# CHAPTER II
# LITERATURE REVIEW

## 2.1. Land

### 2.1.1. Land Use

Land is part of the landscape that includes the notion of the physical environment including climate, topography or relief, hydrology including natural vegetation that all potentially will affect the use of land (Sitorus, 2004). According Hardjowigeno and Widiatmaka (2001) land as an area on the earth's surface, includes all components of the biosphere, including the atmosphere and all the consequences caused by humans in the past and present. Another concept of land held by Sitorus (2004) that describe land as the physical environment consisting of climate, relief, soil, water and vegetation as well as objects that exist on it all has an effect on land use. The physical environment will affect the potential for its use including the result of human activity. Land is an important natural resource (Yeh and Li, 1998) because it was found energy, food, raw materials and it is a habitat for animal life and wildlife. According to Briassoulis (2000) land is natural resource that support life which is the outermost surface of the earth. Biophysical properties of land that illustrate the purpose of use the land is called land use. Land use according to Sandy (1999) is the same terminology with the use of space or spatial.

The term of land use is often defined as land cover. Referring to the understanding of land use and land cover (Lillesand and Kiefer, 1979) there is a principle difference between both of them. Land cover associated with the types of appearance on the surface of the earth, while the land use associated with human activities on the object. Lambiin et al. (2000) also provide a common understanding of the differences in the definition of land cover and land use. Land cover is the biophysical state of the earth's surface and the layer below it. Land cover describes the physical state of the earth's surface as agricultural land, mountain or forest. Land cover is an attribute of the surface and subsurface containing biota, soil, topography, groundwater, and human structures. Land use indicates a different meaning, namely the purpose of human beings in exploiting the land cover. This definition is also supported by Townshend and Justice (1981) which describes the land cover as a physical embodiment (visual) vegetation, natural objects and cultural elements that exist on the surface of the earth regardless of human activities on the object. Briassoulis (2000) describes, land use depicts biophysical properties of the land that shows the function or purpose of the land is used by humans and can be described as a human activity that is directly related to the land, the use of such resources give effect to it.

There are two approaches to determining land use (Mather, 1986). The first approach is based on the assumption that land use is determined by the physical condition of the land, while the second approach is based on the assumption that land use is determined by economic power. Both of these approaches have enormous influence in land use, but the end result of land use is determined by the land user itself. Land use should be well planned, rational, optimal and responsible and in accordance with the ability of carrying capacity (Sugandhy, 1999). Land use which is not accordance with the carrying capacity of land will cause damage to the environment. The danger again, the environmental impact of land use tends to be cumulative and mutually supportive. The impact of environmental damage due to improper land use was greater at this time, due to a rapidly growing population requires a much larger area for the diverse needs (Mather, 1986).

### 2.1.2. Land Use Change

Land and humans have a very close relationship. Lillesand and Kiefer (1997) found a link between land uses with human activity on the land. Land use can be classified into two major categories, namely agricultural and non-agricultural land use. According Arsyad (1989) agriculture land distinguished as dry land, fields, gardens, pastures, production forest, protected forest, and so on, while the non-agricultural land use are distinguished as town or village (settlement), industrial, recreational, mining and so on.

Development trend of the current population of the city began to change, in which population and the rate is higher in the suburbs region compared to its urban center, which resulted in the conversion of fertile agricultural land in the suburbs into urban areas. Land use change in Indonesia is quite high, which is 1,000,000 acres per year. This is an issue that affected the environment (Bappenas et al., 2003). Land use is an important aspect, because it needs to be a study or research that examines these aspects in order to define strategies or steps to anticipate the effects that may occur.

Land use changes can be defined as a process of selecting the use of space in order to obtain optimum benefits, both for agricultural and non-agricultural (Junaedi, 2008). According to Kazaz and Charles (2001) land-use change is a change in the use or activity of the land which different from the initial activity, either for commercial or industrial purposes. While according Nasoetion et al. (1996), land use changes is defined as a change from the previous land use to another land use that may be permanent or temporary and it is a logical consequence of the growth and transformation of the social structure of the local growing economy.

Briassoulis (2000) states that over the last 300 years, the global land use change significantly and the main cause is human. In a period of 300 years the world population increases to five billion and at the same time there is a decrease in forest area of one billion acres. It shows how humans have a very big role on land use. The interaction between the dimensions of space and time with the biophysical and human dimensions resulted in a change of land use (Veldkamp and Verburg, 2004). Several studies and researches have been conducted to analyze the factors that cause a change in land use. Mansur (2001) mentions that three factors that influence land use change is the increase in population, urbanization and an increasing number of members of the upper middle income groups in urban areas. Different things revealed by Rustiadi et al. (2009), which revealed that the process of land use change caused by:

1. The high demand for land as a result of the increasing population.
2. Market failure: the failure of farmers to sell agricultural products at competitive prices so that prefer other types of businesses and change their land use.
3. Government failure: government policy, such as providing investment opportunities in the industrial sector, but not followed by land conversion policy.

Climate change, increasing population and urbanization process is a common cause which is considered by Wu et al. (2006) as factors that contribute to changes in land use. The complexity of the physical factors, biological, social, political, and economic dimensions in space and time at the same time is a major cause of land use change process (Wu et al., 2006).

Land use change as expressed by Rustiadi et al. (2009) is closely related to regional development policy. Regional development is an effort to build and develop a region based approach by considering the spatial aspects of socio-cultural, economic, physical environment, and institutions within a framework of integrated planning and development management. Functionally, an area can be identified based on its constituent components, such as components of biophysical, socio-cultural, economic and institutional (Kodoatie, 2005). Kodoatie (2005) mention that the region system is developed taking into account resources contained in the area concerned, which include:

1. Natural resources, including resource components that make up a system of natural physical or biophysical environment (land / soil, water, air, minerals, flora and fauna), as a part of a wider system.
2. Artificial Resources, includes a built environment (existing) in the form of a network infrastructure as driving variable for activities in an area, which can contribute to encourage, stimulate, and to some extent direct the development / construction region.
3. Human resources, includes a number and human qualities and also includes resources that make up the socio-political system namely

institutional and administrative systems, and social systems in which the development is done thoroughly to form a situation / particular condition.

4. Business activities, includes all components of system activities that can support the region's economy, which will determine the concentration of population in carrying out the activities, places of employment and transaction activity in the region to fulfilling the daily needs.

These four subsystems are mutual interactions within a given territory, thus giving the dynamics of the development of the region. A development must incorporate and adapt land use, water, and other natural resources. All the elements are combined in a single system harmonious environment, supported by a dynamic and harmonious management of population development (Murray and Lopez, 2006). Land use which is not accordance with the carrying capacity of land will cause damage to the environment. The danger again, the environmental impact of land use tends to be cumulative and mutually supportive (Mather, 1986).

### 2.1.3. Land Use Classification

Classification of land cover and land use is an attempt to grouping different types of land cover or land use into a similarity in accordance with a particular system. Classification of land cover and land use classification is used as a guide or reference in the interpretation of remote sensing imagery for the purpose of making land cover maps and land use maps. According to the USGS (United States Geological Survey, 1976) land cover and land use classified as Table 2.1

Table 2.1
Land Cover and Land Use Classification

| Level I | | Level II | |
|---|---|---|---|
| **1** | **Urban or built-up land** | 1.1 | Residential |
| | | 1.2 | Commercial and Service |
| | | 1.3 | Transportation, Communications and utilities |
| | | 1.4 | Industrials and Commercial complexs |
| | | 1.5 | Mixed and commercial complexs |
| | | 1.6 | Mixed urban or built-up land |
| | | 1.7 | Other urban or built-up land |
| **2** | **Agricultural Land** | 2.1 | Cropland and pasture |
| | | 2.2 | Orchads, groves, vineyards, nurseries and ornamental horticultural areas |
| | | 2.3 | Confined feedings operations |
| | | 2.4 | Other agricultural land |
| **3** | **Rangeland** | 3.1 | Herbaceous rangeland |
| | | 3.2 | Shrub-brush land rangeland |
| | | 3.3 | Mixed rangeland |
| **4** | **Forest land** | 4.1 | Deciduous forest land |
| | | 4.2 | Evergreen forest land |
| | | 4.3 | Mixed forest land |
| **5** | **Water** | 5.1 | Streams and canal |
| | | 5.2 | Lakes |
| | | 5.3 | Reservoirs |
| | | 5.4 | Bays and estuaries |
| 6 | **Wetland** | 6.1 | Forested wetland |
| | | 6.2 | Non-forested wetland |
| 7 | **Barren Land** | 7.1 | Bare exposed rock |
| | | 7.2 | Strip mines, quarries and gravel pits |
| | | 7.3 | Transitional areas |
| | | 7.4 | Mixed barren land |

Table 2.1
Land Cover and Land Use Classification (continue)

| Level I | | Level II | |
|---|---|---|---|
| 8 | **Tundra** | 8.1 | Shrub and brush tundra |
| | | 8.2 | Herbaceous tundra |
| | | 8.3 | Bare ground tundra |
| | | 8.4 | Wet tundra |
| | | 8.5 | Mixed tundra |
| 9 | **Perennial Snow or Ice** | 9.1 | Perennial snowfields |
| | | 9.2 | Glaciers |

Source: USGS with modification, 1976

Previous table shows the classification of land cover and land use over the entire area of the existing cover on this earth. That classification is actually used by United State Government to create a land use or land cover map in the United State. In Indonesia itself, has different kind of classification. According to National Standardization Agency, land cover and land use classification divide into two major classifications namely vegetated land and non-vegetated land. Those land use and land cover class in vegetated area derived from consistency of physiognomy structure approaches of plant forms, shape cover, plant height, and spatial distribution. Whereas, land cover classes in non-vegetated area is refer to surface of cover, distribution or density, and height or depth of object for class detailing. Table 2.2 shows the land cover and land use classification used in Indonesia.

Table 2.2
Land Cover and Land Use in Scale of 1:250.000

| No | Land Cover Classification | Description |
|---|---|---|
| **1** | **Vegetated Land** | The area of vegetation coverage (minimum 4%) for at least 2 months in the first year or the coverage of lichens / Mosses more than 25% (if there are no other vegetation) |
| 1.1 | **Agriculture Land** | The cultivated area for food crops and horticulture. Natural vegetation has been modified or removed and replaced with anthropogenic plants and require human intervention to support their survival. Inter-planting season, this area sometimes without vegetation cover. The entire vegetation planted for the purpose of harvesting are included in this class. |
| 1.1.1 | Rice Field | Agricultural areas are flooded or given water, either with the technology of irrigation, rain-fed, and tides. Agricultural area is characterized by a pattern of dikes, with planted crops of short-lived (rice). |
| 1.1.2 | Tidal Rice Field | Rice paddies cultivated in an environment that affected water tidal or river. |
| 1.1.3 | Fields | Dryland farming with cultivation temporarily or move. The field is an area that is used for agricultural purposes with the type of crops other than rice, does not require extensive irrigation, vegetation is artificial and requires human intervention to support their survival. |

Table 2.2
Land Cover and Land Use in Scale of 1:250.000 (continue)

| No | Land Cover Classification | Description |
|---|---|---|
| 1.1.4 | Plantation | Land used for farming without crop replacement for 2 years. |
| 1.1.5 | Amalgamated Plantations | Land planted with perennials more than one type of uniform or not produce flowers, fruit, and sap and how to capture the result is not a way to cut down trees. |
| 1.1.6 | Mixed plants | The land is overgrown by various types of vegetation. |
| **1.2** | **Non-agriculture Land** | The area is not cultivated for food crops and horticulture |
| 1.2.1 | Dry Forest | Forests that grow and develop in dry land habitat which may include lowland forests, hills, mountains, or tropical highland forests. |
| 1.2.1.1 | Dryland Forest Primary | Forests that grow on dry land habitat which may include lowland forests, hills and mountain or highland tropical forests is still compact and has not experienced human intervention or reveal the former logging yet. |
| 1.2.1.2 | Dryland Forest Secondary | Forests that grow on dry land habitat which may include lowland forests, hills and mountain or highland tropical forests that have undergone human intervention or has appeared logged-over (the appearance of grooves and patches of logged-over). |

Table 2.2
Land Cover and Land Use in Scale of 1:250.000 (continue)

| No | Land Cover Classification | Description |
|---|---|---|
| 1.2.2 | Wet Forest | Forests that grow and thrive in wetland habitats such as swamps, including brackish marshes and peat. Wetland regions have unique characteristics, namely (1) the lowlands that stretch along the coast, (2) area of low elevation, (3) a place that is affected by the tides for the area near the beach, (4) the area affected by the season which is located far from the beach, (5) most of the area covered in peat. |
| 1.2.2.1 | Wetland Forest Primary | Forests that grow and thrive in wetland habitats such as swamps, including brackish marshes and peat. Wetland regions have unique characteristics, namely (1) the lowlands that stretch along the coast, (2) area of low elevation, (3) a place that is affected by the tides for the area near the beach, (4) the area affected by the season which is located far from the beach , (5) most of the area covered in peat, have not experienced human intervention. |
| 1.2.2.2 | Forest Wetlands Secondary | Forests that grow and thrive in wetland habitats such as swamps, including brackish marshes and peat. Wetland regions have unique characteristics, namely (1) the lowlands that stretch along the coast, (2) area of low elevation, (3) a place that is affected by the tides for the area near the beach, (4) the area affected by the season which is located far from the beach , (5) most of the area covered in peat, have experienced human intervention. |

Table 2.2
Land Cover and Land Use in Scale of 1:250.000 (continue)

| No | Land Cover Classification | Description |
|---|---|---|
| 1.2.3 | Bushes and Shrubs | Dry land area that has been covered with a variety of natural vegetation heterogeneous and homogeneous density levels are rarely up to the meeting. The area is dominated by low vegetation (natural). Shrubs in Indonesia usually former forest areas and usually no longer used or spotting appeared felling. |
| 1.2.4 | Meadows, Reeds, and Savannah | Open area dominated by grass types are not uniform. |
| 1.2.5 | Marsh Grass | Grasses that grow and live in the swamp. |
| **2** | **Non-vegetated Land** | With a total area of vegetation coverage is less than 4% for more than 10 months, or an area with coverage of lichens / Mosses less than 25% (if there are no woody or herbaceous vegetation) |
| **2.1** | **Bare Land** | Land without cover both natural and artificial. According to the characteristics of the surface, open land is divided into consolidated and unconsolidated surface. |
| 2.1.1 | Lava and larvae | Open land former lava flows and volcanic lava. |
| 2.1.2 | Overlay Sand Beach | Open land associated with marine activities with a material constituent of sand. |
| 2.1.3 | Shoal Beach | The outermost parts of the mainland towards the sea and at high tide this area is an area inundated with violent crushing waves. |

Table 2.2
Land Cover and Land Use in Scale of 1:250.000 (continue)

| No | Land Cover Classification | Description |
|---|---|---|
| 2.1.4 | **Grease Sand** | The dunes are formed by wind-borne sand deposits. Sand dunes are common in the desert or along the coast. There are several types of sand dunes are determined by the amount of sand, the strength and direction of the wind, the surface characteristics of the location of the deposition (sand or rock), the existence of the barrier and groundwater. |
| **2.2** | **Settlement and Non-agriculture Area** | Developed land characterized by the substitution of land cover of natural or semi-natural artificial land cover and often waterproof. |
| 2.2.1 | Developed Land | Areas that have undergone substitution by natural or semi-natural land cover with artificial ground cover that is usually watertight and relatively permanent. |
| 2.2.1.1 | Settlement | Area or land used as a living environment or residential environment and the activities that support life. |
| 2.2.1.2 | Industrial Building | Area used for buildings or industrial plants in the form of industrial estates or companies. |
| 2.2.1.3 | Roads | Transport infrastructure networks that are intended for vehicle traffic. |
| 2.2.1.3.1 | Arterial Road | The main road serving the transport characteristics of long-distance travel and high average speeds, according ISO 6502.4 |
| 2.2.1.3.2 | Collector Roads | Roads that serve transport with characteristics of medium distance trips and the average speed was, in accordance with ISO 6502.4 |

Table 2.2
Land Cover and Land Use in Scale of 1:250.000 (continue)

| No | Land Cover Classification | Description |
|---|---|---|
| 2.2.1.4 | Railway | Railroads |
| 2.2.1.5 | Air Port | The airport that has a complete facility for domestic and foreign airlines. |
| 2.2.1.6 | Harbor | Premises used as a docking and berthing of ships and their activity and cargo loading and unloading passengers. |
| 2.2.2 | Non-developed Land | This land has experienced human intervention so that the natural land cover (semi-natural) cannot be found anymore. However, this land is not experienced as it occurs in the development of undeveloped land |
| 2.2.2.1 | Mining | Open land as a result of mining activities, which cover the land, stone or stockpiled material at these sites are usually those coming from outside the location in question. |
| 2.2.2.2 | Hoarding Trash / Deposit | The location was used as landfill material moved by humans. The materials deposited in these areas are actually coming from outside the location in question. |
| **2.3** | **Water** | All appearance of waters, including the sea, reservoirs, coral reefs, and sea grass beds. |
| 2.3.1 | Lake or Reservoir | The area of water with deep water inundation and permanent inundation of shallow and including its functions. |
| 2.3.2 | Embankment | Activity for fishing or salting-looking pattern bund around the coast. |
| 2.3.3 | Marsh | Stagnant freshwater or brackish water is widely and permanently on the mainland. |
| 2.3.4 | Streams | Where the water flow naturally. |

Table 2.2
Land Cover and Land Use in Scale of 1:250.000 (continue)

| No | Land Cover Classification | Description |
|---|---|---|
| 2.3.5 | Coral Reefs | Collection of marine fauna gathered into one and form reefs. |
| 2.3.6 | The Sandbar Beach | The appearance of the sand on the sea surface and sometimes drowned during neap tide, width <50 m, and not overgrown vegetation. |

Source: SNI, 2010

Those classifications mentioned in the table 2.2 are composite from all land use and land cover all over Indonesia. To facilitate the classification in the Singaraja City and its surrounding area, land use or land cover class would refer to spatial plan document of Buleleng Regency. According to Buleleng Spatial Plan land use classes in the Buleleng Regencey grouped into roads, streams, lake, settlement, forest, plantation, rice field, field, bushes and shrubs, swamp forest, salting area, and dam.

## 2.2. Land Use Modeling

### 2.2.1 Definition of Model

Model is a formal representation of some theories about the case (Wilson, 1974). The model can be regarded as an abstraction, an approximation to reality achieved through simplification of the complex that can be understood and analyzed. The theory provides a general framework to describe a statement of process while the model is a structured representation of the ideal and the real world (Johnston et al., 1994). Harris (1966) even considered model as an experimental design. Definition of the model is also described by Handoko (2005) who explains that the model is a simplification of a system in the real world. Handoko (2005) also distinguish models with the system, he says the system is the mechanism by which various components interact with each other in a certain way to indicate its function in the real world. Another definition is based spatial proposed by Berger et al. (2001), in which a model is an abstraction of a real world system that has significant problems of detail with the problems being studied and also has transparency, so that the mechanisms and key factors affecting the change can be identified. The purpose of the model is easy to understand how the system works to simplify the process.

The model can be used to represent a specific issue on the science related to natural resources, and a variety of other disciplines. Modeling land-use change is one form of modeling that has attracted the attention of several researchers in the world. They studied the existence of a causal relationship between the management of a land with land use changes. Modeling land-use change has several uses, among others, to explore a variety of activities in which the occurrence of a change in land use driven by socioeconomic factors (Batty and Longley, 1994), predicting the economic and environmental impacts that will result from these changes (Theobald and Hobbs, 1998) and to evaluate the impact of government policy in determining the designation of land and land management (Bockstael et al., 1995). It is expected that land use change models have been developed to provide an understanding of the process of land use change and the factors that foster change.

In general, Briassoulis (2000) describe classification of model for analysis of land use and its changes. These models are classified into five major groups, namely statistics and econometrics, spatial interaction models, optimistic model, integrated model and other modeling approaches. Table 2.3 show model classification by Briassoulis (2000).

Table 2.3.
Classification of Land Use Change Model

| Modeling Category | Representative Models |
|---|---|
| Spatial Interaction Model | • Econometric Model<br>• Logit Multinomial<br>• Canonical Correlation Analysis Model<br>• Potential Model<br>• Opportunities Intervening Model<br>• Gravity/Spatial Interaction Model |
| Optimistic Model | • Single & multi objective linear program Model<br>• Dynamic Program<br>• Objective Programming, Hierarchy Programing, Quadratic and Linear Program, and Non-Linear Program<br>• Maximum Utility Model<br>• Multi Objective/Criteria Decision Making Model |
| Integrated Models | • Integrated econometric type model<br>• Integrated Lowry and Spatial based interaction-Gravity Model<br>• Simulation Model<br>❖ Simulation Model Urban/Metropolitan Level<br>❖ Simulation Model Regional, e.g. CLUE (Conversion Land Use and Its Effect) Level<br>❖ Simulation Model Global Level |
| Other Model Approach | • Modeling Approaches Based Natural Science |

Table 2.3.
Classification of Land Use Change Model (continue)

| **Modeling Category** | **Representative Models** |
| --- | --- |
| | • Markov Land Use Change Modeling<br>• Land Use Change Modeling Based GIS |

Source: Briassoulis, 2000

### 2.2.2 Projection Using Markov Chain (*Cellular Automata*)

Markov Chain method was first introduced around 1907 by a mathematician named Andrei A. Markov from Russia. Markov Chain method will be associated with a series of processes in which the possibility of the occurrence of an event is assumed to depend only on the condition that immediately preceded it and do not depend on a series of previous events (Veldkamp and Lambin, 2001). Markov Chain can be applied in various fields such as economics, politics, population, industry, agriculture and others. One of the uses of Markov Chain method is to project future land use. Researchers Muller and Middleton (1994) utilize this method in studying the dynamics of land use change in Ontario, Canada. Other researchers, Vandeveer and Drummond (1976) used it to assess the impact of the construction of a reservoir. Markov Chain often plays into the basic concepts used in the advanced development such as CA-Markov models. Matrix of transition opportunities will be generated and used as the basis to projecting future land use. The shape of the transition matrix is as follows.

$$P = (P_{ij}) = \begin{vmatrix} P_{11} & P_{12} & \dots P_{1n} \\ P_{21} & P_{22} & \dots P_{2n} \\ \dots\dots & & \\ P_{n1} & P_{n2} & \dots P_{nn} \end{vmatrix}$$

**P***ij* is the probability of land use changes from i into j, where n represents the number of land use classes. The value of the P*ij* should qualify that:

$$\mathbf{0 \leq P_{ij} \leq 1 (i, j, = 1, 2, 3, \dots., n)}$$

Markov chain is the foundation of land use projection systems. This method was then developed by Ulam and Von Neumann in 1940 to create a formal framework to examine the behavior of complex systems. The method developed by Ulam and Von Neumann is known as Cellular Automata (CA). CA is a dynamic model of local interactions between cells in a regular grid (Hand in Munibah et all., 2008). CA is also defined as a two-dimensional grid, in which each cell represents land use while the land use change depending on the rules that take into account the neighbor land use (Manson in Munibah et all., 2008).

CA model is dynamic, the unit is in the form of discrete space (pixel or cell) and is a function of time and can be fixed (updated) simultaneously (state synchronously) (Messina and Walsh, 2001). The main component of CA is the cell, state, rule or change function (transition rule or transition function) and adjacency (neighborhood) (Chen et al. in Munibah et all., 2008).

The cell is a two-dimensional space of the same size, for example pixels (Chen et al. in Munibah et all., 2008). Pixel serves as the unit of analysis with varying sizes. Some pixel size used in the CA modeling are 30 m raster (Huigen; Manson; Parker;

Polhill et al. in Munibah et all., 2008), 100 m raster (Manson, in Munibah et all., 2008), 200 m raster (Parker in Munibah et all., 2008), and 1 km raster (Manson; Verburg et al. in Munibah et all., 2008).

State is a discrete variable in each cell that is the function of time (CSIRO, 2003). State that many CA approaches examined is the type of land use. Changes in land use in each cell (pixel) depending on the neighbors and initial period land use (Berger, et al., 2001; Manson in Munibah et all., 2008), and controlled by a set of rules system or transition function (Chen et al. in Munibah et all., 2008; Wolfram, 1984; Manson in Munibah et all., 2008). Transition function can be deterministic or stochastic (Wolfram, 1984; Manson in Munibah et all., 2008). In its application the rule transition can be a transition probability matrix (TPM), logistic regression, nearest neighbor probability.

Adjacency means land use changes on the pixels will be affected by neighbor land use pixels. In this case the number of pixels is needs to be defined that are considered as neighbors. The concept of neighborhood is technically translated with the filter / window. Some illustrations are presented filter size in Figure 2.1. Filter mean how much neighbors cell consider to influence the state of its cell. The cells around the initial cell affected its cell state. Consideration of the number of neighbor cell very important to get the future cell state.

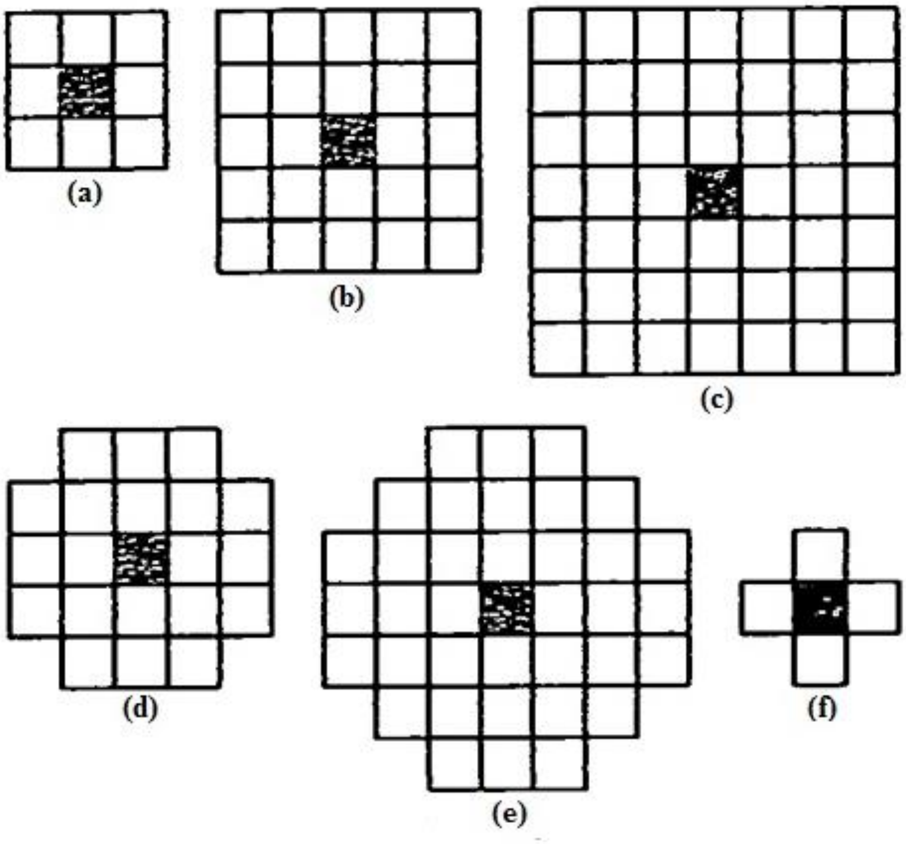


Figure 2.1.
Illustration of filter size, (a) Filter 3x3, (b) 5x5 filter, (c) Filter 7x7, (d) Oktogonal Filter 5x5, (e) Oktogonal Filter 7x7, (f) 4 Cros Filter nearest neighbor (Jensen, 1986).

## 2.3. Remote Sensing

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 without direct contact with the object, area, or phenomenon under study (Lilesand et al., 2004). Remote sensing in the language of England called Remote Sensing, called Teledetection in French, German is Fernerkundung, Portuguese called the Sensoriamento Remota, Russia called Distantionaya, and Spain called Perception Remota.

Remote sensing components consist of:

1. Sources

   Power sources use in the remote sensing such as natural energy and artificial energy. Natural energy derived from solar and artificial so-called pulse. Remote sensing that using solar system is called passive system and the use of pulse power is called active system. Passive system can record the reflected power and radiance. By using the excess pulses can be used for taking pictures at night.

2. Object

   Remote sensing objects are all objects that exist on the earth's surface, such as soil, mountains, water, vegetation, and human cultured, city, farmland, forest or objects in the sky like a cloud.

3. Sensors

   The sensor is a device used to receive the reflected energy or electromagnetic radiation. For examples aerial cameras and scanners.

4. Detector

   The detector is contained in a tape recorder to record the force sensor and the reflected beam.

5. Vehicle

   The vehicle means for storing the sensor such as aircraft, satellites and space shuttle.

Remote sensing systems are distinguished on photographic and non-photographic system. Photographic system has the advantage of simple, inexpensive, and good quality. The electronic system has advantages as greater capabilities and more definitively in distinguish between objects and the analysis process is faster because it uses a computer. Based on the energy used remote sensing system divided into radiant energy and reflected energy. Based on its vehicle, remote sensing was distinguished into aerospace sensing system (airborne system) and space (spaceborne system).

The utilization of remote sensing data is for mapping application or inventory of land cover and change detection. Various data has been used, both with optical and radar sensors. For this purpose, various techniques have been used such as Mahalanobis Distance (Trisasongko et al. 2009), Neural Network (Putignano et al. 2006) or Support Vector Machines. Changes in land use can be explored from remote sensing data through two major approaches. The first approach is an approach that is commonly used is the comparison of thematic maps. Various classification techniques can be utilized in this approach, as described in the previous section. The next step is to compare two or more thematic data in a process of analysis, commonly known by the analysis of Land Use / Cover Change (LUCC). The second approach does not involve the classification procedure, so there is no thematic data generated as a data intermediary. Various statistical procedures can be used in this approach, including the alteration Multivariate Detection (MAD), which was introduced by Nielsen et al. (1998). The second approach is generally known as Change Detection. In general, this study uses the first approach that the primary objective of this activity is the study and modeling of land use change (Land Use Modeling).

## 2.4. Landsat Imagery

Landsat image is a picture of the earth's surface taken from space with a height of approximately 818 km from the Earth's surface, with a scale of 1: 250,000. In each recording Landsat imagery has a coverage area of 185 km x 185 km so that certain aspects of the object can be identified without a broad enough range throughout the area surveyed or studied. Landsat imagery is generated imagery of some spectrum with different wavelengths, namely:

1. Channel 4 with a wavelength of 0.5 to 0.6 μm in the blue region of the spectrum, either for detecting aquatic sediment load in your body, charred, sediment suspension and reefs.
2. Channel 5 with a wavelength of 0.6 to 0.7 μm in the green region of the spectrum, both for detecting vegetation, culture, etc.
3. Channels 6 with wavelengths from 0.7 to 0.8 μm in the red region of the spectrum, both for detecting surface relief of the earth, water and land boundaries.
4. Channel 7 with a wavelength of 0.8 to 1.1 μ m in the infrared region, which is less likely to detect the earth's surface relief when compared with channel 6.
5. Channel 7 with a wavelength of 0.8 to 1.1 μm in the infrared region, which is less likely to detect the earth's surface relief when compared with channel 6.

Each color in satellite imagery provides a particular meaning, the color image is a reflection of the value of vegetation, water bodies or body surface rock and earth.

Therefore, through the geological interpretation of Landsat imagery is based on the difference in the reflection.

### 2.5.1 Landsat 7 Imagery

Landsat 7 is satellite that aligned with the sun orbit and crossed the equator at 10:00 local time. This satellite has the ability to cover the same area every 16 days. Image of Landsat ETM+ (Enhanced Thematic Mapper) is one type of multispectral images. Landsat ETM remote sensing imagery is now often used, this image has 7 channel consisting of the visible spectrum in channels 1, 2, and 3, the near infrared spectrum at channels 4, 5, and 7 and the thermal infrared spectrum at channel 6. Those channel classifications show in Table 2.4.

Table 2.4
Characteristics of Landsat Spectral

| No. | Chanel | Wavelength (μm) | Spatial Resolution (m) |
|---|---|---|---|
| 1 | Blue | 0.45-0.52 | 30 |
| 2 | Green | 0.53-0.61 | 30 |
| 3 | Red | 0.63-0.69 | 30 |
| 4 | Near Infrared | 0.78-0.90 | 30 |
| 5 | Short Wave Infrared | 1.55-1.75 | 30 |
| 6 | Thermal infrared | 10.4-12.5 | 60 |
| 7 | Short Wave Infrared | 2.09-2.35 | 30 |
| 8 | Panchromatic | 0.52-0.9 | 15 |

Source: Liliesand and Kiefer, 1996

Landsat ETM imagery also has the characteristics of spatial marked with the spatial resolution sensors to detect objects. Spatial resolution of the sensor itself is the aggregated power necessary to be able to distinguish objects that exist on the surface of the earth (Liliesand and Kiefer, 1996).

### 2.5.2 Landsat 8 Imagery

Landsat 8 is a continuation of the Landsat mission is to be the first time since 1972 the earth observation satellite (Landsat 1). Landsat 1, which was originally named the Earth Resources Technology. Satellite 1 was launched July 23, 1972 and start operating until January 6, 1978. The next generation, Landsat 2 was launched January 22, 1975 which operated until 22 January 1981. The Landsat 3 launched March 5, 1978 ending March 31, 1983; Landsat 4 was launched July 16, 1982, discontinued 1993. Landsat 5 was launched March 1, 1984 are still functioning until now but experienced severe disruption since November 2011, as a result of this disturbance, on December 26, 2012, USGS announced that Landsat 5 will be disabled. In contrast to 5-generation predecessor, Landsat 6 was launched October 5, 1993 failed to reach orbit. While Landsat 7, launched April 15 Dec 1999, still functioning despite damage since May 2003 (Liliesand and Kiefer, 1996).

Landsat 8 is actually better suited to call continuing the mission of a satellite Landsat 7 than called the new satellite with new specifications as well. This is evident from the characteristics that are similar to Landsat 7, both the resolution (spatial, temporal, spectral), the method of correction, the flying height and the sensor characteristics are taken. It's just that there are some additions that is the refinement of the Landsat 7 as the number of bands, the lowest range of the spectrum of electromagnetic waves that can be captured by sensors as well as the bit value (value range Digital Number) of each pixel image. As published by the USGS, Landsat 8 satellite flying at an altitude of 705 km from the Earth's surface and has a wide scan area of 170 km x 183 km (similar to the previous version). NASA was targeting that this Landsat satellite will be operate for five years (OLI sensors for 5 years and TIRS sensor designed for 3 years). Do not rule out the possibility of productive age Landsat 8 can be longer than the age that proclaimed as occurs in Landsat 5 (TM), which initially targeted only three years in operation until 2012 but it still works.

Landsat 8 has sensors Onboard Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) with 11 numbers of channels. Among these channels, 9 channels (bands 1-9) are in the OLI and 2 others (bands 10 and 11) on TIRS. Most of the channels have specifications similar to Landsat 7. The channel type, wavelength and spatial resolution of each band on Landsat 8 compared with Landsat 7 as shown in the Table 2.5.

Table 2.5
Comparison Between the Characteristics of Each Channel Landsat 7 and Landsat 8

| **ETM+ (Landsat 7)** | | | **ETM+ (Landsat 8)** | | |
|---|---|---|---|---|---|
| **Number of Band** | **Wavelength (μm)** | **Spatial Resolution (m)** | **Number of Band** | **Wavelength (μm)** | **Spatial Resolution (m)** |
| | | | ❖ Band 1 Coastal | 0.43 - 0.45 | 30 |
| ❖ Band 1 Blue | 0.45 - 0.52 | 30 | ❖ Band 2 Blue | 0.45 - 0.51 | 30 |
| ❖ Band 2 Green | 0.52 - 0.60 | 30 | ❖ Band 3 Green | 0.53 - 0.59 | 30 |
| ❖ Band 3 Red | 0.63 - 0.69 | 30 | ❖ Band 4 Red | 0.64 - 0.67 | 30 |
| ❖ Band 4 NIR | 0.77 - 0.90 | 30 | ❖ Band 5 NIR | 0.85 - 0.88 | 30 |
| ❖ Band 5 SWIR 1 | 1.55 - 1.75 | 30 | ❖ Band 6 SWIR 1 | 1.57 - 1.65 | 30 |
| ❖ Band 7 SWIR 2 | 2.09 -2.35 | 30 | ❖ Band 7 SWIR 2 | 2.11 - 2.29 | 30 |

Table 2.5 Comparison Between the Characteristics of Each Channel Landsat 7 and Landsat 8 (continue)

| ETM+ (Landsat 7) | | | ETM+ (Landsat 8) | | |
|---|---|---|---|---|---|
| **Number of Band** | **Wavelength (μm)** | **Spatial Resolution (m)** | **Number of Band** | **Wavelength (μm)** | **Spatial Resolution (m)** |
| ❖ Band 8 Pan | 0.52 - 0.90 | 15 | ❖ Band 8 Pan | 0.50 - 0.68 | 15 |
| | | | ❖ Band 9 Cirrus | 1.36 - 1.38 | 30 |
| ❖ Band 6 TIR | 10.40 - 12.50 | 60 | ❖ Band 10 TIRS 1 | 10.6 - 11.19 | 100 |
| | | | ❖ Band 11 TIRS 2 | 11.5 - 12.51 | 100 |

Source: ESRI, 2014

## 2.5. Classification Method

Image classification is a process performed to classify an object of the satellite image by identifying the appearance of objects (Lillesand and Kiefer, 1990). Classification is a technique used to remove the detailed information of the input data to show important patterns or spatial distribution to ease of interpretation and analysis of the image so that the image obtained useful information. For land cover mapping, the results can be obtained from the multispectral classification satellite imagery. Multispectral classification algorithm itself is designed to present a thematic piece of information by classifying phenomena based on the criteria that the spectral values.

Multispectral classification begins with determining the value of each object pixel as a sample. Furthermore, the pixel values of each sample were used as fill in the classification process. Acquisition of land cover information was obtained by color of the image, static analysis and graphical analysis. Static analysis is used to consider the average value, standard deviation and variance of each class of samples taken to determine differences in the sample. Graphical analysis is used to see the distribution-the distribution of pixels in a class. Classification methods commonly used are:

**a. Supervised**

Supervised classification is based on the idea that the user can select a sample pixel in an image that represents the particular land use class and then direct the image processing software to use the preferred choice as a reference for grouping other pixels in the image. Training area was chosen based on knowledge of the user. Users can specify a limit to express how close the results to be achieved. This limit is often determined based on the spectral characteristics of local examples. Users can also design their output. As an example of how many classes are required in the final image that classification (Dharmawan, 2012).

In supervised method, the first analysis is to define some training area (the sample) in the image as a particular land class. The determination is based on knowledge of the regions in the image analyst on land cover areas. Pixel values in the sample are then used by the computer as a key to identify the other pixels. Area which has similar pixel values will be incorporated into land classes predetermined. In supervised method, the initial analysis is to identify the class of information that is then used to determine the spectral classes that represent the information class

(Dharmawan, 2012). Algorithms that can be used to complete the supervised method are the minimum distance and parallelepiped.

**b. Unsupervised**

The working of unsupervised method is the opposite of the supervised method, in which the pixel values is grouped by computer into spectral classes using cluster algorithms (Dharmawan, 2012). In this method, the start of the analysis will usually determine the number of classes. Then establishes land classes for spectral classes that have been grouped by computer. The result then was generated the analyst could combine a few classes that are considered to have the same information into a single class. For example, class I, class 2 and class 3, respectively, are rice fields, plantations and forests, the analyst can classify classes into one class as the class of vegetation. So in unsupervised methods, classification is not entirely without human intervention. Several algorithms can be used to resolve this unsupervised method including the K-Means and ISODATA.

## 2.6. Geographic Information System

Geographic Information Systems (GIS) is an information management tool in the form of a computer-aided system that are closely related to mapping and analysis of all things and events that happen on earth. GIS technology integrates database-based data processing operations that are commonly used today, such as the retrieval of data based on need, as well as statistical analysis with the unique visualization and use of the various advantages that are able to offer through geographic analysis through the map images (Ekawati and Wirawan, 2010).

GIS is a formal unity that consists of a variety of physical and logical resources pertaining to the objects contained in the earth's surface. Thus, GIS is a computer-based system that is used to store and manipulate geographic information. GIS is designed to collect, store and analyze objects and phenomena where geographic location is an important or critical characteristics to be analyzed.

Thus, GIS is a computer system which has the following four capabilities in handling geographic referenced data: (a) input, (b) data management (storage and retrieval), (c) the analysis and manipulation of data, (d) output (Aronoff, 1989).

Conceptually a GIS technology must have the following capabilities:

1. Location, GIS must be able to demonstrate the existence of an object based on the location of the images presented on the map. Location of the object described as a way to achieve it, such as a place name, postal code, or can also use the geographical position of objects such as latitude and longitude.
2. Conditions, a GIS technology should be able to determine the condition of an object depicted in the map. This condition such as type of soil, flora and fauna and so on.
3. Trends, GIS must be able to demonstrate the changes that occur in a certain object, after a lapse of some time.
4. Pattern, GIS must be able to provide information about the pattern of an object in a particular area, such as pollution in industrial areas, the bustle of traffic and so on.

5. Modeling, GIS should be able to make a model to develop a system, for example: what happens if the addition of the road network (Prahasta, 2001).