II. LITERATURE REVIEW

2.1 Swamps Potential in Indonesia

Swamps are a form of wetland with some flooding of large areas of land by shallow bodies of water. A swamps generally covered by vegetation, or vegetation that tolerates periodical inundation. The two main types of swamps are "true" or swamps forest and "transitional" or shrub forest. The water of swamps may be fresh water, brackish water and sea water.

Swamps area is considered as low or level water or any broad expanse of land with a general low level. This type of land is relatively flatter or lower than adjacent land. The typical characteristic of swamps is inundation for some time due to poor drainage, where seasonal flooding may occur. Swamps in Indonesia become more important remaining land resources for the development of food crops. The development of swamps has to create a suitable condition for agriculture and settlement. Almost 9 million ha of tidal swamps is indicated potential for agriculture and more than 3,6 million ha has been reclaimed. Most of reclaimed swamps are in Sumatera and Kalimantan (Bappenas 2006; Wignyosukarto 2006).

In general, the swamps development in Indonesia is driven by transmigration program, whereby major reclamation projects were implemented in order to settle farmers from densely isles of Java, Madura and Bali. In the time period, the issues of food security and food sufficiency become the main objective of swamps development and management, which is to fulfill the food requirement by intensifying the existing reclaimed swamps area (Suryadi 1996; Euroconsult 1997).

Swamps in Indonesia can be grouped into three categories (Suryadi 1996):
1. Tidal swamps. These swamps are located along the coasts and along lower reaches of rivers where the river regimes are dominated by tidal fluctuation. They include a generally narrow zone of mangrove, followed by extensive fresh water swamps. Land elevations are generally around the tidal high water level. From water management point of view these area are characterized by shallow inundation in the wet season, caused mainly by stagnant rainwater.
The daily low tide in the rivers offers in the principle good opportunities for drainage of excess water. In the certain areas the high tide offers opportunities for tidal irrigation.

2. Non tidal swamps, beyond the zone of tidal swamps seasonal fluctuations in the river water levels are more pronounced and may cause deep inundation of lands in the wet season. The absence of daily low water in the rivers requires adopted approaches for drainage. In the many cases flood protection will be required.

Inland swamps, separated from the above swamps by surrounding uplands. These swamps cover relatively small areas.

Commonly, the swamps are found in the coastal zone (tidal swamps) and river floodplain (non tidal, inland swamps). Table 1 has identified approximately 39 million swampy land in the whole country, 65% of these area is located in Sumatera and Kalimantan and 35% of swamps area can be found in Papua and Sulawesi. Moreover, up to 65% of the swampy land is tidal swamps and 37% is inland swamps. Table 2 shows the suitable tidal swamps for agricultural cropland in four major islands.

<table>
<thead>
<tr>
<th>Table 1  Swampy land resource in four major islands (in thousand hectares)</th>
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<tbody>
<tr>
<td>Type of</td>
</tr>
<tr>
<td>Tidal swamps</td>
</tr>
<tr>
<td>Inland swamps</td>
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<tr>
<td>Total</td>
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Source: Settlement and Regional Infrastructure Department and Rijks Waterstaat Netherlands. 2002

<table>
<thead>
<tr>
<th>Table 2  Suitable tidal swamps in four major islands (in thousand hectares)</th>
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<tr>
<td>Type of</td>
</tr>
<tr>
<td>Not Cultivated</td>
</tr>
<tr>
<td>Cultivated</td>
</tr>
</tbody>
</table>

Source: Settlement and Regional Infrastructure Department and Rijks Waterstaat Netherlands. 2002
2.2 Remote Sensing Application

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact area or phenomenon under investigation (Lillesand and Kiefer 2000).

![Electromagnetic spectrum](image)

The earth’s surface and atmosphere emit individual characteristic signatures within the visible light and electromagnetic radiation spectrum. The spectrum is divided into spectral bands ranging from short gamma rays to long radio waves. As indicated, most remote sensing devices make use of electromagnetic energy. However, the electromagnetic spectrum is very broad and not all wavelengths are equally effective for remote sensing purposes. Furthermore, not all have significant interactions with earth surface materials of interest to us. Figure 1 illustrates the electromagnetic spectrum. The atmosphere itself causes significant absorption of shorter wavelengths such as the ultraviolet (UV). As the result, the first significant window (i.e., a region in which energy can significantly pass through the atmosphere) opens up in the visible wavelengths. Even here, the blue wavelengths undergo substantial attenuation by atmosphere scattering, and are thus often left out in remote sensed images. However, the green, red and near-infrared (IR) wavelengths all provide good opportunities for gauging earth surface interactions without significant interference by the atmospheric. In addition, these regions provide important clues to the nature of many earth materials. Chlorophyll, for example is very strong absorber of red visible wavelengths, while
the near-infrared wavelengths provide important clues to the structures of plant leaves. As a result, the bulk remotely sensed images used in GIS-related applications are of taken in these regions.

Extending into the middle and thermal infrared regions, a variety of goods windows can be found. The longer of the middle infrared wavelengths have proven to be useful in a number of geological applications. The thermal regions have proven to be very useful for monitoring not only the obvious cases of the spatial distribution of heat from industrial activity, but a broad set of applications ranging from fire monitoring to animal distribution studies to soil moisture conditions.

After the thermal IR, the next area of major significance in environmental remote sensing is in the microwave region. A number of important windows exist in this region and area of particular importance for the use of active radar imaging. This can thus be used as a supplement to information gained in other wavelengths, and also offers the significant advantage of being usable at night (because as an active system it is independent of solar radiation) and in regions of persistent cloud cover (since radar wavelength are not significantly affected by clouds).

When electromagnetic energy strikes a material, three typed of interaction can follow: reflection, absorption and/or transmission. It can be seen in Figure 2. Our main concern is with the reflected portion since it is usually this which is returned to the sensor system. Exactly how much is reflected will vary and will depend upon the nature of the material and where in the electromagnetic spectrum our measurement is being taken. The result can be characterized as a spectral response pattern or sometimes called as a signature. Most human are familiar with spectral response patterns since they are equivalent to human concept of color.

Finding distinctive spectral response patterns is the key to most procedures for computer-assisted interpretation of remotely sensed imagery. This task is rarely trivial. Rather, the analyst must find the combination of spectral bands and the time of year at which distinctive patterns can be found for each of the information classes of interest.
Remote sensing is used extensively to gather measurements. Satellite-based systems can measure phenomena that change continuously over time and cover large, often inaccessible areas (Aronoff 1991). The ideal of perfect remote sensing system has yet to be developed. Consequently, error creeps into the data acquisition process can degrade the quality of the remote sensor data collected. These errors may have an impact on the accuracy of the subsequent human or machine-assisted image analysis. Therefore, it is usually necessary to pre-process that remotely sensed data prior to analyze it to remove some of these errors (Lillesand and Kiefer 2000).

Digital image processing involves the manipulation and interpretation of digital images with the aid of a computer. The central idea behind digital image processing is quite simple. The digital image is fed into a computer one pixel at a time. The computer is programmed to insert these data into an equation, or series of equations and store the result of computation for each pixel (Lillesand and Kiefer 2000).

The procedures of digital image processing are following some broad types of computer assisted operations: image rectification, image enhancement, image classification.

2.2.1 Image Rectification

Image rectification are operations aiming at correcting distorted or degraded image data, which stem from image acquisition; to create a more faithful
representation of original scene. The procedures of image rectification consist of geometric correction, radiometric correction and noise removal.

a. **Geometric Correction**

Raw digital images usually contain geometric distortions so significant that they cannot be used as maps. The geometric correction process is normally implemented as two-step procedure. First, those distortions those are systematic or predictable. Second, those distortions that are essentially random or unpredictable are considered (Lillesand and Kiefer 2000).

As systematic distortions are constant and predictable they do not constitute a problem to the user of satellite imagery. The agencies that supply the imagery do the corrections. The main systematic distortions are panoramic (or scanner), distortion, scan skew and change in scanning velocity (Meijerink et al. 1994).

Systematic distortions are well understood and easily corrected by applying formulas derived by modeling the sources of the distortions mathematically. Random distortions and residual unknown systematic distortions are corrected by analyzing well-distributed ground control points (GCPs) occurring in an image. As with they counterparts on aerial photographs, GCPs are features of known ground location that can be accurately located on digital imagery. Some features that make good control points are highway intersections and distinct shoreline features (Lillesand and Kiefer 2000).

b. **Radiometric Correction**

The radiometric correction is necessary to remove variations in the radiometry that influence the compatibility of multi-temporal/multi-sensor data. The sources of radiometric distortions in VIR (Visible InfraRed) data are

- Atmosphere (atmosphere scattering, absorption)
- Sensor (stripping)
- Sun illumination

Image enhancement is procedures that applied to image data in order to effectively display or record the data for subsequent visual interpretation.
Steps that most commonly applied digital enhancement technique can be categorized as contrast manipulation, spatial features manipulation or multi image manipulation.

2.2.2 Image Enhancement

Image enhancement procedures are applied to image data in order to more effectively display or record the data for subsequent visual interpretation. Normally, image enhancement involves techniques for increasing the visual distinction between features in a scene. The objective is to create “new” images from the original image data in order to increase the amount of information that can be visually interpreted from data (Lillesand & Kiefer 2000).

2.2.3 Image Classification

The overall objective of image classification procedures is to automatically categorize all pixels in an image into land cover classes or themes. Normally, multispectral data are used to perform the classification and indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. That is, different feature types manifest different combination of DNs based on their inherent spectral reflectance and emission properties. In this light, a spectral pattern is not all geometric in character. Rather, the term pattern refers to the set of radiance measurements obtained in the several of classification procedures that utilizes this pixel by pixel spectral information as the basis for automated land cover classification.

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 of remotely sensed data is used to assign corresponding levels with respect to groups with homogeneous characteristics, with the aim of discriminating multiple objects from each other within image. Classification thus necessarily involves definition of class boundaries that should be clear, precise, possibly quantitative, and based on objective/criteria.

Supervised classification is the procedure most often used for quantitative analysis of remote sensing image data. It rests upon using suitable algorithm to label the pixels in an image as representing particular ground cover types, or
classes. In supervised classification, this is realized by an operator who defines the spectral characteristics of the classes by identifying sample areas (training areas). Supervised classification requires that the operator must be familiar with the areas of interest. The operator needs to know where to find the classes of interest in the area covered by the image. This information can be derived from general area knowledge or from dedicated field observations (Janssen and Goerte 2000).

2.3 Landsat TM Characteristics

The kind of Landsat that are useful for image interpretation for much wider range applications is Landsat Thematic Mapper ™. The characteristic of Landsat Thematic Mapper ™ which first loaded on Landsat 4 in 1982 was designed to provide improved spectral and spatial resolution over the Multi Spectral Scanner (MSS) instrument. Landsat Thematic Mapper ™ is designed to capture electromagnetic in 7 spectral bands. It has three bands in visible region (band 1, 2 and 3), one band in near infra red (band 4), two bands in mid infra red (band 5 and 7) and one band in thermal infra red (band 6). All bands have 30 m spatial resolution except for Image acquisition on 15 April 2000, support for TM imagery with the addition of a co-registered 15 m panchromatic band (Lillesand and Kiefer 2000).

Landsat TM image is useful for image interpretation of a much wider range of applications than other satellite images. This is due to the Landsat has both an increase in the number of spectral bands and an improvement in spatial resolution. A list of the seven spectral bands of the Landsat TM, along with a brief summary of the intended principal application of each, that shown in Table 3.
### Table 3: Thematic mapper spectral bands

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength (µm)</th>
<th>Nominal Spectral Location</th>
<th>Principal Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.45-0.52</td>
<td>Blue</td>
<td>Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil/vegetation discrimination, forest type mapping.</td>
</tr>
<tr>
<td>2</td>
<td>0.52-0.60</td>
<td>Green</td>
<td>Designed measure green reflectance peak of vegetation discrimination and vigor assessment.</td>
</tr>
<tr>
<td>3</td>
<td>0.63-0.69</td>
<td>Red</td>
<td>Designed to sense in chlorophyll absorption region aiding in plant species differentiation.</td>
</tr>
<tr>
<td>4</td>
<td>0.76-0.90</td>
<td>Near-Infrared</td>
<td>Useful for determining vegetation types, vigor, and biomass content, for delineating water bodies and for soil moisture discrimination.</td>
</tr>
<tr>
<td>5</td>
<td>1.55-1.75</td>
<td>Mid-Infrared</td>
<td>Indicative of vegetation moisture. Also useful for differentiation of snow from clouds.</td>
</tr>
<tr>
<td>6</td>
<td>10.4-12.5</td>
<td>Thermal Infrared</td>
<td>Useful in vegetation stress analysis, soil moisture discrimination and thermal mapping applications.</td>
</tr>
<tr>
<td>7</td>
<td>2.08-2.35</td>
<td>Mid-Infrared</td>
<td>Useful for discrimination of mineral and rock types. Also sensitive to vegetation moisture content.</td>
</tr>
</tbody>
</table>

Source: (Lillesand and Kiefer 2000)

### 2.4 Land Suitability

Land evaluation is the process of assessing of land performance when the land is used for specified purposes (FAO, 1976). The land is the ultimate source of wealth and the foundation on which civilization is constructed. Due to the benefit of the land, then are merged efforts to utilize it. Land evaluation leads to
rational land use planning and appropriate and sustainable use of natural and human resources. Land suitability represents a method of land evaluation.

Land suitability analysis estimates which areas suitable or not suitable for certain development. The land suitability can be determined by using matching methods between land suitability criteria and land characteristics. The process of land suitability classification is the appraisal and grouping of specific areas of lands in terms of their suitability for a defined use. The suitability is the aptitude of a given type of land to support a defined use.

To produce the land suitability, two concept of land evaluation are known, i.e. physiographic approach and parametric approach. Physiographic approach utilizes landform framework to identify the natural unit, while parametric approach divides the land following the distinguish land value and its combination. Parametric approach is more suitable for this research, due to all of parameters that are quantized. In this study two categories are recognized: orders and classes. The orders indicate whether or not given types of land are suitable for the concerned land utilizations type and are expressed by symbols S and N. It can be seen in Table 4.

Table 4 Land suitability order

<table>
<thead>
<tr>
<th>Order</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>S (Suitable)</td>
<td>Land on which sustained use is expected to yield benefits which justify the inputs, without un acceptable risk of damage to land resources</td>
</tr>
<tr>
<td>N (Not Suitable)</td>
<td>Land whose qualifies appear to preclude sustainability for the considered land use</td>
</tr>
</tbody>
</table>

Source: FAO, 1976

Classes reflect degrees of sustainability within the order “suitable”. Normally three classes are recognized:
Table 5 Land suitability classes

<table>
<thead>
<tr>
<th>Classes</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 (highly suitable)</td>
<td>Land which has no significant or only minor limitations to the sustained application of the given land utilization.</td>
</tr>
<tr>
<td>S2 (moderately suitable)</td>
<td>Land which has limitations that are moderately severe for sustained application of the given land utilization. The limitations will reduce productivity or benefits and will increase the required inputs</td>
</tr>
<tr>
<td>S3 (marginally suitable)</td>
<td>Land which has severe limitations for sustained application of the land utilization</td>
</tr>
<tr>
<td>N (not suitable)</td>
<td>The limitations are so severe that they preclude the successful application of the given land utilization</td>
</tr>
</tbody>
</table>

Source: FAO, 1976

Because it is based only on physical aspect of suitability orders, there will be no differentiation between N1 and N2. In this case, the “not suitability” of land for paddy field will be assumed as N (not suitable).

2.5 Previous Related-Researches

Land surface temperature is sensitive to vegetation and soil moisture, hence it can be used to detect land use and land cover changes, e.g. tendencies towards urbanization, desertification etc.

Hanqiu Xu. (2007) proposed a technique to extract urban built up land features from Landsat Thematic Mapper ™ and Enhanced Thematic Mapper (ETM+) imagery using three indices, Normalized Difference Built up (NDBI), Modified Normalized Difference Water Index (MNDWI) and Soil Adjusted Vegetation Index (SAVI) respectively. These indices is used to represent three major urban land use classes, built up land, open water body and vegetation, respectively. As a result, the spectral signatures of the three urban land use classes are more distinguishable in the new composite image than in the original seven band image as the spectral clusters of the classes are well separated.
Nugroho et al. (2007) present detecting tidal flood pattern with Landsat TM remote sensing data in South Sumatera coastal area. The method in the research is using transformation image that included Maximum Likelihood, Principle Component Analysis (PCA) and Tasseled Cap (all in IDRISI version Window 2.0). The result stated that the humidity of earth surface is one of the results from the transformation moist.

Guha and Lakshmi (2002) proposed one way of determining soil moisture contents from remotely sensed data is by using the thermal emissions from soils in the microwave range, generally sensitive to moisture variations in the top five cm of the soil. Saturated surfaces emit low levels of microwave radiation, whereas dry soils emit much higher levels of microwave radiation. However, in many applications it is difficult to separate the microwave signal from saturated and unsaturated soil due to competing effects of moisture content, surface roughness, vegetation, liquid precipitation, and complex topography unless the variables are known a priori (Schmugge 1985; Bindlish et al. 2003).

Hence, an extensive amount of calibration is necessary to fit the parameters and prior knowledge of the surface cover and state must be known (Kerr 2007). Indeed, Wagner et al. (2007) state that microwave remote sensing systems can capture the general trends in surface soil moisture conditions, but cannot be used to estimate absolute soil moisture values. A more promising approach to obtain soil moisture variability is to remotely sense the greenness variations of biomass within an otherwise homogeneous canopy (Yang et al. 2006), because variations in soil water directly affect the growth patterns of the overlying vegetation.

Frazier et al. (2000) applied the simple digital image processing techniques to map riverine water bodies with Image acquisition on 16 May 2006 TM imagery. The image classification method used a single density slicing then compared to a 6-band maximum likelihood classification over the same area. The water boundaries delineated by each of these digital classification procedures were compared to water boundaries delineated from color aerial photography acquired on the same day as the TM data.

Frazier et al. (2003) applied satellite imagery in many studies that seek to relate river flow to floodplain inundation. This method accounted for rapid
variation in daily discharge using before-flood and after-flood sequences of Landsat TM imagery in reference to predefined wetland vector coverage. This procedure established a relationship between wetland inundation and river discharge.


Yu et al. (1998) did the automated identification of swamps land incorporating Landsat TM Image and GIS data. This research describes an ongoing project on the potential study of Landsat TM for the monitoring of wetland resources with a concern of peat deposit. Preliminary results show the following improvements that are: 1) The outlines of the swamp are clearly drawn out by incorporating geomorphical data and the accuracy is reasonable 2) The estimation of peat deposit could be improved with the DEM 3) The whole procedure can be easily and automatically repeated when new data are available.