2 LITERATURE REVIEW

The essential and important issue of coastal zone management for sustainable development have had concerned about coastal landuse, coastal ecosystem and environment, carrying capacity and land suitability, which in this study handled with information technology that emphasize in application of remote sensing for coastal landuse change detection. The key words are Coastal Landuse, Remote Sensing (RS), Landsat, Supervised Classification and Change Detection. So, it's needed to determine a definition of keys words and some portion relationship in order to effective and efficient for performing and accomplishment in this study.

2.1 Coastal Zone

In the United States of America, the term coastal zone (legal definition for coastal zone management) means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each and in proximity to the shorelines of the several coastal states, and includes islands, transitional and inter-tidal areas, salt marshes, wetlands, and beaches (NOAA, 1998).

For mapping purposes in Indonesia, coastal zone is defined as an area between land and sea that affects each other, having a specific geosphere characteristics, to the direction of land that is limited by the effect of marine socio-economic and physical characteristics, while to the direction of sea it is limited by the natural process and caused by human activities against the land environment.

Sometimes coastal zone definition depends on the project purposes, such as that defined for the Land-Ocean Interactions in the Coastal Zone (LOICZ) project. The coastal zone is considered to extend from the coastal plains to the outer edges of the continental shelf, approximately matching the region that has been alternately flooded.
and exposed during the sea level fluctuations of the late-Quaternary period.

Definitions of coastal zone may extend to the landward and seaward limits of marine and terrestrial influence respectively. At the other extreme, the coastal zone can be restricted to the coastline and adjacent geomorphological features determined by the action of the sea on the land margin. Coastal zone boundary is presented in Figure 1.

\[ \text{Figure 1. Coastal zone boundary (Holligan and de Boois, 1993).} \]

2.2 Shoreline (Coastline)

Shoreline is intersection of the land with the water surface. The shoreline represents the line of contact between the land and a selected water elevation. In areas affected by tidal fluctuations, this line of contact is the mean high water line. In confined coastal waters of diminished tidal influence, the mean water level line may be used (NOAA, 2001). Furthermore, coastlines vary in time, and coastline detected by Remote Sensing may be influenced by this variation, so that a correction might be necessary. Several different shoreline definitions are in use by various state, and local authorities. The use of inconsistent shoreline definitions between maps, charts, Geographic Information Systems (GIS), and other products can lead to confusion by users and can contribute to misinformed decision-making.

Shoreline defined as the line of ordinary low water along that portion of the coast that is in direct contact with the open sea and the line marking the seaward limit of inland
waters. In coast survey usage, shoreline is considered synonymous with coastline and
defined as the line of contact/crossing line between the land and a body of water. On
coastal and geodetic survey nautical charts and surveys, the shoreline approximately
uses the mean high water line (Saptarini, 1998).

Another definition of shoreline is the line where the average high tide, known as
mean high water (MHW), interacts the coast. Basically, planning map uses high water
line or mean sea level as shoreline reference as they are easier to be determined and
frequently exposed. This is different from the depth reference in bathymetric map that
usually uses low water line for safe navigation as applied in most ports of Indonesia.
However, use mean sea level (MSL) as reference level for comparative morpholo-
gical studies or sea level changes.

2.3 Remote Sensing Technique for Coastal Management

Remote sensing is the technique of collecting information from a distance. By
convention, “from a distance:” is generally considered to be large relative to what a
person can reach out and touch, hundreds of feet, hundreds of miles, or more. Remote
sensing techniques are used intensively to gather measurements, Satellite-based
systems can now measure phenomena that change continuously over time and cover
large, often inaccessible areas (Aronoff, 1991).

There are various journal concerns the application of remote sensing for coastal
management, such as, fisheries detection using NOAA satellite, why can fishing
grounds be monitored by remote sensing, monitoring the water sediment dynamics,
satellite ocean color use for oceanic resources, general inventory of shrimp
aquaculture potential, suitable land selection for shrimp farm development,
bathymetry mapping, and coral reef mapping in order to manage coastal resource into
sustainable development carry on. However, Landsat imagery is useful for image
interpretation for a much wider range of application than other satellite images. This
is caused of the Landsat TM and ETM* has both an increase in the number of spectral bands and an improvement in spatial resolution.

2.4 Landuse and Coastal Landuse

Landuse is defined in terms of a specific combination of land activity and landcover. Land "activity" is regarded as the active use man makes of the land. It is not to be confused with other variables, such as, tenure, ownership, economic activity or land value. Landcover is regarded as the vegetative, natural or artificial construction covering the land surface (Yusuf, 2001).

Definitions of landuse raise the following issues:
- The difference between present and proposed uses needs to be clarified
- Both landcover and land activities need to be included
- Landcover complicates the inventory and its unnecessary

Coastal landuse is defined in terms of a specific combination of land activity and landcover on the coastal zone. Land "activity" is regarded as the active use man makes of the land occurred on the coastal zone. Coastal landcover is regarded as the vegetative, natural or artificial construction covering the coastal land surface. Coastal landuse, such as, natural area and agriculture might be either change into paddyfields, fishponds or settlement. Moreover, those may be change by natural hazard, such as, storm, floodwater, landslide and earthquake. However, the faster one that has effected with coastal landuse is human activities. Coastal landuse changed very important phenomena because its have influent with biogeomorphological function. For example, coral reefs zone, calcareous algae, and a range of shell-producing animals that contribute to the formation of calcareous sediments, sea grass, salt marsh and macro algae communities that tend to trap land or ocean derived particulate material, benthos invertebrates that can stabilize or destabilize near shore sediments; and
various organisms (micro algae, bacteria) that promote sediment cohesiveness through the production of extra cellular metabolites.

2.4.1 Coastal Landuse Change

Coastal landuse change is one of the most critical dynamic elements of coastal zone. This pattern is a product of the interaction between ecological and socioeconomic processes. Understanding the function and structure of coastal landuse, primarily in terms of human impacts, requires integration of biological and socioeconomic knowledge. Natural resource managers, in particular, need this integration to effectively evaluate the social and environmental cost of alternative management scenarios.

The basic concept of landuse changes is related to the biogeochemical cycle, energy cycle, global climate change, and the aspect of human dimension. Energy flows through an ecosystem in a cyclic manner and do materials that necessary for a life, such as, carbon, oxygen, nitrogen, potassium, water, and many others. The path these substances take a place in the environment are called biogeochemical cycles. Some biogeochemical cycles are keeping up by large storages in the atmosphere and other are dominated by terrestrial storages, usually in rocks and sediment. Energy in an ecosystem (and also humansystem) is eventually derived from the sun, called solar energy. The energy passes through a series of storages by way of many paths, before lastly being return to the space as radiant energy. Ecosystems consist of all living organisms in a defined geographic area together with all the physical entities (soil, water, dead organic matter, and so on), with which they interact. Since one type of organism in an ecosystem consume another, a pattern of energy flow through the ecosystem is set up, called food chain.

There is a general recognition about the significance of coastal landuse changes to the variety of global environmental issues, among others, the role of coastal landuse and
coastal landcover in effecting the biochemical flows, and the states of the biosphere
gerophere. Also coastal landuse in its own right as it interacts with human activities
that drive and take action to the environmental change. Changes in coastal landuse
may result in deforestation and soil degradation, such as, desertification and
salinization, loss of wetlands, changes in hydrology function, and changes in the
distribution of chemical and biological properties of aquatic and terrestrial ecosystem
(Yusuf, 2001).

There are four aspects of large-scale environmental perturbations that are considered
as the term of “global change”: 1). Change in landuse and landcover, 2). Worldwide
decline in biodiversity, 3). Change in atmospheric composition, especially the
increase in CO₂ concentration and 4). Change in climate. The most rapid changes of
coastal zone are in coastal landuse, mainly in terms of coastal landuse conversion,
such as, forest conversion for agricultural purpose, fishery cultivation purpose, human
settlements, industrial areas, and other intensive uses.

2.4.2 Coastal Landuse Change Monitoring

Determination of coastal landuse change monitoring can be conducted using various
methods, among others, mapping using GPS (Global Positioning System). In recent
decades, remote sensing technique has been use for monitoring landuse changes.
Remote sensing techniques consist of some methods, such as, map-used, aerial
photograph, and data imagery. Beginning with the early use of aerial photography,
remote sensing has been recognized as a precious tool for viewing, analyzing,
characterizing, and making decision about environment problems. Remote sensing
technology though a larger instantaneous field of view therefore it is acquired in
larger scope of areas, fast and cost-effective. Satellite remote sensing has become
more and more important as a technique for regional studies, especially for less
accessible large areas where previously information was very limited. Some scientist
has been used Remote Sensing technique to detect and monitor environmental
changes; especially, landuse and landcover changes and for this study have used for detecting the change in coastal landuse.

2.5 Landsat Imagery

2.5.1 Landsat-5 TM (Thematic Mapper)

Landsat-5 TM was lunch in 1984. Thematic Mapper (TM) is instrument that upgrades included improved ground resolution (30 meters) and 3 new channels or bands. The TM is a highly advanced sensor incorporating a number of spectral radiometric and geometric design improvements relative to the MSS. Spectral improvements include the acquisition of data in seven bands instead of four, with new bands in the visible (blue), mid-infrared, and thermal portions of the spectrum. Also, based on experience with MSS data and extensive field radiometer research result, the wavelength range and location of the TM bands have been choose to improve the spectral differentiability of major earth surface feature.

Radiometrically, the TM performs its onboard analog-to-digital signal conversion over a quantization range of 256 digital numbers (8 bits). This corresponds to a fourfold increase in the gray scale range relative to the 64 digital numbers (6 bits) used by the MSS. This finer radiometric precision permits observation of smaller changers in radiometric magnitudes in a given band and provides greater sensitive to changes in relationships between bands. Thus, difference in radiometric values that are lost in one digital number in MSS data may now be distinguished.

Geometrically, TM data are collected using a 30-m ground resolution cell (for all but the thermal band, which has 120 m resolution). This represents a decrease in the linear dimensions of the ground control cell of approximately 2.6 times, or a reduction in the area of the ground resolution cell of approximately 7 times. At the same time, several design changes have been incorporated within the TM to improve the accuracy of the geodetic positioning of the data. Most geometrically corrected TM
data are supplied using 28.5 X28.5-m pixels registered to the Space Oblique Mercator (SOM) cartographic projection. The data may also be fit to the Universal Transverse Mercator (UTM) or Polar Stereographic projection (Lillesand and Kiefer, 1994). The TM bands and TM Technical Specifications are presented in Table 1.

Table 1. TM Bands and TM Technical Specifications (NASA, 2002).

<table>
<thead>
<tr>
<th>TM Bands</th>
<th>TM Technical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Band</td>
<td>Micrometers</td>
</tr>
<tr>
<td>1</td>
<td>0.45-0.53</td>
</tr>
<tr>
<td>2</td>
<td>0.52-0.60</td>
</tr>
<tr>
<td>3</td>
<td>0.63-0.69</td>
</tr>
<tr>
<td>4</td>
<td>0.76-0.90</td>
</tr>
<tr>
<td>5</td>
<td>1.55-1.75</td>
</tr>
<tr>
<td>6</td>
<td>10.40-12.50</td>
</tr>
<tr>
<td>7</td>
<td>2.08-2.35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>opto-mechanical sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial resolution</td>
<td>30-120 m</td>
</tr>
<tr>
<td>Spectral range</td>
<td>0.45-12.5 μm</td>
</tr>
<tr>
<td>Number of bands</td>
<td>7</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>16 days</td>
</tr>
<tr>
<td>Size of image</td>
<td>185 x 172 km</td>
</tr>
<tr>
<td>Swath</td>
<td>185 km</td>
</tr>
<tr>
<td>Stereo</td>
<td>n</td>
</tr>
<tr>
<td>Programmable</td>
<td>y</td>
</tr>
</tbody>
</table>

2.5.2 Landsat-7 ETM+ (Enhanced Thematic Mapper Plus)

The Land Remote Sensing Act of 1992 once again transferred the management responsibility for the Landsat program with the design and operation of Landsat-7 and its successors. Under this legislation NASA and the Department of Defense (DOD) jointly managed the program. According to the design of Landsat-7 has been developed in an attempt to meet the needs of both the defense community and civilian users. At the time of this writing (1993), many aspect of the design and operation of Landsat-7 were still under discussion (particularly in light of launch failure of Landsat-6). The following describes the plans for the system as of that date. The design of the ETM+ (Enhanced Thematic Mapper Plus) stresses the provision of data
continuity with Landsat-4 and Landsat-5. Similar orbits and repeat patterns are used, as is the 185-km swath width for images. As with the ETM planned for Landsat-6, the system is designed to collect 15-m-resolution “panchromatic” data and six bands of data in the visible, near-IR, and Mid-IR spectral regions at a resolution of 30 m. A seventh, thermal band is to be incorporated with a resolution of 60 m. As with the ETM, high and low gain setting for the individual channels may be controlled from the ground.

Several other design features characterize the ETM+. First, the system will include a dual mode solar calibrator, “in addition to an internal lamp calibrator. This will greatly improve the radiometric calibration of the ETM+ data. Also, data can be transmitted to ground in three possible ways: directly, via the tracking. Finally, because the spacecraft includes a GCP receiver, subsequent geometric processing of the data will be facilities (Lillesand and Kiefer, 1994). The ETM+ bands and ETM+ Technical Specifications are presented in Table 2.

Table 2. ETM+ Bands and ETM+ Technical Specifications (NASA, 2002).

<table>
<thead>
<tr>
<th>Band</th>
<th>Micrometers</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45 to .515</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>.525 to .605</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>.63 to .690</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>.75 to .90</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>1.55 to 1.75</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>10.40 to 12.5</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>2.09 to 2.35</td>
<td>30</td>
</tr>
<tr>
<td>Pan</td>
<td>.52 to .90</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>opto-mechanical scanner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial resolution</td>
<td>15/30/60 m</td>
</tr>
<tr>
<td>Spectral range</td>
<td>0.45-12.5 μm</td>
</tr>
<tr>
<td>Number of bands</td>
<td>8</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>16 days</td>
</tr>
<tr>
<td>Size of image</td>
<td>183 x 170 km</td>
</tr>
<tr>
<td>Swath</td>
<td>183 km</td>
</tr>
<tr>
<td>Stereo</td>
<td>n</td>
</tr>
<tr>
<td>Programmable</td>
<td>y</td>
</tr>
</tbody>
</table>
2.6 Classification

2.6.1 Supervised Classification

Classification is an abstract representation of the situation in the field using well-defined diagnostic criteria: the classifiers. Sokal (1974) defined it as "the ordering or arrangement of objects into groups or sets on the basis of their relationships." A classification describes the systematic framework with the names of the classes and the criteria used to distinguish them, and the relation between classes. Classification thus necessarily involves definition of class boundaries that should be clear, precise, and possibly quantitative, and based on objective criteria (Jensen, 1986).

Supervised classification is the method used to transform multispectral image data into thematic information classes. This procedure typically assumes that imagery of a specific geographic is gathered in multiple regions of the electromagnetic spectrum.

The basic steps in supervised classification are presented in Figure 2.

Figure 2. Basic steps in supervised classification (Lillesand and Kiefer, 1994).
Supervised classification, the identifying and location of feature classes or cover types (urban, forest, water, etc) are known beforehand through fieldwork, analysis of aerial photographs, or other means. Typically, identify specific areas on the multispectral imagery that represent the desired known feature types, and use the spectral characteristics of these known areas to train the classification program to assign each pixel in the image to one of these classes. Multivariate statistical parameters, such as, means, standard deviation, and correlation matrices are calculated for each training region, and each pixel is evaluated and assigned to the class to which it has the most likelihood of being a member (according to rules of the classification method chosen).

One of the simple classification strategies that may be used is Maximum Likelihood Classifier. The Maximum Likelihood Classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel. In essence, the maximum likelihood classifier delineates ellipsoidal “equiprobability contours” in the scatter diagram. These decision regions are showed in Figure 3. The shape of the equiprobability contours expresses the sensitivity of the likelihood classifier to covariance.

Figure 3. Equiprobability contours defined by a maximum likelihood classifier (Lillesand and Kiefer, 1994).
An extension of the maximum likelihood approach is the Bayesian classifier. This technique applies two weighting factors to the probability estimate. First, the analyst determines the “a priori probability”, or the anticipated likelihood of occurrence for each class in the given scene. Second, a weight associated with the “cost” of misclassification is applied to each class. Together, these factors act to minimize the “cost” of misclassifications, resulting in a theoretically optimum classification. In practice, most maximum likelihood classification is performed assuming equal probability of occurrence and cost of misclassification for all classes. If suitable data exist for these factors, the Bayesian implementation of the classifier is preferable (Jensen, 1986). Image classification is an automatically categorize all pixels in an image into coastal landuse classes or themes. These categorized data may then be used to produce thematic maps of the coastal landuse present in an image and produce summary statistic on the areas covered by each land cover type.

2.6.2 Knowledgebase Classification

The human visual interpretation that is mainly an object-based has to be considered as a natural and logical alternative, since the traditional computer-assisted algorithms have produced less information than is desirable when they are applied to higher resolution remotely sensed data. To integrate geographical information system (GIS) and remote sensing (RS) system it is important that both systems are object oriented. A data structure with a higher information level can be obtained by using the concept of terrain objects. In GIS terrain objects are represented by three components: an identifier, a thematic data, and a geometric data. In RS the information derived from classification is feature based. Of late there has been lots of research going on how to link GIS and RS. The integration between GIS and RS is vital since in GIS the data can become obsolete quickly, so it is essential to update periodically with new spatial and thematic data. Remote sensing is often the most cost effective source for these updates (Yusuf, 2001).
Remote sensing data is used by a variety of users from ecologist, geologist, landuse planner and meteorologist to oceanographer. For many of these surveying applications the images are classified into classes that are relevant to the users. The classification is based on spectral characteristics. The spectral characteristics are difficult to classify because we require knowledge about the class in terms of texture, pattern, and shape of the objects. Additional information in form of ancillary data can be used to enhance the classification; the latter category is called “knowledgebased classification” (Middelkoop et al., 1991).

The knowledge base in our case takes the form of a production rule base. The knowledgebased system has three types of rules: the initialization rules, landcover to landuse rules and local consistency rules. These rules have been adapted in classifying our landcover maps to landuse. The initialization rules use a priori knowledge to give a score to each landcover. For coastal landuse classification it is not possible to retain all characteristic features of an object. The criteria of classification have to be selected (this implies that some features will be emphasize) and some other neglected. The most common systems of classification are: physiognomic, ecological, geographical, dynamic or evolutionary and functional system.

The level of detail may also determine the criteria of classification. For example, when inventories have to be made over extensive areas using remote sensing techniques, physiognomic criteria will acquire more importance. Physiognomic systems are more related to the landcover than to the actual use to which the land is put. Landuse is inferred from analysis and interpretation of landcover features. The success of such interpretation relies on the analyst’s ability to identify relevant physical characteristics of land attributes and relate those observable parameters to the use made of local resources. Assessment of the actual landuse is also dependent on the availability of an appropriate classification. A logical succession of operations is presented in Figure 4. Human knowledge with respect to texture, shape, size,
neighborhoods, proximity and association, as well as pattern (quality analysis) due to the requirement of landuse classification for satellite images.

![Diagram of landuse classification process]

**Figure 4. Landuse inventory – a logical succession of operations.**

### 2.7 Change Detection

Coastal landuse change detection is needful for updating coastal landuse maps and the coastal resources management. The change is usually by comparison between two dates images, or sometimes between an old map and update remote sensing image.

Change detection is a method to identify the changes in imagery of the same geographic area obtained at different times. Aerial photo and data imagery are two of data source that often used in change detection. Digital change detection is a method that involving data imagery as source of data. A fundamental assumption of digital change detection is that there exists a difference in the spectral response of a pixel on two dates if the landcover or landuse changes from one type to another. A change detection method should be based on a sensor system that:

- Has a systematic period between over flights,
- Records imagery of the same geographic area,
- Reduces relief displacement as much as possible, and
- Records reflected radiant flux (Jensen, 1986).
The change detection processing using satellite imagery is an ideal way to determine changes in coastal landuse in order to enable organizations to maintain the integrity of the data that they manage. The periodic availability of remotely sensed data makes it well suited to change detection applications. Multidate imagery can be processed to highlight changes in pixel spectral response between image dates. Such information can be used in the decision making process, or used to monitor changes over time as an aid to updating information database.

2.8 Validation Method

2.8.1 Error Matrix

One of the most common means of expressing classification accuracy is the preparation of a classification error matrices (sometimes called a confusion matrix or a contingency table). Error metrics compare, on a category-by-category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification. Such matrices are square, with the number of rows and columns equal to the number of categories whose classification accuracy is being assessed (Lillesand and Kiefer, 1994). The matrix is a square array of numbers set out in rows and columns that express the labels of samples assigned to a particular category in one classification relative to the labels of samples assigned to a particular category in another classification. Example error matrix is presented in Figure 5.

2.8.2 Ground Truth

A commonly used term for observations made on the surface of the earth with respect to remotely sensed data is ground truth. Other terms of a similar meaning are in situ data, or collateral data, but all refer to sample data gathered in order to establish a relationship between the sensor response and particular surface conditions. It is
commonly used to determine the accuracy of categorized data obtained through classification (ER Mapper, 1997).

<table>
<thead>
<tr>
<th>Classified Data</th>
<th>Reference Data</th>
<th>Coastal Landuse Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>P</td>
<td>AG</td>
</tr>
<tr>
<td>65</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>P</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>AG</td>
<td>11</td>
<td>85</td>
</tr>
<tr>
<td>S</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>115</td>
</tr>
<tr>
<td>column total</td>
<td>75</td>
<td>103</td>
</tr>
<tr>
<td>row total</td>
<td>115</td>
<td>100</td>
</tr>
</tbody>
</table>

**PRODUCER'S ACCURACY**
- F = 65/75 = 87%
- P = 81/103 = 79%
- AG = 85/115 = 74%
- S = 90/141 = 64%

**USER'S ACCURACY**
- F = 65/115 = 57%
- P = 81/100 = 81%
- AG = 85/115 = 74%
- S = 90/104 = 87%

Figure 5. Example error matrix (Modified from Green, K. and Congalton, R.G., 1999).

1. Dilarang menggubah sebagian atau seluruhnya untuk tujuan pendidikan, penelitian, penulisan, pelaporan, Izin penerbit, atau tujuan lain yang tidak dimanfaatkan untuk tujuan pendidikan.