure has a vertical profile temperature ranging from a depth of 0.1 m to a depth of 3 m has a shape similar to the vertical profiles at station 8. The temperature of the water from a depth of

0.1 m to 3 m depth was in the range from 29.29 ºC to 29.30 ºC. As stated at station 8, the vertical temperature profile and the profile temperature at station 9 indicated that those sites are most suitable site for seaweed cultivation.

4 CONCLUSION

Water temperature on Grupuk Bay based on LANDSAT 8 remote sensing data is ranging from 28-28,5 – 29,5 ºC, whereas those obtained from field observations were ranging about 28,44 – 29,29 ºC. Field observation at 9 stations conducting simultaneously with Landsat 8 satellite data acquition period, there are 2 stations that has the most stable vertical temperature profile up to 300 cm depth, which is at 29.3 ºC.

There are differences in temperature values between Landsat 8 data and field observation results, which are due to the difference in the process of obtaining those data. Observation period and the Landsat 8 data acquisition were not simultaneously implemented. However, the different of temperature between Landsat 8 data and field observation was only 0.53 ºC.

A water temperature ranging from 25–30 ºC is best for growing seaweeds. In shallow waters near the beach, the water temperature can become high especially during a sunny day. Such an area is not suitable for planting seaweeds. The ideal area is one between the spring low tide limit and the reef edge or the area which does not dry up during these extreme low tides occurring during full or new moon. Grupuk Bay's will be feasible for seaweed cultivation.

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