REMOTE SENSING APPLICATIONS FOR MARINE STUDY

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Abstract

Sensing is a process of acquiring some information on an object or a phenomenon using sensor equipment In environment areas, remote sensing applications are mostly for mapping and monitoring environment elements which are of micro, mezzo, macro, or even global scale.

I. INTRODUCTION

Remote sensing is sensing from a distance. Sensing is a process of acquiring some information on an object or a phenomenon using sensor equipment. Since the sensing process is performed from a distance, it needs : (1) (artificial) **sensors** to record the information on the sensed thing or phenomenon, (2) some mean of transportation to carry the sensor, which is commonly called **platform**, (3) and **energy** to carry the characteristics of the object or phenomenon for recording. Sensing is conducted on the result of this recording, rather than the sensed object.

Remote sensing is commonly classified based on its platform, energy used in the recording, and recording result which is identical to the sensor.

Based of its platform, remote sensing system is classified into :

- *Airborne System* : recording system from air (air balloon, airplane)
- *Spaceborne / Satellite System* : recording system from space / satellite.

Based on the energy used in the recording process, broadly speaking, remote sensing system is classified into :

- **Passive Remote Sensing System** : using natural energy (sunlight, thermal energy)
- **Active Remote Sensing System** : using artificial energy (artificial lights, radar)

In more detailed, remote sensing system is classified into :

- **Ultraviolet Remote Sensing System** : using near ultraviolet energy (0.3 – 0.4 µm)
- **Panchromatic Remote Sensing System** : using panchromatic energy (0.4 – 0.7 µm)
- **Near Infrared Remote Sensing System** : using near infrared energy (0.7 – 1.5 µm)

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- **Middle Infrared Remote Sensing System** : using the middle infrared energy (1.5 – 3 μm)
- **Thermal / Far Infrared Remote Sensing System** : using the thermal infrared energy (3.5 – 5.5 μm and 8 – 14 μm)
- **Microwave Remote Sensing System** : using the microwave energy (1 mm – 100 cm)
- **Multispectral Remote Sensing System** : using various wave lengths for each recording, to obtain several recording results for the same area with different forms.

Based on the recording results, remote sensing system can be classified into :

1. **Analog / Pictorial Remote Sensing System** : the recording results are in the form of images.
- **Photo Image** : recorded with camera sensor
- **Non-photo Image** : the recording sensor is not a camera, but a scanner
- **Digital Remote Sensing System** : the recording result is some numbers which indicates the brightness value of the smallest square of image element (pixel). This brightness value is commonly called **digital value** or **pixel value** which can be processed using a computer and displayed in the form of images, tables, diagrams, or maps.

II. REMOTE SENSING BENEFITS

Remote sensing development and use has accelerated for the past five decades.
The use of remote sensing, which rapidly grows, is indeed supported by its tremendous benefits, such as :

a. The acquirement of complete coverage (synoptic) and quick repetition spatial data

Spatial data are data with clear position and attributes. Attribute is description, magnitude and classification of object or phenomenon (Juppenplatz & Tian, 1996). Position is stated in grid system, in the form of longitude-latitude or other grid systems.

It is said as complete coverage since the recorded items are not only of one object (article or phenomenon), but rather all objects which are not too small either in its size or in its energy reflection / radiation, and not protected by other objects.

Data Type	Scale	Recording Period	Coverage Area
Aerial Image	1 : 100.000	1/100 sec.	529 km^2
Landsat Image	1 : 3.300.000	25 sec.	34.000 km^2
NOAA Image	---	---	9.600.000 km^2

Table 1. The following table gives an overview of the data collection.

This speed cannot be gained by terrestrial method which requires the surveyor to explore the field, moreover for difficult areas like Indonesia (with its forests, swamps, mountains).

Quick and repetitive data recording enables remote sensing to :

- Map and monitor environment objects which change quickly such as the weather which changes every hour, changes caused by disasters, etc.
- Map disasters and the affected areas, just when disasters occur (volcano explosions, floods, forest fires, tsunamis).

For remote sensing images that are currently used, recording of the same areas repeats every 26 days to 0.5 hour.

Just as an idea about how fast mapping can be conducted with the help of remote sensing, it is known that to finish a big scale topographic map for the whole Germany, the time ratio was 100 years : 10 years : 1 year, if it was conducted using the terrestrial way, aerial imaging, and satellite imaging, respectively. This is a very significant acceleration.

For Indonesia, topographic mapping with a scale of 1 : 50,000 also increases considerably since the increase of aerial photography capturing at the end of the sixties (towards the end of the First Five Year Period Development) and the use of satellite imaging since the seventies.

Year	Coverage	Increase / year
1950	14 %	--
1974	14 %	0 %
1982	20 %	0.75 %
1993	60 %	3.30 %
1996 (June)	70 %	4.00 %

Table 2. The following table shows the coverage of topographic maps with a scale of 1 : 50.000 in Indonesia, calculated in its percentage against terrestrial area.

The writer does not wish to say that this increase was caused by remote sensing alone, but remote sensing has clearly gave a significant contribution towards it.

b. The low cost data collection and its mapping

The writer has not obtained any data on this inexpensiveness for Indonesia. Therefore, the data must be obtained from the United States, one of the developed countries who invented and developed this new technology.

Paine (1981) states that if forest mapping in the United States was done through aerial photography, that would mean a saving of 35 % of the total cost. If the mapping was done through satellite imaging, the cost would be greatly cheaper.

Mapping cost per unit area is determined by three factors, namely mapping theme, scale, and the area of the region being mapped. Hagget (1972) says that to map a forest (mapping theme) with a scale of 1 : 20,000 in the United States for an area whose area is proportional to 25 km^2 : 100 km^2 : 500 km^2, the mapping cost per unit area will be proportional to 100 : 37 : 10.

Therefore, the larger the area of the region being mapped, the lower the cost of mapping per unit area. Hence remote sensing offers far more benefits for countries with large areas such as Brazil, United States, Canada, Rusia, China, India, Indonesia, and Australia.

For Indonesia, the urgency to use remote sensing technology is not only caused by the factor of its wide area, but was also caused by the areas which are mostly difficult to reach by terrestrial survey and by the scarcity of data which are required in development planning and environment management.

It is necessary to be mindful that data gathering and its mapping which can be done more quickly and cheaper must be compensated with less degree of accuracy when compared to the terrestrial method, but still within the acceptable limit of accuracy. The speed and cheapness are important factors for developing countries, which are generally not rich and lack of data.

III. REMOTE SENSING APPLICATIONS FOR MARINE ENVIRONMENT

In environment areas, remote sensing applications are mostly for mapping and monitoring environment elements which are of micro, mezzo, macro, or even global scale. This is made possible by the fact that every image sheet covers an area of 1.2 km^2 or less, for small format aerial image, to ± 1/3 of the total area of the earth for GMS (*Geosynchronous Meteorological Satellite*) weather satellite images.

The urgency of its use increases for :

- Quickly changing environmental elements
    - Routine changes (temperature, clouds, winds, rain falls, etc.)
    - Changes by disasters (storms, floods, volcano explosions, forest fires, etc.)
- Wider area
  Quick mapping for wide area is difficult to do using the terrestrial method.
- Combination between the two
  The urgency of remote sensing use is getting bigger for global environment which changes quickly (global cloud pattern, global temperature average, global wind pattern, etc.)

With no exception, there are several applications with quite significant urgency for small areas, such as **water pollution by hot water drainage and other pollution.** The urgency of the use is tremendous since hot water is invisible for the eyes. Measurement and mapping using the terrestrial method takes a long time, hence it cannot keep up with the changes.

IV. WATERS MAPPING

Considering its area, environment in the form of open water body covers 74 % of the earth surface. Table 3.1 shows a detailed description of the waters area (Campbell, 1996).

Waters Type	Percentage	
	Surface area *	Volume *
Sea / ocean	94.90	97.10
River and lakes	0.40	0.02
Ground water	----	0.60
Permanent ice layer	4.69	2.20
Earth atmosphere	----	0.001

Source : Campbell, 1996

Table 3. Detailed description of water body

* Percentage of area and volume against area and volume of water body

According to table 3 sea covers 95 % of the total surface area of water body. Rivers and lakes only cover 0.4 % of it, however their significance for human life is far greater than this small percentage. Ground water contained in the soil and rock is only approximately 1 % of the total water body volume, but it also has tremendous advantages.

Water body data are commonly collected based on widely spread sampling points; too widely spread to describe a dynamic object with such a wide coverage. It is not surprising that remote sensing technology is widely used for mapping of environment in the form of water body.

a Bathymetric Mapping

Despite the area of the sea surface is 74 % of the earth surface, seabed mappings are very general (not detailed) and many are out of date. Detailed and advanced seabed mappings are required, particularly for the shallow sea around an island / a continent, where sedimentation, erosion, and coral reel growth can change the seabed topography only several years after bathymetric measurement is completed. These shallow areas are important for sailing, fish catching, and other resources inventorization and evaluation. Geomorphology knowledge on oceanic spreading center, transform fault, and submarine volcanoes are mostly used in acquiring more knowledge about tectonic plates. All these are very important for Indonesia as a **maritime continent**. Remote sensing technology is required to accelerate this bathymetric mapping.

Seabed sensing is hindered by the characteristics of water which absorbs and reflects most electromagnetic energy. Only the visible spectrum can penetrate water, and it is limited to the blue and green bands which can penetrate water up to 30 m (Lo, 1996) or 50 m deep (Drury, 1996) in clear water. Kennie and Matthews (1985) states differently about the deepness of water which can be penetrated by lights, namely 50 m from airplane and 20 m from satellites; with an accuracy of >= 90 % for water depth up to 15 m. In a very clear water, lights can penetrate to the depth of several meters. Up to 10 m deep, 50 % of blue and green bands are transmitted. In that depth, less than 10 % of red band is transmitted, and almost all is absorbed at near or middle infrared bands. Therefore, with recording by any sensors, blue band (0.4 – 0.5 µm) or part of it is always used for bathymetric purposes.

The magnitude of reflection by shallow seabed depends largely on the weather condition, the roughness of the wave, the clearness of water, the color and the size of suspended materials, basic color of the waters, and the wavelength of electromagnetic energy used in recording (Kennie and Matthews, 1985; Drury, 1990; Sabins, 1997). The influence of wavelength is further clarified in table 2, whereas the influence of water clearness is shown in table 4

Clearness	λ (µm) with maximum transmission	Transmission (µ)
Clearest sea water	0.47	98.1
Average clear sea water	0.475	89.0
Clearest shore water	0.50	88.6
Hell shore water	0.55	72.4
Average inshore	0.60	60.8

Source : Kennie and Matthews, 1985

Table 4. Transmission characteristics of water body to a certain depth based on the wavelength of electromagnetic energy

Table 4 shows that to achieve maximum transmission, the longer wavelength is required for more turbid sea water. Transmission is lessen for more turbid water. On the contrary, more turbid water causes greater reflection.

Bathymetric measurement using visible spectra has been used in several areas by using various images, one of them is done by Sabins (1987) in the Sibutu archipelago in Sulawesi Sea (at the east of Kalimantan Shore) using the Landsat MSS satellite images.

Even though the microwave spectrum does not penetrate water, the radar image can be used to recognize the shallow seabed relief up to 30 m deep, particularly for stretched relief such as valleys, sandbars, river flow areas, etc. These relieves are reflected on the stretched dark and bright colors which are clearly shown on the water body surface.

b Chlorophyl Concentration

The color of the sea water by the estuary / river mouth is more influenced by the suspended sedimentation from decomposition on the land. Farther from the shore, the sea water color is determined by suspended organic materials, particularly phytoplankton. Different phytoplankton concentration is reflected on the image by the different color brightness caused by the different reflection.

Four reflection curves show different chlorophyl concentrations. However, the differences are not clear when the recording is done using wideband (0.4-0.7 µm). If recording is done using narrow band, for instances 1, 2, 3, and 4 band on CZCS (Coastal Zone Color Scanner) image, the bed will be clearer hence it is easier to recognize. This difference is even clearer when the ratio is calculated, particularly the ratio between 2 and 3 band (2/3).

Chlorophyl concentration is important for fish exploration. Another method in fish exploration using remote sensing is by sensing the sea surface temperature (the meeting point of hot and cold current), since the fish phytoplankton concentration is obtained from a flying low airplane using blue or green band (Lillesand and Keifer, 1994).

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