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REMOTE SENSING FOR CORAL REEF MONITORING

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ABSTRACT: Remote sensing and in-situ measurements has been doing for validate the field data. The results will guide you to inform about SST influence from coral bleaching using Advanced Land Observing Satellite (ALOS) data from period 2003 – 2009, NOAA comparing with ALOS data. In coral reef to validate with ALOS data using belt transect method + underwater short movie. The Average Percent cover of coral reef on three site study in Bunaken island is good category (50 – 75%). Based on satellite data, there is no close correlation between SST and bleaching events at Bunaken on each site study. All the research location especially mortality index are low (healthy category).
KEY WORDS: Remote sensing, SST, coral reef.

1. Background

Coastal zone and Indonesian seas have a potential and high biodiversity (mega biodiversity) in the world also include in CTC (Coral Triangle Center) region. The highly biodiversity comprise in genetic, species and other ecosystem to develop Indonesia economics, environment, sustainability and carrying capacity also Law reinforcement. (Anonymous, 2007).

Coral reefs are especially vulnerable to predicted climate change because they bleach rapidly and dramatically in response to increased Sea Surface Temperatures (SSTs). Corals live in environments that are close to their thermal threshold (the upper temperature limit for life), and even temperature increases of 1 or 2ºC above average over a sustained period of time (i.e. a month) can cause mass bleaching (Hoegh-Guldberg, 1999). The potential severity of the predicted increases of 1–3 ºC in SSTs by 2050 (Hoegh-Guldberg, 1999) and 1.4–5.8ºC in Earth surface temperatures by 2100.

One of high biodiversity in Indonesia is coral reef about 14% wider coral reefs in the world. Coral reef status dominantly are hard coral which comprising in 362 type, Its condition divided into: 6,04% very good, 22,95% good, 31,16% bad condition and 39,86% are very bad condition (Suharsono, 2008).

Based on Global Coral Reef Monitoring Network (GCRMN) in the world has comprised in: (a) 372 Coral Reefs Scientists and Manager from 96 countries and states; (b) 11 from SE and 5 NE Asia; (c) 46 from Micronesia; and (d) Combine data and information from research, government level, reef check and other community or socioeconomic monitoring. Coral maping by satellite imagery is relatively new to supporting database.

Based on the background, the aims on this research are: 1) determine the Percent cover of coral based on ALOS data; 2) to develop possible marine monitoring design to observe by using satellite data; and 3) to predict SST anomaly changing influences on coral bleaching.

2. Study Area

Research location was conducted in: Bunaken Island as the one part island of Bunaken National Park in May 2010.

Figure 1. Survey location map to support data validation in Bunaken Island as the one part of Bunaken National Park-North Sulawesi. Red dot is research points that are Ron's Point, Celah-Celah, and Muka Kampung.

3. Methods

3.1. Benthic Life Form

Belt Transect Method (Unsupervised)

This involves a pair of observers swimming along the belt transect and counting the target invertebrate species as well as special features on the reef, such as coral health or physical damage. The each transect line/location 50 meters which 2.5 meters on the left and right along the transect by using *underwater video technique*.

Shannon-Wiener Index using for count of life form *diversity index*. Similarity index and Dominancy index. Odum (1998) with formula:

1. Diversity Index, Shannon-Wiener :

$$H' = - \sum_{i=1}^{s} (n_i/N) \ln (n_i/N) \quad (1)$$

2. Simalrity index :

$$E = \frac{H'}{H_{max}} \quad (2)$$

3. Dominancy index :

$$D = - \sum_{i=1}^{s} (n_i/N)^2 \quad (3)$$

Remarks:
H' = Diversity Index Shannon-Wiener
E = Similarity index
D = Dominancy index simpson
ni = Genus individual -i
N = Total of individual in all genus
H_{max}= Maximum Diversity Index
(= ln S, whereas S = Total of benthic)

The percent cover based on Gomez and Yap (1988) divided into four categories: poor category if percent cover 0–25%; fair category if percent cover 25–50%; good category if percent cover 50–75%; and very good category if percent cover 75–100%.

3.2. ALOS Analysis

The ALOS analysis applied in this research is depicted in Figure 2.

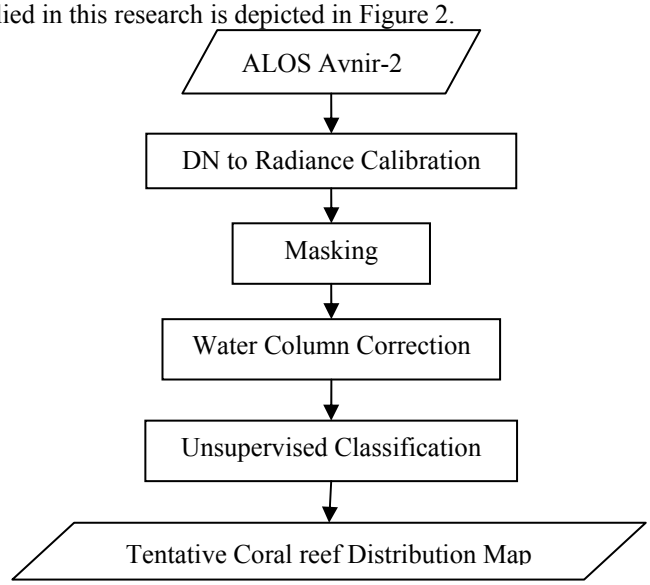

Figure 2. Flow Chart of ALOS Avnir-2

3.2.1. Digital Number to Radiance Calibration

This paper process ALOS AVNIR-2 image is converting from digital number to radiance number (W/m2-sr-µm), the radiance value can be use to next step for processing. Conversion to radiance uses gain and offset value from leader files as follows:

$$Radiance = DN \times gain - offset \quad (6)$$

Where, DN is digital number, gain and offset represent calibration coefficient. Coefficient value different for each band, depend on gain setting that uses at image accuracy. The gain and offset value shown in table 1.

Table 1. Gain and offset value for ALOS Avnir-2

	band 1	**band 2**	**band 3**	**band 4**
Gain	0.5880	0.5730	0.5020	0.8350
Offset	0	0	0	0

3.2.2. Masking

The focus of this research is ocean area, removing land area by masking applied in this research. Masking is determining the boundary pixel value of land and sea using band 4 of the image by doing sampling on land and sea border

points. Then, as the known threshold value that exceeds. The threshold value (land) conducted masking by giving value as zero.

3.2.3. Water Column Correction

Water column was an important variable in mapping coral reef, that effect an absorption and scattering of wavelength. A method for multispectral data is water column correction describe by Lyzenga (1981). Base on sampling data in homogeny area, then calculate attenuation coefficient using algorithm:

$$\frac{k_i}{k_j} = a + \sqrt{(a^2 + 1)} \quad (7)$$

$$where, \quad a = \frac{\sigma_{ii} - \sigma_{jj}}{2\sigma_{ij}}$$

$$\sigma_{ij} = \overline{X_i X_j} - (\overline{X}_i \times \overline{X}_j)$$

σ_{ii} = nilai varian band i

σ_{ij} = vartance value band j

σ_{ii} = vartance value band i

$\overline{X}_i$ and $\overline{X}_j$ = mean value at band i and band j

The attenuation coefficient for ij band that contain composite of blue-green band, because at 0.48 µm wavelength is the highest at water body spectrum. Thus, by measuring the amount of this displacement, a changing the bottom reflectance can be detected even if the water depth is not know amount of this displacement is given by (Lyzenga, 1981) :

$$Index\ Y_{ij} = \ln(L_i) - \left[\left(\frac{k_i}{k_j}\right).ln(L_j)\right] \quad (8)$$

Where,

L_i = radiance value band i

L_j = radiance value band j

3.2.4. Unsupervised Classification

The concept in unsupervised classification is assign pixel in an arbitrary initial cluster vector and classified each pixel to the closest cluster. There are two type of unsupervised classification K-mean and ISODATA clustering, this research is use ISODATA cluster. The ISODATA algorithm has some further refinements by splitting and merging of clusters (Jensen, 1996).

4. Results

4. 1.Muka Kampung

Data collect in to 4 meters depth which is high intensity of light. The health condition of coral reef are good. species encountered comprise in 8 species : *Porites sp, Acropora sp, Favites sp, Pocillopora sp, Platygyra sp, Montipora sp, Pectinia sp,* dan *Galaxea sp.* Otherwise for Hard coral (HC) cover on that depth = 63%; Soft Coral (SC) = 5%; Sponge (SP) = 3%; Coral Millepora (CME) = 2%; Dead Coral with Algae 9(DCA) = 7%; Sand (S) = 17% and other (OT) = 3%.

4. 2.Celah Celah

The characteristic in Celah-celah site are similar with Muka Kampung, But on location it is far away to the village. Species encountered comprise in 6 species: *Porites sp, Acropora sp, Favia sp, Pocillopora sp, Platygyra sp,* dan *Montipora sp.* Otherwise for Hard coral (HC) cover on that depth = 46%, Soft Coral (SC) = 1%; Rubble (R) = 9%; Dead Coral with Algae 9(DCA) = 7%; Rock (RCK) = 10% and Sand (OT) = 27%.

4. 3.Ron's Point

Data was collect into 5 meters depth. Species encountered comprise in 6 species: *Porites sp, Acropora sp, Pocillopora sp, Favites sp, Fungia sp,* dan *Pectinia sp.* Hard coral (HC) cover on that depth = 60%, Soft Coral (SC) = 2%; Turf Algae (TA) = 4%; Dead Coral with Algae 9(DCA) = 7%; Rubble (R) = 12%, Rock (RCK) = 4%; Sand (S) = 7% and Other (OT) = 2%.

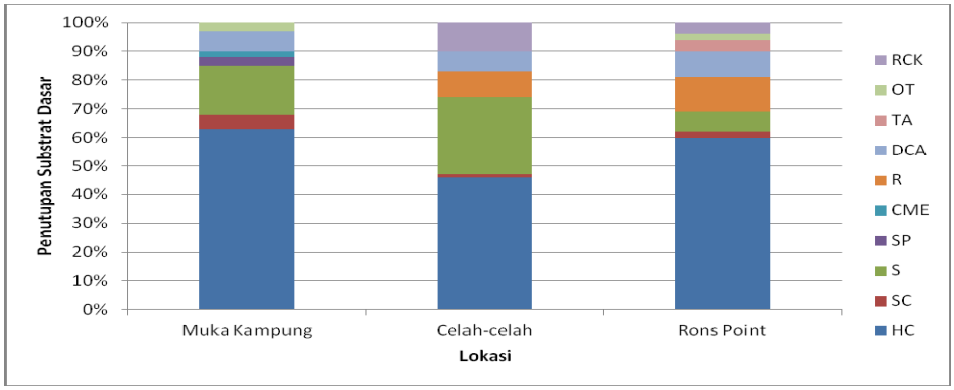

Figure 3. Percent cover on Benthic Life Form

Table 2. Mortality index

No	Lokasi	IMK
1	Muka Kampung	0.10
2	Celah-celah	0.26
3	Rons Point	0.26

Based on mortality index category on each location has low of coral damaged/dead and driven up to zero (0). Which is mean all the research location especially mortality index are low (healthy category).

Table 3. *Diversity Index(H'), Similarity Index (E), & Dominancy Index (C)*

Location	H'		E		C	
	Value	Category	Value	Category	Value	Category
Muka Kampung	1.82	Low	0.88	Stable	0.19	Low
Celah-celah	1.49	Low	0.83	Stable	0.27	Low
Rons Point	0.71	Low	0.40	U. pressure	0.68	Fair

4. 4.Validation on ALOS

In Rons point with starting point Latitude: N $01^0$36'28.0"/ E $124^0$44'04.6"and Finish: N $01^0$36'22.3" / E $124^0$44'09.4". Are identified by Categorize: Coral 3, Coral 1, Sand 3, Rubble 1, and Rubble 2. Meanwhile, in Muka Kampung site starting point: N $01^0$35'39.3"/ E $124^0$46'30.1" and finished N $01^0$35'38.39"/ E $124^0$46'31.3" are identified: Coral 1. Otherwise, in Celah-celah site starting point: N $01^0$36'19.0"/ E $124^0$46'05.9" and finished N $01^0$36'18.4"/ E $124^0$46'04.6" with Coral 2 categorize.

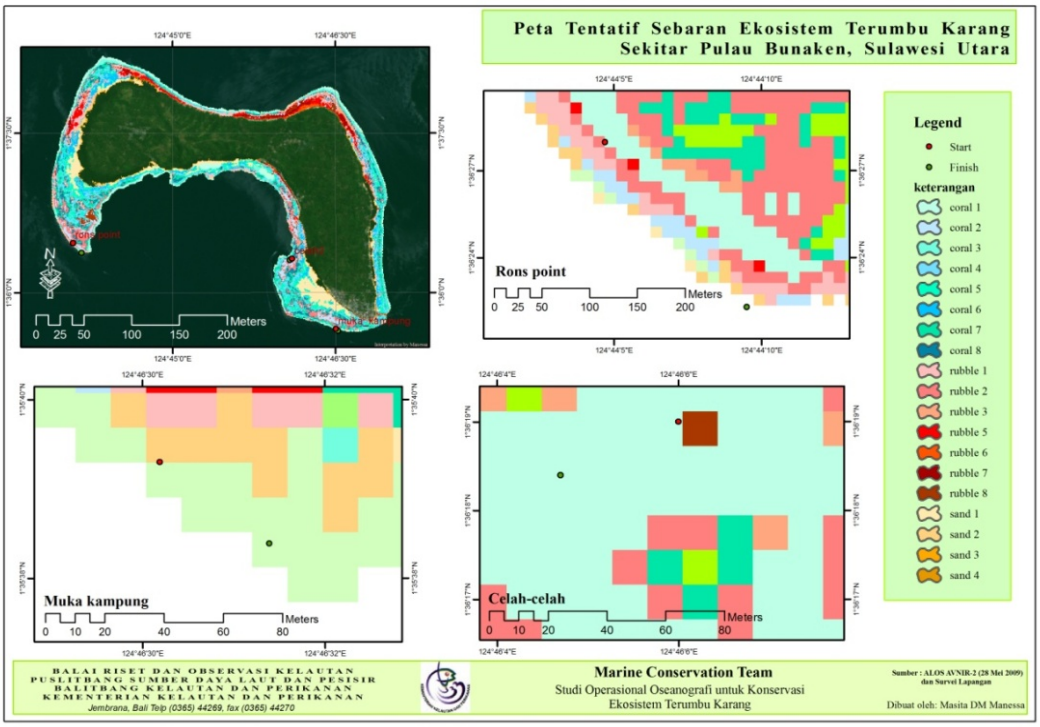

Figure 4. Map Based on ALOS data

Based on coral reef watch data (www.coralreefwatch.noaa.gov) that TN Bunaken in the normal condition even in the several time has reached bleaching threshold. Whereas results of Modis-Aqua data TN Bunaken is over to bleaching threshold. Average of high weekly temperature maximum on April – June and September – October with higher value 30,59^{O}C. The higher temperature during 2003 – 2009 has been occurred on shift season in 2008 precisly on May : 31,52^{O}C. The average of highly temperature in dry monthly season for period 2003 – 2009 is 31,25^{O}C on May (Ampou and Manessa, 2010).

5. Conclusion and Suggestion

5. 1.Conclusion

Based on satellite data, there is no close correlation between SST and coral bleaching events at Bunaken on each site study. Sentinel station is useful to monitor local changes in coral ecosystem & for data validation. Larger system of observation is useful for wider area under large spatial and temporal resolution and using appropriate method to validate the

data. The Average Percent cover of coral reef (esp. Hard & soft coral) on three site study in Bunaken island is good category (50 – 75%).

5. 2. Suggestion

For the future on the field, it must be using supervised method (Point Transect) to make it easy correlation between satellite imagery and field data.

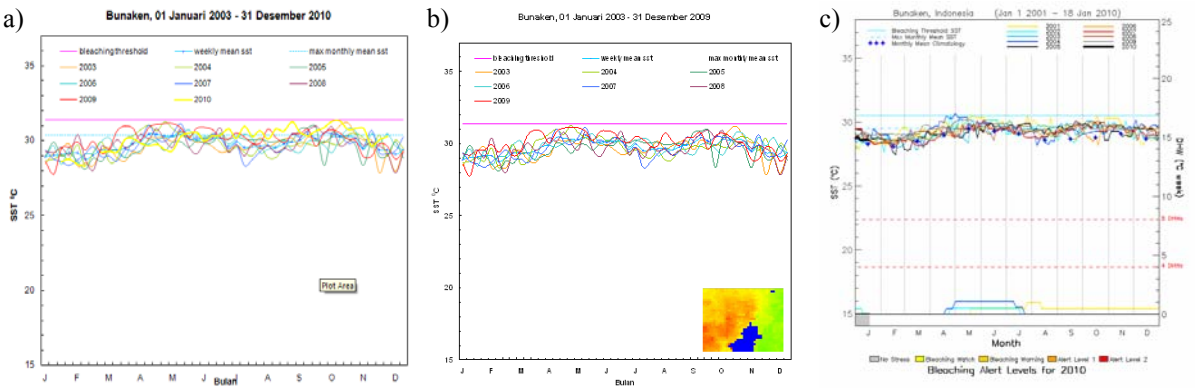

Figure 5. SST at Bunaken island from: (a) MODIS, (b) NOAA (in situ/downscaling at Bunaken island), and (c) NOAA (http://coralreefwatch.noaa.gov)

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