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FORECASTING PLANT VIGOR THROUGH VEGETATION INDEX MAPPING

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This report is submitted in partial fulfillment of the requirements for the Bachelor of Computer Science ~~(Software Development)~~

Super AI

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2013

DECLARATION

I hereby declare that this project report entitled

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Is written by me and is my own effort and that no part has been plagiarized without citations.

STUDENT :FATEHAH HANIM BT AHMAD OTHMAN Date: 6/9/2013

SUPERVISOR : DR. ASMALA BIN AHMAD Date: 6/9/2013

DEDICATION

My dedication is to my beloved parents, Mr Ahmad Othman bin Dziauddin and Mrs Saodah binti Hussin. As well as to my siblings, Ahmad Firdaus bin Ahmad Othman, Ahmad Faris bin Ahmad Othman and Ahmad Fauzi bin Ahmad Othman. I am thankful for your support and believe in me.

To my supervisor, Dr Asmala bin Ahmad for the guidance and advice during the completion of my final year project.

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ABSTRACT

The purpose of this project is to forecasting plant vigor through vegetation index mapping. The Normalized Difference Vegetation Index (NDVI) is a simple graphical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. Remote sensing in conjunction with Landsat-5 satellite is used to map the NDVI information map. Remote sensing (RS) is a technique that uses a sensing device to collect information on given objects or phenomena from afar without physical contact. The area cover for this study is Klang, Selangor. Density slicing is a digital data interpretation method used in analysis of remotely sensed imagery to enhance the information gathered from an individual brightness band. The ISODATA classification algorithm is regarded as a common method in the field of analyzing remote sensing images. Density slicing technique will be compare with ISODATA classification technique for accuracy assessment. The methodology consist of 4 phases; analysis, design, implementation and verification.

ABSTRAK

Tujuan projek ini adalah untuk meramal kesuburan tanaman melalui pemetaan indeks tumbuh-tumbuhan. *The Normalized Difference Vegetation Index* (NDVI) adalah penunjuk grafik yang boleh digunakan untuk menganalisis pengukuran *remote sensing*, kebiasannya tetapi tidak semestinya dari satu ruangan platform, dan menilai sama ada sasaran yang diperhatikan mengandungi tumbuh-tumbuhan hijau atau tidak. *Remote sensing* dengan kerjasama dari satelit Landsat-5 digunakan untuk memetakan maklumat peta NDVI. *Remote Sensing* (RS) adalah teknik yang menggunakan alat pengesan untuk mengumpul maklumat mengenai objek yang diberikan atau fenomena dari jauh tanpa sentuhan fizikal. Kawasan untuk kajian ini ialah Klang, Selangor. *Density slicing* adalah kaedah tafsiran data digital yang digunakan dalam analisis imej yang dikesan untuk memperbaiki hasil maklumat yang dikumpul dari kumpulan kecerahan secara individu. Pengelasan algoritma *ISODATA* dianggap sebagai kaedah yang biasa digunakan dalam bidang menganalisis imej hasil dari *remote sensing*. Teknik *density slicing* akan bandingkan dengan teknik pengelasan *ISODATA* untuk penilaian ketepatan. Kaedah ini terdiri daripada 4 fasa, analisis, reka bentuk, pelaksanaan dan ujian pengesahan.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The Normalized Difference Vegetation Index (NDVI) is a simple graphical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. NDVI has been in use for many years to measure and monitor plant growth (vigor), vegetation cover, and biomass production from multispectral satellite data.

To determine the density of green on a patch of land, researchers must observe the distinct colours (wavelengths) of visible and near-infrared sunlight reflected by the plants. As can be seen through a prism, many different wavelengths make up the spectrum of sunlight. When sunlight strikes objects, certain wavelengths of this spectrum are absorbed and other wavelengths are reflected. The pigment in plant leaves, chlorophyll, strongly absorbs visible light (from 0.4 to 0.7 µm) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 µm). The more leaves a plant has, the more these wavelengths of light are affected, respectively.

In general, if there is much more reflected radiation in near-infrared wavelengths than in visible wavelengths, then the vegetation in that pixel is likely to be dense and may contain some type of forest. If there is very little difference in the intensity of visible and near-infrared wavelengths reflected, then the vegetation is probably sparse and may consist of grassland, tundra, or desert.

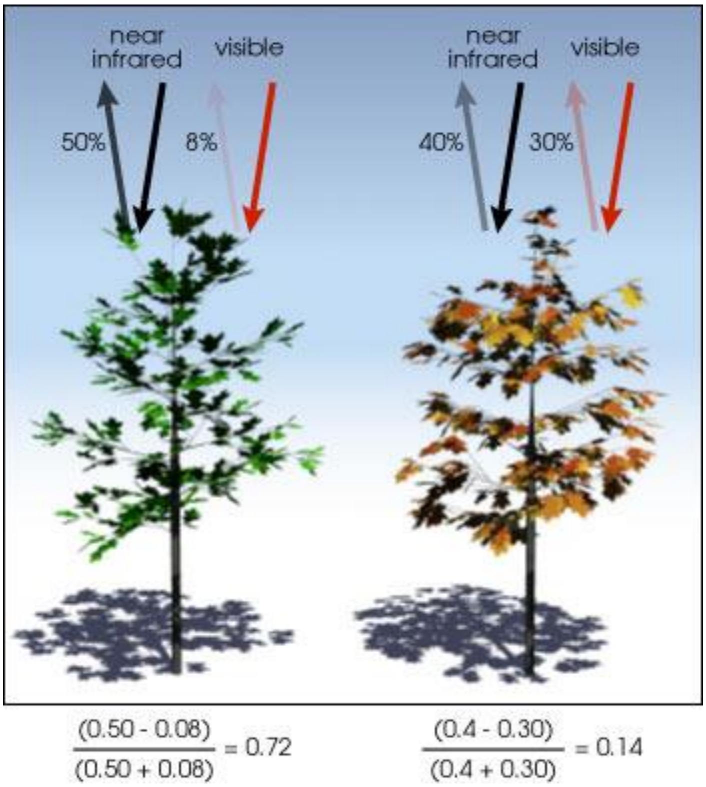

Figure 1: Representative of NDVI values

NDVI is calculated from the visible and near-infrared light reflected by vegetation. Healthy vegetation (left) absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation (right) reflects more visible light and less near-infrared light. The numbers on the figure 1 above are representative of actual values, but real vegetation is much more varied.

Nearly all satellite Vegetation Indices employ this difference formula to quantify the density of plant growth on the Earth — near-infrared radiation minus visible radiation divided by near-infrared radiation plus visible radiation. The result of this formula is called the Normalized Difference Vegetation Index (NDVI). Written mathematically, the formula is:

NDVI = (NIR — VIS)/(NIR + VIS)

As a result, vigorously growing healthy vegetation has low red-light reflectance and high near-infrared reflectance, and hence, high NDVI values. This relatively simply algorithm produces output values in the range of -1.0 to 1.0. Increasing positive NDVI values, shown in increasing shades of green on the images, indicate increasing amounts of green vegetation. In other word, the NDVI is higher over vegetated than non-vegetated areas regardless of the presence of green leaf area. NDVI values near zero and decreasing negative values indicate non-vegetated features such as barren surfaces (rock and soil) and water, snow, ice, and clouds.

The importance of acquiring information from NDVI can address immediate needs for information. The information helps to assist cultivators, agriculturists and modern farmers to be acknowledged of their environment and surroundings.

Remote sensing is the acquisition of information about an object or event without involves any physical contact with the object. This term implies to the usage of aerial sensor technology to detect and classify objects on earth. Remote sensing in conjunction with Landsat-5 satellite is used to map the NDVI information map. Landsat-5 satellites has provided multispectral imagery products for 30 years, and their long history and reliability has made them a popular source for documenting changes in land cover and use over time. Landsat-5 sensor is called Thematic Mapper (TM). The specifications of the sensor are as follows:

- Seven spectral bands, including a thermal band:

  - Band 1 Visible (0.45 - 0.52 µm) 30 m
  - Band 2 Visible (0.52 - 0.60 µm) 30 m
  - Band 3 Visible (0.63 - 0.69 µm) 30 m
  - Band 4 Near-Infrared (0.76 - 0.90 µm) 30 m
  - Band 5 Near-Infrared (1.55 - 1.75 µm) 30 m
  - Band 6 Thermal (10.40 - 12.50 µm) 120 m
  - Band 7 Mid-Infrared (2.08 - 2.35 µm) 30 m

1.2 Problem Statement

- The acquisition of data for NDVI information map requires relatively high cost and manpower needs to working manually. In other word an impractical way of gaining data.
- The aim of this study is to develop or derive a method that resulted of NDVI information map.

1.3 Objectives

- To design a method to derive NDVI information
- To develop a NDVI information method
- To assess the accuracy of the NDVI map

1.4 Scope

i. Software
   - The software involves for this study are ENVI(Environment for Visualizing Images) and Matlab

ii. Study Area
   - The area cover for this study is Klang, Selangor. The latitude and longitude coordinates of the study area is 3.0333° N, 101.4500° E respectively. Area of Klang is 573 km^2.
   - To derive the NDVI information map, all band are used (Band 1 – Band 7)

iii. User Scope
   - The information is specifically made to assist researcher, science officer and any field related to education.

1.5 Project Significant

- Generally this study does not high consuming in term of time and cost. It is inexpensive because less manpower is assigned to perform the task. It is only related to knowledgeable people who are familiar with the ENVI software. The reason why this study is less time consuming is because it involves no physical contact with the area covered.
- The Normalized Difference Vegetation Index (NDVI) shows patterns of vegetative growth from green-up to senescence by indicating the quantity of actively photosynthesizing biomass on a landscape (Burgan 1996). Such images allow for the production of maps, which indicate visual greenness and can be extremely valuable to land managers and researchers in determining changes in vegetation over time.

1.6 Expected Output

- The main expected results are to generate a NDVI information map of Klang area. The NDVI information map can assist researchers in making prediction of vegetation covered.

1.7 Conclusion

In the end of the day, the first chapter revolve around the background of this project and indicate what are the problem statements that leads to the objectives to acquire the information map. The scope of this study specify on the software used, the selected area and intellectual person who related to this field of study can gain a lot of information and knowledge and its significant to the modern environment.

CHAPTER 2

LITERATURE REVIEW AND METHODOLOGY

2.1 Why Remote Sensing?

Remote sensing (RS) is a technique that uses a sensing device to collect information on given objects or phenomena from afar without physical contact. Hand held cameras, photographic instruments installed in aircrafts, and satellite sensors are devices that can be used in data gathering. Remote sensing techniques have provided a range of useful methods that quantitatively measure land change process as on a larger scale with less expense compared with traditional methods, such as field surveys (Wang, 2012). Vegetation studies based on remotely sensed data began to be used in the mid-1970s with data obtained from Landsat MSS (Multi Spectral Scanner). The use of remotely sensed data from satellite platforms for crop and drought monitoring has become wide spread since the mid and late 1980s. Moreover, remote sensing has become an important source of information for monitoring vegetation conditions and land use or land-cover changes (Chu et al. 2009).

2.2 Vegetation Index

The Normalized Difference Vegetation Index (NDVI) calculated from the red and near-infra-red bands, is one of the most widely used vegetation indexes in a variety of vegetation studies such as measuring plant growth or extracting phenological metrics (Wang, 2012). A comparative method using Normalized Difference Vegetation Index (NDVI) has been developed for monitoring the presence and spread of cheatgrass (Winter, 2003). Vegetation Index (VI) time series derived from satellite images are some of the most important sources of information in detecting vegetation conditions as well as in monitoring land cover processes (Wang, 2012). Traditional methods, such as field surveys, are labor intensive relative to remote sensing, which has emerged as the most useful data source for quantitatively measuring land-cover changes at the landscape and smaller scales with a relatively low expense. As for result, such images allow for the production of maps, which indicate visual greenness and can be extremely valuable to land managers and researchers in determining changes in vegetation over time (Winter, 2003).

The NDVI (Normalized Difference Vegetation Index) is one of the most widely used vegetation indices in recent years that measure and monitor plant growth, vegetation cover, and biomass production from multi-spectral satellite data. First introduced by Tucker (1979). NDVI is evaluated for monitoring seasonal changes in live vegetation moisture (Burgan, 1999). NDVI calculated from two bands of AVHRR data, is the difference in reflectance between the near infrared and visible red wave length divided by sum of the two measurements (Burgan, Hardy, 1999). As a result, high NDVI values will appear with vigorously growing healthy vegetation because of the low red-light reflectance and high near-infrared reflectance. This relatively simple transformation leads to output values ranging from -1.0 to 1.0. NDVI relates linearly to increasing leaf canopy density, which indicates increasing amounts of green vegetation. NDVI values near or less than zero relate to non-vegetated features like barren surfaces (rock and soil) and water, snow, ice, and clouds (USGS, http://ivm.cr.usgs.gov/whatndvi.php). The NDVI is calculated from two bands reflectance of a sensor as follows:

NDVI= (NIR-RED) / (NIR+RED)

Where RED and NIR bands represent the spectral reflectance measurements in the red band and near infrared band, respectively. Theoretically, NDVI of a given pixel scales from -1 to +1. The observed NDVI range for a land surface with vegetation is from 0.05 to 0.8. A non-vegetated pixel typically has a value close to 0, and highly vegetative pixels have high positive values.

The NDVI has been correlated to many variables such as crop nutrient deficiency, final yield in small grains, and long-term water stress. However, rather than exclusively reflecting the effect of one parameter, NDVI has to be considered as a measurement of amalgamated plant growth that reflects various plant growth factors (Verhulst, Govaerts, 2010). The NDVI value indicates a level of photosynthetic activity despite varied levels of resilience among different vegetation species. The NDVI is successful in predicting photosynthetic activity, because this vegetation index includes both near infrared and red light ((Verhulst, Govaerts, 2010).).

At the end of the day, notice that vegetation has a unique spectral signature that enables it to be distinguished readily from other types of land cover in an optical/near-infrared image. The reflectance is low in both the blue and red regions of the spectrum, due to absorption by chlorophyll for photosynthesis. It has a peak at the green region. In the near infrared (NIR) region, the reflectance is much higher than that in the visible band due to the cellular structure in the leaves. Hence, vegetation can be identified by the high NIR but generally low visible reflectance. This property has been used in early reconnaissance missions during war times for "camouflage detection".

2.3 Methodology

In order to achieve the objectives of this study, the method used are describe here. Based on the literature review, this study will carry out approach by Damon Winter that proposed a comparative method using Normalized Difference Vegetation Index (NDVI) has been developed for monitoring the presence and spread of cheatgrass.

Methodology in this study development refers as a framework that is used to structure, plan, and control the process of develop an information system. Methodology model that is choose in this project is waterfall model that has a sequential design process, where the step will take inputs from the previous step and gives output to next step. It is often used in development process when requirements are well understood. Waterfall model as shown on figure 2 contains analysis phase, design phase, implementation phase and verification phase.

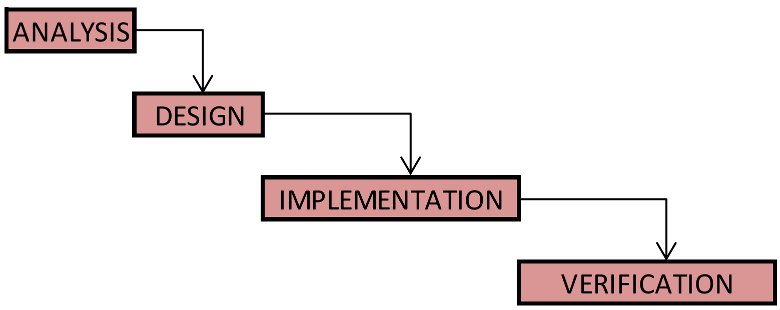

Figure 2: Waterfall Model

The waterfall methodologies model has an excellent technical documentation. It is also very structured and it is easier to measure the progress by refer to milestones. Below is a description of each phase in this waterfall methodology:-

a) Analysis Phase

The activities in analysis phase are to find the problems of the previous techniques of mapping processes. Study the existing method to gain some knowledge that can derive to the problem statement. After that, objectives are stated after performing the analysis and understanding the relevant information. Next, find the hardware and software requirement of remote sensing mapping processes and select the location of study area to proceed for the next process the satellite images. Project plan are also made in this phase.

b) Design Phase

The activities in design phase are the flow chart of mapping process for NDVI. Based on the requirements and the detailed analysis, the NDVI map will be produced. Design phase is the most crucial phase in the development of NDVI map.

c) Implementation

Implementation phase is where theory turned into practice. The major steps involved in this phase are getting the information and documentation of NDVI. What exactly the step that take part during the whole process of developing NDVI map. The most important thing is information such as vegetation index value and its statistics will be shown on the resulted map.

d) Verification

After the implementation phases are complete, the output is verified and any faults in earlier phases will be removed in this phase. The result will be compare compared with one more technique for accuracy assessment. The study of NDVI will provide the information about vegetated and non-vegetated area.

CHAPTER 3

ANALYSIS

3.1 Problem Analysis

Generally the development for NDVI information map requires satellite data which should contain enough sufficient data that mainly obtained from Landsat-5 Thematic Mapper (TM).

The study area plays an important role in this study. The suitable area will determined the value of NDVI. In the context of suitable is the selected area is recognized and believed to have vegetation. Although NDVI can also help to make prediction on non-vegetation area, but for this study, the focus is more on vegetated area.

The step by step process involve in this study. What are the criteria of the task needed to be performed in order to achieve the objectives of this study? The pre-processing step used on the raw satellite data and the next step is the masking procedure which is use to eliminate unwanted things. For example use to ocean masking and cloud masking. All these step by step procedure will be elaborated on the next chapter.

3.2 Requirement Analysis

3.2.1 Satellite Data

The input data for this study are collected through the satellite Landsat-5 TM (Landsat TM 7 spectral bands 30m spatial resolution 16 day repeat cycle)**.** The basic functions of most satellite sensors are to collect information about the reflected radiation along a pathway, also known as the field of view (FOV), as the satellite orbits the Earth. The smallest area of ground that is sampled is called the instantaneous field of view (IFOV). The IFOV is also described as the pixel size of the sensor. This sampling or measurement occurs in one or many spectral bands of the EM spectrum. The data collected by each satellite sensor can be described in terms of spatial, spectral and temporal resolution.

(i) Spatial resolution

The spatial resolution (also known as ground resolution) is the ground area imaged for the instantaneous field of view (IFOV) of the sensing device. Spatial resolution may also be described as the ground surface area that forms one pixel in the satellite image. The IFOV or ground resolution of the Landsat Thematic Mapper (TM) sensor, for example, is 30 m. The ground resolution of weather satellite sensors is often larger than a square kilometer. There are satellites that collect data at less than one meter ground resolution but these are classified military satellites or very expensive commercial systems.

(ii) Temporal resolution

Temporal resolution is a measure of the repeat cycle or frequency with which a sensor revisits the same part of the Earth’s surface. The frequency will vary from several times per day, for a typical weather satellite, to 8—20 times a year for a moderate ground resolution satellite, such as Landsat TM. The frequency characteristics will be determined by the design of the satellite sensor and its orbit pattern.

(iii)Spectral resolution

The spectral resolution of a sensor system is the number and width of spectral bands in the sensing device. The simplest form of spectral resolution is a sensor with one band only, which senses visible light. An image from this sensor would be similar in appearance to a black and white photograph from an aircraft. A sensor with three spectral bands in the visible region of the EM spectrum would collect similar information to that of the human vision system. The Landsat TM sensor has seven spectral bands located in the visible and near to mid infrared parts of the spectrum.

The sensors aboard the Landsat satellite measures reflected radiation in seven spectral bands from the visible through the thermal infrared. The sensors high spatial resolution (approximately 30m) makes it useful in precision agriculture. The spectral response and higher spatial resolution make it suitable for assessing vegetative condition for individual fields but the overpass frequency is only once every 16 days. The less frequent overpass makes it difficult to use these data for assessing rapidly changing events such as insect outbreaks or water stress. New satellites with enhanced capabilities are planned and remotely sensed data will become more widely used in management support systems.

3.2.2 Software

The required software for this study is called ENVI (an acronym for "Environment for Visualizing Images"). ENVI is a software application used to process and analyze geospatial imagery. It is commonly used by remote sensing professionals and image analysts. ENVI bundles together a number of scientific algorithms for image processing a lot of which are contained in automated, wizard-based approach that walks users through complex tasks.

One more software that will be used for this study is Matlab. Matlab is a high-level language and interactive program from The MathWorks for numeric computation and visualisation. MATLAB supports numerical analysis, matrix computation, signal processing, linear algebra, statistics, Fourier analysis, filtering, optimisation and numerical integration. It can output two and three dimensional graphics and can be integrated with C, C++, Fortran, Java, COM and Microsoft Excel.

Image Processing by using Mathlab provides a comprehensive set of reference-standard algorithms, functions, and apps for image processing, analysis, visualization, and algorithm development. It can perform image enhancement, image deblurring, feature detection, noise reduction, image segmentation, geometric transformations, and image registration. Many toolbox functions are multithreaded to take advantage of multicore and multiprocessor computers. Matlab software is estimated to be used during PSM 2.

3.2.3 Ancillary

Ancillary data is non-remote sensing data for interpretive model analysis or for integration into Geographic Information Systems. In this project ancillary data is needed for reference and comparison with the output.

Ancillary data are secondary data, pertaining to the area or classes of interest, such as topographic, demographic, or climatological data. Ancillary data may be digitized and used in conjunction with the primary remote sensing data.

3.3 Conclusion

In the end of the day, requirement of data is very important in order for an analysis to be accurate and generated good result.

CHAPTER 4

DESIGN

4.1 Introduction

This chapter explains about the output development process of NDVI information map. Starting from the input data type used for this study up to the final output result. The satellite data (image) need to go through several stages of the process to produce the output. The accuracy assessment will take part once the output is obtained. The process flow are based on waterfall methodology.

4.2 NDVI Process

The sequences of NDVI development process are shown by figure 3. For every component stated on the flow chart, it needs to meet the specification so that desired output will be achieved. Each component in the flow chart process plays different roles and offers various information for the NDVI information map. Each process is conducted based on specific types of algorithm. The formula used must be appropriate for each component involved. The end result of this stage should be analyzed so as to obtain a good result. The final output for this study is a NDVI map that represents useful information about vegetation index to end users. The result obtained from this study is important and useful for further analysis and research.

Flow chart for NDVI

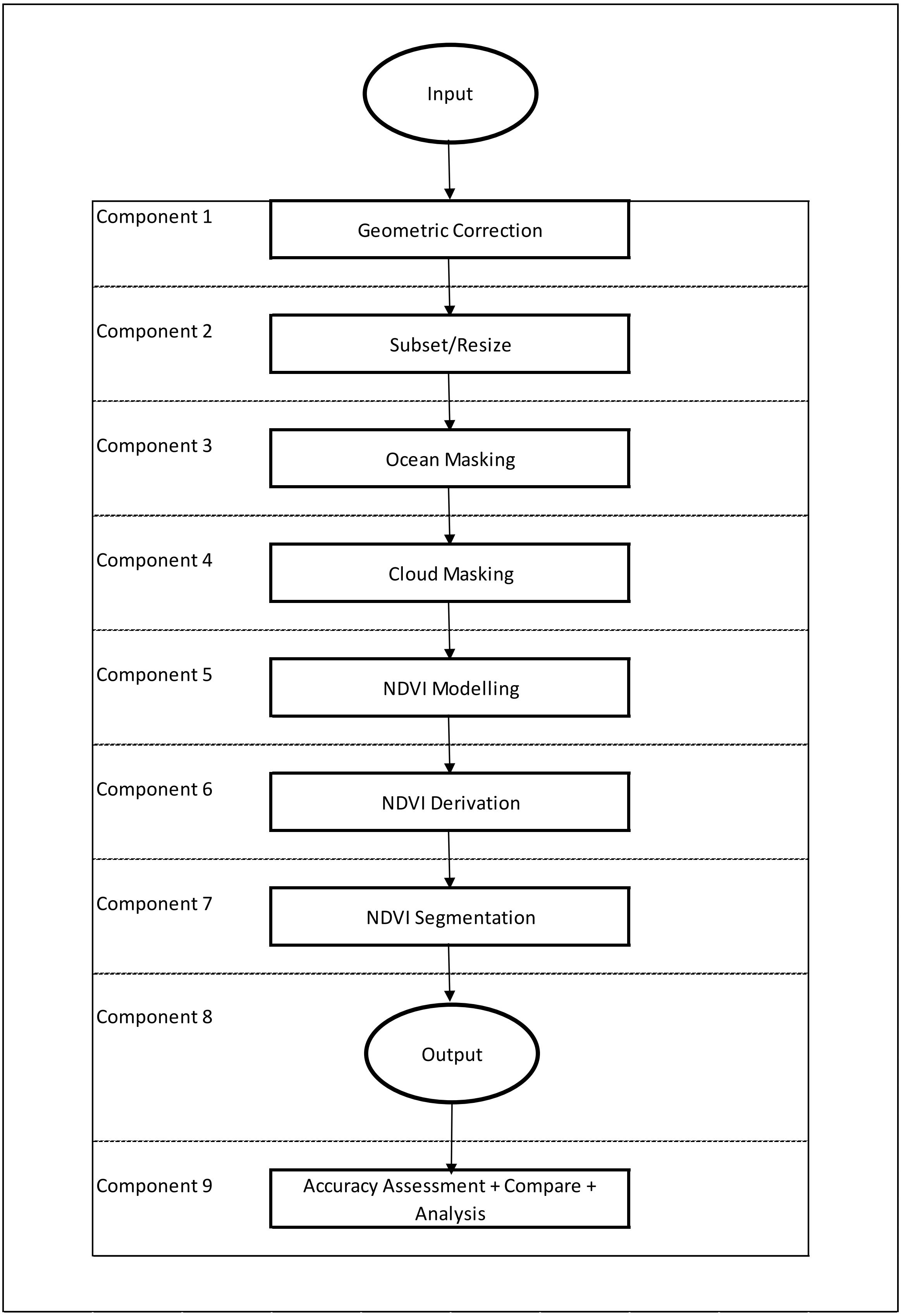

Figure 3: The flow chart of NDVI process

4.2.1 Input

Input is a data that is included in a program to be processed into an information to certain parties. Selected input must meet certain criteria that are appropriate to the program that will be carried out. Sufficient input will produce a good output for the program. Input source also plays an important role during the selection process inputs. Resources must be truthful and reliable and certified by the appropriate bodies.

Input format used in this study is the satellite image. Satellite images are generated from multiple cameras extensively, instruments and sensors installed in satellites that orbiting the earth. The data provided from these sources offers great use to forecasters, urban planners, scientist and other user.

4.2.2 Geometric Correction

The transformation of image data, such as Landsat data, to match spatial relationships as they are on the Earth. Includes correction for band-to-band offsets, line length, Earth rotation, and detector-to-detector sampling delay. For Landsat, a distinction is made between data that have been geometrically corrected using systematic, or predicted, values (Level-1G) and data that have been geometrically corrected using more precise ground control point data (orthorectified, Level-1G-Terrain).

Correction of errors in remote sensing data, such as that caused by the satellite does not live on a fixed height or the sensor does not work from the main focal plane. Image is often compared with the ground control points and resampled accurate basemaps, so that the exact location and the values of the appropriate pixel can be calculated.

4.2.3 Subset/Resize

Resize Data (Spatial/Spectral) is used to subset images. Subset is generally use for larger portion image. Usually the satellite data that received from remote sensing agency covers more than interested region that user wants. Selection is made based on some kind of image of a particular method. There are two types of subsets, which are spatial subset and spectral subset. Spatial subset use to limit applying functions to the image. Selecting interactively from the image. Spectral subset use to limit application of a function to selected bands of an image. For example user wish to use only certain bands (spectral ranges) in the