Chapter I
INTRODUCTION

Remote Sensing is defined as the technique of obtaining information about objects through the analysis of data collected by special instruments that are not in physical contact with the objects of investigation (Avery and Berlin, 1992). As such, remote sensing can be regarded as reconnaissance from a distance. Remote sensing thus differs from in situ sensing, where the instruments are immersed in, or physically touches the objects of measurement, such as portable soil pH-meter.

In this decade, many remote sensing sensors have been developed for civilian applications, particularly for earth monitoring. In the early years of remote sensing development, people/scientists were using aerial photograph to conduct monitoring. In the further development, electromagnetic devices were used instead of using photographic sensors.

In Indonesia, both systems are widely implemented. For instance, forestry sector still uses aerial photograph, while also uses Landsat TM or SPOT data. The data are used in different applications. Aerial photograph is utilized to collect base informations such as topography, timber volume prediction, etc. In the other hand, Landsat TM or SPOT are used for annual monitoring.

Aerial Photograph

Aerial photograph analysis involves the identification and delineation of specific features recognized by their distinct signatures (combinations of image characteristics). The characteristics are tone, texture, pattern, shape, size, shadow, site, situation and association. Additionally, examination of the aerial photograph stereoscopically enables the interpreter to observe the vertical as well as the horizontal spatial relationships of the subject features. Due to the complexity of the interpretative process and the wealth of data within the aerial photo, accurate photo interpretation requires considerable expertise. The
accuracy of the interpretation fully depends on the quality of photography and the analyst experience.

Photographic systems acquire spectral information with films of various spectral sensitivities. In order to maximize photo-interpretation result, it is important to select a film type, which will provide maximum contrast between different plant communities. Choices available for camera systems are color, color infrared (CIR) and panchromatic (black and white) films. First and widely implemented in Indonesia is panchromatic film.

Most aerial photograph analyst in Indonesia is still using manual interpretation technique. The technique has disadvantage since human ability is major factor in analysis. This disadvantage may leads to inconsistency and inaccurate result, depends on experience of the analyst.

Recent development in computer and computing creates breakthrough in utilization of aerial photographs. In this decade, digital photogrammetry was widely introduced and followed by the industries creating tools for analysis. However, these tools mostly developed for specific utilizations such as topographic derivation, utility mapping such as parcels, telecommunications, electricities, etc. Development of digital photogrammetry or interpretation for natural resources were less. The use of single or limited band/channel and no standard procedure in aerial photograph processing inhibits further development in natural resources applications. This research focuses on utilization of digitized aerial photograph for land use discrimination.

Digital Image, Tone and Texture

Digital image as a pictorial information is represented as a function of two variables \((x, y)\). The image is stored in storage media as a two-dimensional array. 

\[ L_x = \{1, 2, ..., Nx\} \quad \text{and} \quad L_y = \{1, 2, ..., Ny\} \]  

are the \(X\) and \(Y\) spatial domains, then \(L_x \times L_y\) is the set of resolution cells and the digital image \(I\) is a function which assigns some gray-tone value \(G \in \{1, 2, ..., Ng\}\) to each and every resolution cell; \(I: L_x \times L_y \rightarrow G\). Various two-dimensional analyses are performed on \(I\) to achieve specific image processing task such as restoration, enhancement and classification.

Classification of pictorial data can be done on a resolution cell basis (such as in identifying crop category of a resolution cell on satellite imagery) or on a block of contiguous resolution cells (such as in identifying crop category of an
entire agricultural field extending over a large number of resolution cells). The most difficult step in classification pictorial information from large block of resolution cells is that of defining a set of meaningful features to describe the pictorial information from the block (Haralick, et al., 1973).

In search for meaningful features for describing pictorial information, Haralick et al. (1973) described three fundamental pattern elements used in human interpretation: spectral, textural and contextual. Spectral features describe the average tonal (grayscale) variation in various channel/band. Texture features contain information about distribution of grayscale variations within specific channel. Contextual features contain information derived from blocks of pictorial data surrounding the area being analyzed. Context, tone and texture are always present in the image, although at times one feature may dominate others. In a small observation area, tone and texture dominate interpretation process.

The notion of texture admits to no rigid description. Texture may be defined as "something composed of closely interwoven elements". The description of interwoven elements is intimately tied to the idea of texture resolution, which one may think of as the average amount pixels for each discernible texture element. If this number is large, one can attempt to describe the individual elements in some detail. However, as this number near unity it becomes increasingly difficult to characterize these elements individually and they merge into less distinct spatial patterns (Ballard and Brown, 1982).

Jensen (1996) provided another description of texture as follow. A discrete tonal feature is a connected set of pixels that all have the same or almost the same gray shade (brightness value). When a small area of the image (e.g., a 3 x 3 area) has little variation of discrete tonal features, the dominant property of that area is a gray shade (tone). Conversely, when a small area has a wide variation of discrete tonal features, the dominant property of that area is texture.

Land use discriminations could be done by using different approaches. In aerial photograph, we use some standard framework to differentiate land uses such as Nine Interpretative Keys (Sembilan Unsur Interpretasi). The framework uses nine different characteristics i.e. tone, texture, pattern, shape, size, shadow, site, situation and association. Discrimination of land use classes employs one or more distinct keys in order to gain more acceptable results. Unfortunately, the
framework was designed for manual interpretation. Since digital processing has different approach in interpretation scheme, adapting framework is necessary. However, some characteristics such as texture are challenging since it is exist in all natural imageries.

It is often found that classes of land cover/land use may be discriminated in digital imagery on the basis not only of their characteristic tone (i.e. mean digital number value) but also on their texture. Several authors have attempted qualitatively to define texture. Jensen (1996) notes that texture dominates when small area has a wide variation of discrete tonal features.

Several investigations on high-end image analysis softwares such as Erdas Imagine 8.3.1 and PCI EasiPace 6.3 showed that texture classification procedures are not or less supported. These softwares basically provide texture transformations only. Therefore the results of these processes are in form of texture images instead of texture-classified images. This condition is key factor in the research. Some proposed technique will be described in following chapters.

Objectives

The research has three primary goals:

- Assess textural characteristics that derived from panchromatic images i.e. aerial photograph
- Analyze textural transformation methodologies, particularly for land use discrimination.
- Develop framework for land use discrimination based on texture classification.