

THE IMPLEMENTATION OF PREPROCESSING DATA THROUGH REMOTE SENSING AND GIS METHODS IN LAND SUITABILITY AND SOIL COMPACTION STUDIES

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Abstract

This paper studies the implementation of preprocessing data using Remote Sensing and GIS software. The selections of satellite imagery are important during preprocessing. Nowadays, Remote Sensing and GIS technologies widely are used in agriculture especially in precision farming and land suitability studies. There are several sensors that have been launched such as Quickbird, Ikonos, SPOT, and LANDSAT. In addition, the sensor development can improved our analysis of result. In this study, preprocessing part involves digital image preprocessing, digital image enhancement, digital image classification and GIS integration. During preprocessing part, RMSE should be less than 1 in order to get the accurate results. The selection of datum and projection should be suite with our local region which is Kedah 1948 and MRSO. This study used ArcGIS and ERDAS Imagine software for preprocessing and powerful workstation to run the processing data. Ground truth data, topographic map, soil map, land use map used as ancillary data for image analysis. Thematic map is produced using unsupervised classification and supervised classification.

Keywords- Preprocessing, Remote Sensing, GIS, Land Suitability, Sensor

1. Introduction

At development sensor development stage, sensor configuration (spectral bands, spatial resolution, radiometric quantization, etc.) are decided based on wide consultation of application sectors, in an attempt to provide capabilities that meet actual requirements. [1] Remote Sensing is the science and art of obtaining information about an object, area or phenomena through the analysis of data acquired by a device that is not in contact with the object, area or phenomena under investigation. [2]

The photograph is scanned and subdivided into pixels with each pixel assigned into digital number representing its relative brightness. The computer

displays each digital value at different brightness levels. Sensors that record electromagnetic energy, electronically record the energy as an array of numbers in digital format right from the start. These two different ways of representing and displaying remote sensing data, either photographically or digitally are interchangeable as they convey the same information although some detail may be lost when converting back and forth. Image brightness is proportional to pixel value; therefore, 0 means that 0 represent black and 255 represent white. [3]

The use of remote sensing imagery may also provide important information that can reduce or eliminate the need for measuring soil cone index. To characterize the state of soil compaction in a field using soil cone index and to determine if remotely sense images could identify compacted regions that require deep tillage. The results of linear correlation determinations between the various indices associated with the cone index measurements and the LANDSAT reflectance data are recorded in grid cells of Ellis Field 31. While better correlation must be established before remote sensing measurements used to identify areas of likely compaction. However, additional strategies should be explored in a search for more useful remote imagery for identifying areas of potential soil compaction. [4]

The LU/LC map is produced by processing and interpreting a Landsat TM image. Soil map, topographic maps and ground truth data are used as ancillary data for image analysis. After image interpretation, the thematic map resulted in the following LU/LC classes: urban/developed, water, agriculture, pasture and forest. A triangular irregular network (TIN) is interpolated from contour lines and elevation points (VIPs) considering drainage as breaklines. The slope map is created from DEM with 30

meters cell resolution and it is recorded in 5 classes. The soil map is converted into a grid. The combination of both LU/LC and LUC maps allowed the production of land-use suitability (LUS) map in which discrepancies could be detected as a result. This information can be used in decision-making, management and monitoring agricultural areas in order to avoid soil sustainability losses. [5]

The most common date for land use analysis is satellite data. They become very popular in recent years because of their better spatial and spectral resolution and their capacity to generate multitemporal products more cheap than aerial photos. Besides that, land suitability analysis needs thematic maps such as soil, slope and rainfall maps. The spectral signature of an object is usually represented by characteristics reflectance curves in the part of the solar spectrum, covered by satellite sensor (e.g. Landsat, SPOT). Soil and vegetation spectral signatures like those of other objects, vary according to parameters such as moisture and state of vegetation etc. [6]

The land potential of the study area is categorized in very high, high, moderate, low and very low by adopting the logical criteria. These categories were arrived at by integrating the various layers with corresponding weights in a Geographical Information System (GIS). [7]

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The objectives of this project are to evaluate the potential of satellite imagery in mapping purpose, land suitability analysis and identify areas of possible soil compaction. However, the image processing or preprocessing part has been done before analysis study.

2. Materials and methods

2.1. Study Area

This research is conducted in Perlis; Figure 1 shows the boundary area that involved in this study.

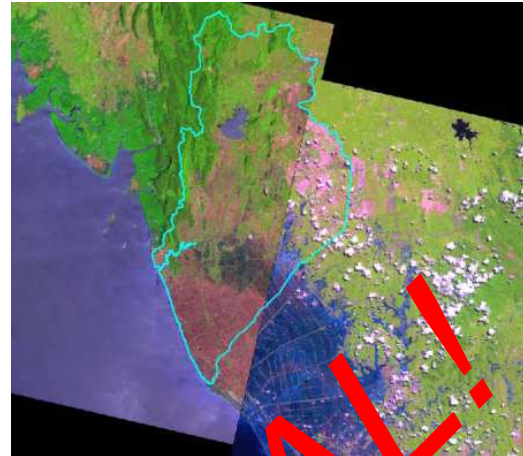


Figure 1: Study Area

2.2. Data Acquisition

2.2.1. Satellite Imagery The selection of satellite imagery is important in an attempt to provide the capabilities and meet requirement of this research. The selection of sensor configuration is useful for implementation of this study.

SPOT
The SPOT-5 Earth observation satellite successfully placed into orbit by an Ariane 4 from the Guiana Space Centre in Kourou during the night of 3 to 4 May 2002. The VEGETATION 2 passenger instrument on SPOT-5 also provides continuity of environmental monitoring around the globe, like its predecessor on SPOT-4. SPOT Image Corporation is composed of four subsidiaries, including an office in Germany and a dense global network of receiving stations, channel partners, and distributors. [8]

Table 1 and Table 2 show the characteristic of SPOT image and LANDSAT image.

Table 1: Characteristic of SPOT image

Sensor - Satellite	Spatial Resolution	Spectral Resolution	Temporal Resolution	Swath
Spot	10m MS	MS 4 bands :- 0.59 – 0.59 μm : Green 0.61 – 0.68 μm : Red 0.79 – 0.89 μm : NIR 1.58 – 1.75 μm : SWIR	2 – 3 days	60 x 60 km
	2.5m Pan	0.51 – 0.73 μm		

b) LANDSAT

LANDSAT-1 is the world's first earth observation satellite (EOS), launched by the United States in 1972. It is recognized for its ability to observe the earth far from space. Its excellent set of capabilities emphasized the importance of state-of-the-art remote sensing. Following LANDSAT-1, LANDSAT-2, 3, 4, 5, and 7 were launched. LANDSAT-7 is currently operated as a

primary satellite. LANDSAT-5 is equipped with a multispectral scanner (MSS) and thematic mapper (TM). MSS is an optical sensor designed to observe solar radiation, which is reflected from the Earth's surface in four different spectral bands, using a combination of the optical system and the sensor. TM is a more advanced version of the observation equipment used in the MSS, which observes the Earth's surface in seven spectral bands that range from visible to thermal infrared regions. [8]

Table 2: Characteristic of LANDSAT image

Sensor - Satellite	Spatial Resolution	Spectral Resolution	Temporal Resolution	Swath
Landsat 1, 2, 3 MSS	60mx80m	MS 4 bands :- 500-600nm : Green 600-700nm : Red 700-800nm : Near IR 800-1100nm : Near IR	18 days	185x185 km
Landsat 4 & 5 TM	30m MS 120m TIR 15m Pan	MS 7 bands :- 450-520nm : Blue 520-600nm : Green 630-690nm : Red 760-900nm : Near IR 1550-1750nm : Mid IR 2080-2350nm : Mid IR 10400-12500nm : TIR Pan (520-900nm)	16 days	185x172 km
Landsat 7 ETM+	30m MS 60m TIR	MS 7 bands :- 450-520nm : Blue 520-600nm : Green 630-690nm : Red 760-900nm : Near IR 1550-1750nm : Mid IR 2080-2350nm : Mid IR 10400-12500nm : TIR	16 days	185x172 km

Table 3 below shows the data collection of satellite images that collect from Agency Remote Sensing Malaysia. See figure 2 and figure 3 for the original image of SPOT 5 and LANDSAT 5 TM.

Table 3: Data collection of satellite image

Sensor/Satellite	Date	Resolution
Landsat 5 TM	01/02/2005	30 meter
Spot 5	25/09/2010	2.5 meter

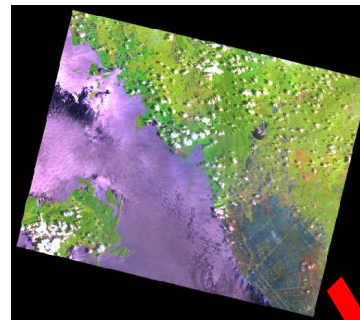


Figure 2: SPOT 5 Image



Figure 3: LANDSAT 5 TM Image

2.2.2. Ancillary Data. Table 4 shows the several maps given by Soil Resource Management and Conservation Division, Department of Agriculture. This map used for land suitability and soil compaction studies.

Table 4: Characteristic of map

Types of Map	Scale
i) Reconnaissance Soil Map	1: 100 000
ii) Soil suitability map	1: 100 000
iii) Present Land Use Map	1: 100 000
iv) Agriculture Rainfall Index Map	1: 100 000

2.2.3. Soil sampling. Penetrometer (Soil compacter) is used to indicate soil compactness and strength with various depths. Then, handheld GPS used to locate and record coordinate during soil sampling. Figure 4 shows the soil sampling data uploaded and displayed using Garmin MapSource.

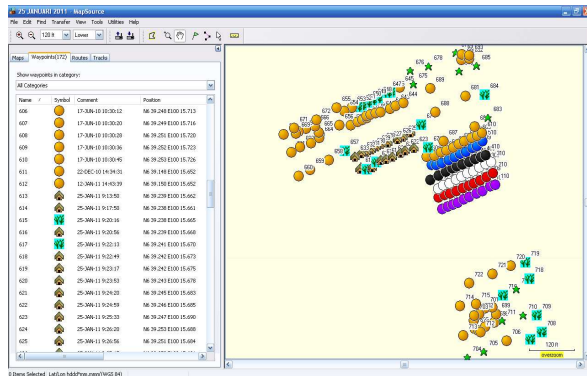


Figure 4: Point Coordinates of Soil Sampling

2.3. Digital Image Processing

The digital image processing is a task of processing and analyzing a digital data using some image processing algorithm. There are several parts of digital image processing that involves in this study.

- Digital Image Pre-Processing
- Digital Image Enhancement
- Digital Image Classification
- Data merging and GIS integration

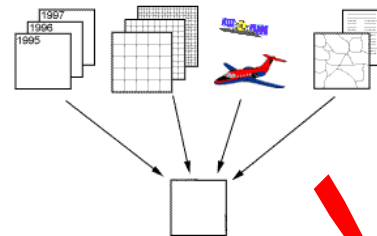
In this study, pre-processing part involves image rectification, reprojection and registration. Image pre-processing should be done before doing any other processing such as enhancement, manipulation, interpretation and classification of satellite images. Rectification and reprojection of satellite imagery is performed to MRSO or *Malayan Rectified Orthomorph* which is coordinate systems commonly used in Peninsular or West Malaysia.

Before starting visually interpreting satellite images, some image enhancement techniques are applied to improve and enhance features. This processing involves image data fusion, image stacking, Wetness Index and NDVI (Normalized Differential Vegetation Index).

Digital image classification techniques are less time consuming than visual techniques. Digital satellite image can be classified digitally using supervised or unsupervised image classification. The latest land use maps can be produced using this method for land suitability analysis and mapping purpose.

Besides that, ArcGIS software is very useful as analyzing tool, map overlaying and digitizing tool. Data integration involves combination data in different sources such as map, satellite imagery, aerial

photograph, database and so on. Fig. 5 shows the potential of GIS in data integration and data merging.



3. Results and Discussion

3.1. Preprocessing

The Geometric Correction is needed for uncorrected images that have been taken from the satellite images caused by the distortion. There are three common methods for resampling which are nearest neighbor, bilinear interpolation and cubic convolution. For this study, nearest neighbor is chosen as resampling method. Figure 6 shows the result of Geometric Correction. Figure 7 and Figure 8 showed the result of subset image for study area.

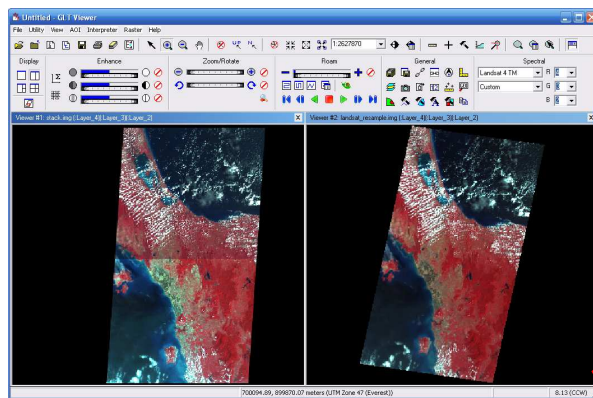


Figure 6: Result of Geometric Correction

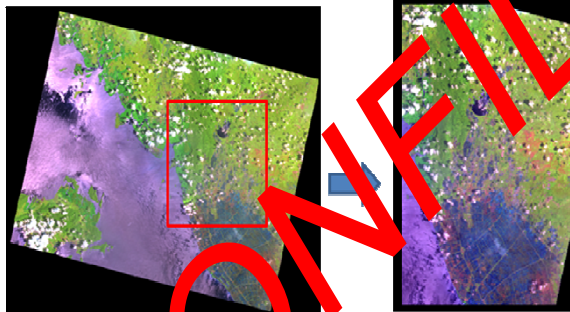


Figure 7: Subset Image of SPOT 5

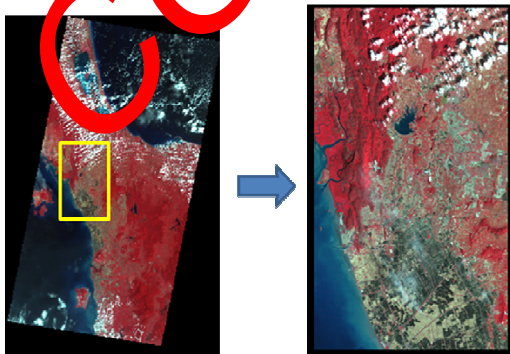


Figure 8: Subset Image of LANDSAT 5 TM

3.2. Georeferencing

Before starts editing or digitizing, paper map is registered into real-world coordinates. This allows us to digitize features directly in geographic space. ArcGIS software is used in this method using georeferencing tools. Figure 9 shows the procedure of map registration which is four control points being choose at each corner of map to key in x coordinates and y coordinates in MRSO projection.

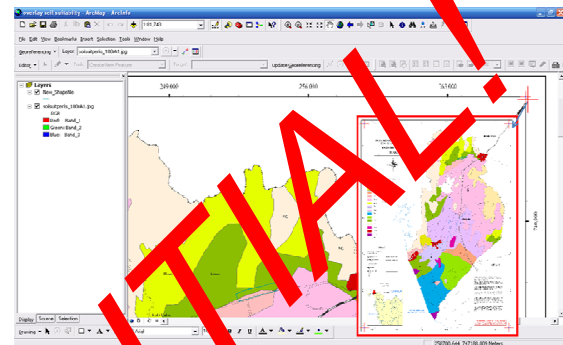


Figure 9: Map Registration

3.3. RMS Error

The RMS error should be less than 1 in order to gain the accurate result. Table 5 shows the total RMS Error for map registration which is 0.18227.

Table 5: Residual Error

Link	X Source	Y Source	X Map	Y Map	Residual
1	711.932024	-700.509924	225760.000000	733900.000000	0.18227
2	8795.394769	-700.481047	266850.000000	733900.000000	0.18227
3	8804.480938	-11796.446556	266850.000000	699800.000000	0.18227
4	720.884980	-11796.407252	225760.000000	699800.000000	0.18227

Auto Adjust Transformation: 1st Order Polynomial (A) Total RMS Error: 0.18227

3.4. Map Composition

Figure 10 shows the land use land cover map that produced using image classification method in ERDAS Imagine software and map mapped using ArcGIS software. This map will be used for land suitability analysis.

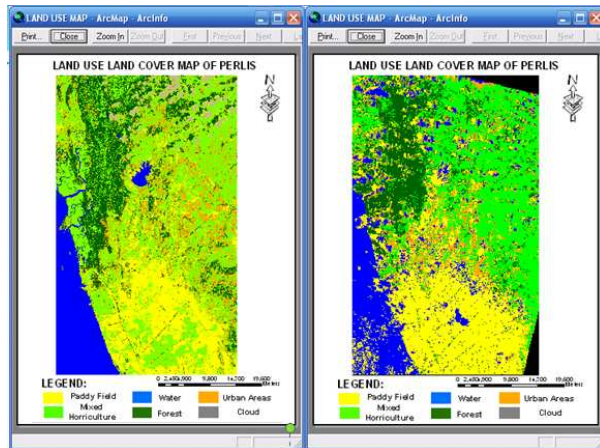


Figure 10: Land Use Land Cover Map

4. Conclusion

There are several parts that involved in digital image processing such as image rectification, image enhancement, image classification and GIS integration. Image processing is almost always the first step of any remote sensing application. Resampling of the image data is inevitable during the georectification process. The RMSE of Geometric Correction should be less than 1 pixel to get the accurate result. The result of residual error of map registration is 0.18277 which is less than 1 pixel. Datums and projections are important during image processing and georeferencing and should be suite with our local region. Thematic maps are the most important products of remotely sensed images which derived by visual interpretation or computerized classification. The unsupervised classification was applied to produce land use land cover map of Perlis. In addition, the selections of satellite imagery are necessary for any application of research study. The selection of satellite image of research study depends on spatial resolution, spectral band, radiometric quantization, etc. Landsat 5 TM image and SPOT 5 image are chosen for this study with different

resolution. Satellite image of Landsat 5 TM is low resolution (30 meter resolution) and SPOT 5 is high resolution (2.5 meter resolution).

5. References

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