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COMPARATIVE STUDIES OF REMOTELY SENSED COASTLINE MAPPING TECHNIQUES

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ABSTRACT

The shoreline is always changing its shape and position dynamically. There are many remote sensing techniques can be used to depict coastline. Band Ratio, Tasselled Cap Transformation, ISODATA and NDWI are amongst the established technique use to map coastline. A comparison is needed to identify which of these techniques is offer better accuracy. Thus, the aim of this study is to identify the optimum method for mapping coastline. In order to achieve this aim, the objectives of this project are: i) to study technique of coastline extraction using remote sensing image, ii) to map coastline using the selected remote sensing technique for comparison and iii) to determine accuracy these techniques by using local authority data as the baseline. The study area for this research is at Pantai Puteri, Tanjung Keling, Melaka. The techniques explored in this study are Band ratio, Tasseled Cap Transformation, Unsupervised Classification (ISODATA) and Normalized Difference Water Index (NDWI). For processing, the main data use is Landsat 8 OLI imagery which is downloaded from USGS website. The result shows that Band Ratio offer highest accuracy as compared to the other tested techniques.

***Keywords**: coastline, remote sensing, band ratio, tasseled cap, isodata, ndwi*

INTRODUCTION

The coastal management is a crucial and important issue for government and community as it's provides economic, social and environmental benefits and services (Nayak, 2002). Monitoring coastline changes is important to environmental protection and sustainable development. Major issue in coastal management is the impacts of coastal erosion to the dynamics changes of coastline. Coastline erosion happens because of two major elements; the human activity (anthropogenics) and the environmental factors (wave, tides, tsunami etc.).

In the past, aerial photo, photogrammetry techniques and ground survey were used to detect changes in coastal area. Aerial photo is used together with ground survey to determine the changes (Kauth and Christ, 1986). The progress of the surveying works is time consuming, with the drastic and dynamics changes of coastline getting the results in time would be difficult. In some cases, the processes take months or even years to achieve a complete result especially when the sites involved multiple coastal boundaries. Besides, conventional method also demands for professional surveyor and hydrographer and thus it is costly. It is also involved a few sophisticated instruments to add up to the expensive professional fees. In this study, remote sensing technique is explored and investigates to detect the coastline. The availability of various techniques to depict coastline has become a major challenge. Thus, it is at urge to identify which one of these techniques offer better accuracy. Recently, remote sensing and Geographical Information System (GIS) have been widely used as another option than conventional method for monitoring shoreline position (Raju et al., 2010). Early research in the

application of satellite sensor images for shoreline mapping relied on coarse spatial resolution satellite sensor images (Lipakis, 2006).

METHODOLOGY

Study Area and Research flow

Pantai Puteri, Tanjung Keling, Melaka has been chosen as a study area. Pantai Puteri is previously known as Pantai Kundur. This area is chosen because the place is well-known and situated at a strategic point in west coast. Melaka is located at western of east coast Semenanjung Malaysia. The coordinate of Pantai Puteri is at Latitude 2’13’36’’, Longitude 102’09’27’’. Figure 1 show the processes adopted in this study while the location of the study area, is illustrated in Figure 2.

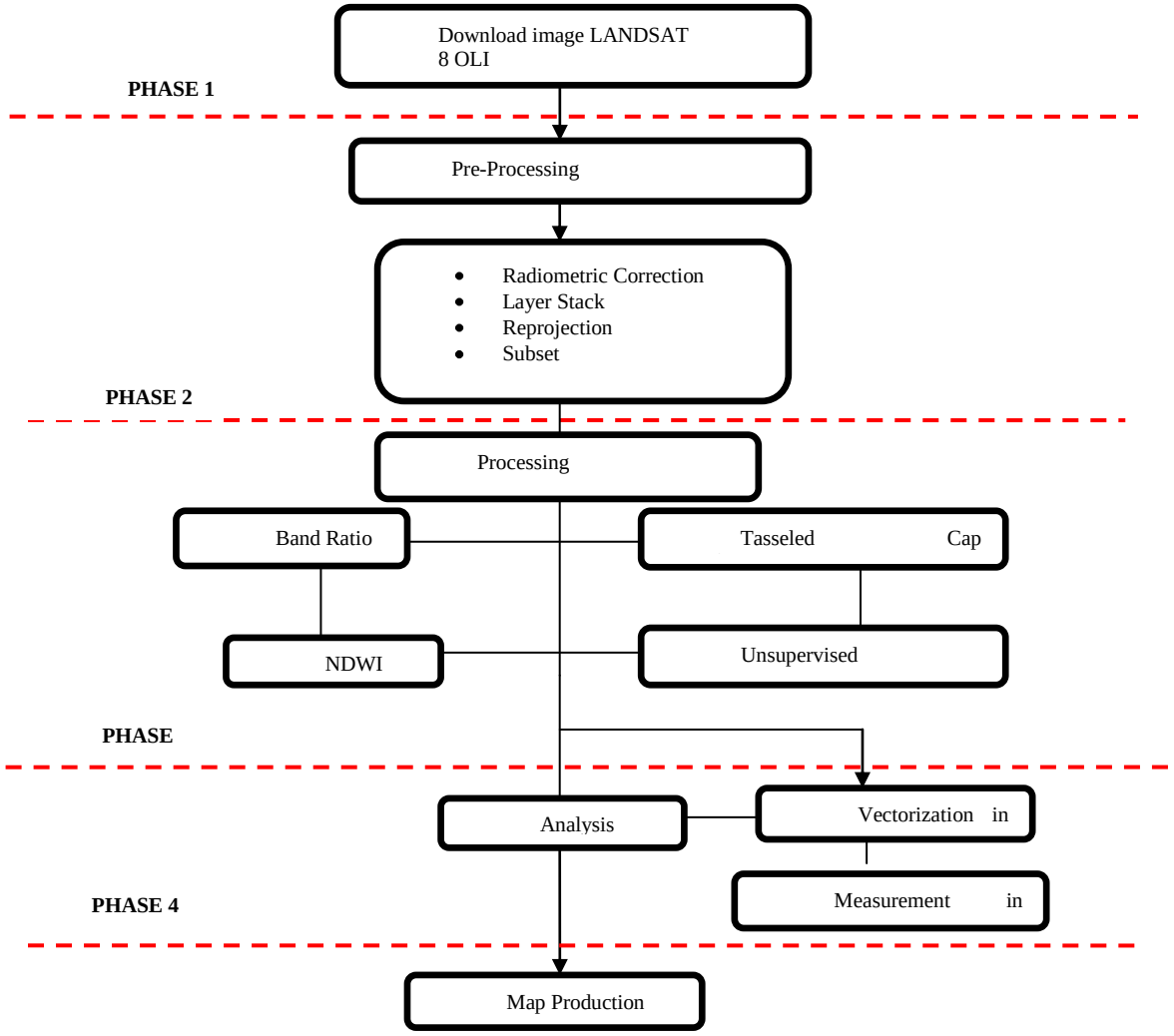


Figure 1: Methodological Flowchart

Figure 2: The Study Area.

Remote Sensing Techniques for Mapping Coastline

Several studies were conducted for monitoring the dynamic changes of coastal line for sustainable environmental management (Li and Damen, 2010; Rahman et al., 2011 and Alesheikh et al., 2007). It is important to monitor a coastline for sustainable development and environmental protection. The coastline detection can be determine by several techniques such as unsupervised ISODATA, band ratio, vector slicing, supervised classification, histogram thresholding and mores (Gen, 2007).

Band ratio is applied to multi spectral image data and known as one of the most common mathematical operations. The calculations involved by calculate the ratio of image by divide DN values in one spectral band with corresponding pixel value in another band (Klemas, 2009). This technique can decrease the environmentally induced variation in DN values of a single band impact from topographic slope and aspect, shadows in sunlight illumination angle. Besides, band ratio can give information that is not providing in any single band for extract earth surface feature. Tasselled cap transformation on the other hand is a semi-automated method that compresses spectral data into several bands. This method can divide into three categories which are brightness, greenness and wetness (Baig et al., 2014).

The Normalized Difference Water Index is used to study the areas covered with water. It is similar to NDVI but using the green band instead of the red one. With this algorithm, the water was assumed to be positive values, while terrain and vegetation have negative values; dry sand, due to its high reflectance in a green band and in the near infrared band, is characterized by positive values but near to zero. Unsupervised training is dependent upon the data itself for the definition of classes. This method is usually used when less is known about the data before classification. They are simply clusters of pixels with similar spectral characteristics.

Baseline and Transect

Using AutoCAD, baseline and transect is construct. Baseline is acquired to construct in order to make transect perpendicular to baseline. To construct a baseline, each baseline segment must be placed entirely offshore perpendicular to the shorelines. Then, construct transect line by offset 500 meter. The transect line that intersect with each shoreline is then being measure using measurement tool in AutoCAD. The distance between reference shoreline to shorelines is calculated. Figure 3 shows the baseline; transect line and spacing, reference line and all shorelines.

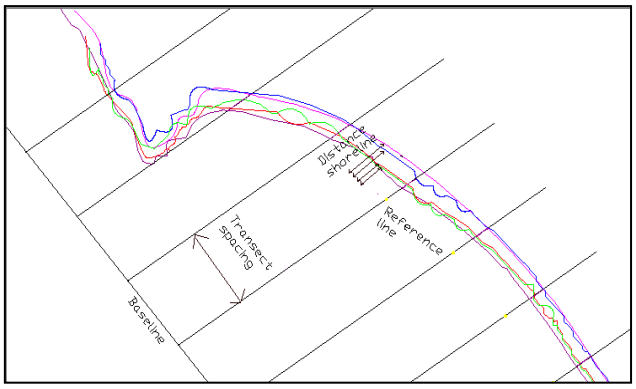


Figure 3: Baseline and transect line

The baseline approach or also called transect method is implied for determining the degree of shoreline recession. The comparison between reference line which is reference coastline acquired from JUPEM with test coastline which is the four techniques used is calculated. Figure 4 shows that the illustration of baseline approach or transect method to compare the true coastline and the test line. The true coastline represents the reference line acquired from JUPEM while the test line represents the 4 techniques used. Then transect is constructed perpendicular to the baseline and transect will intersect with true coastline and the test line

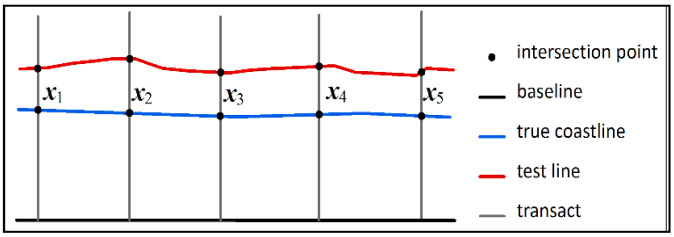
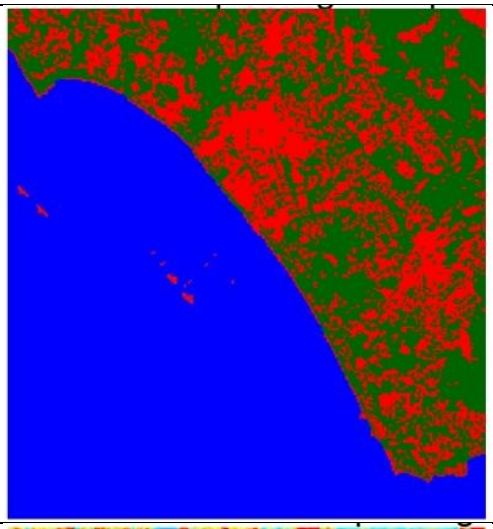
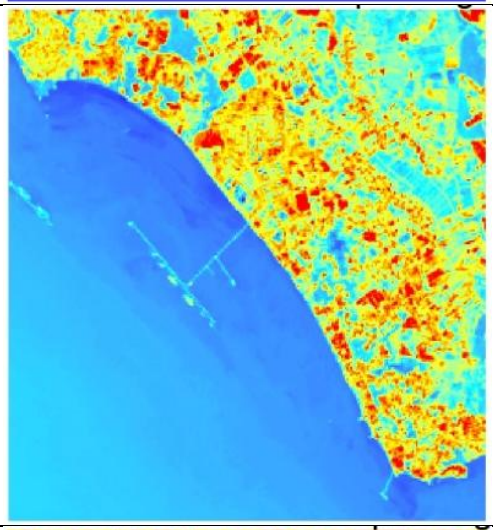
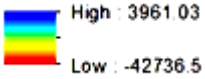
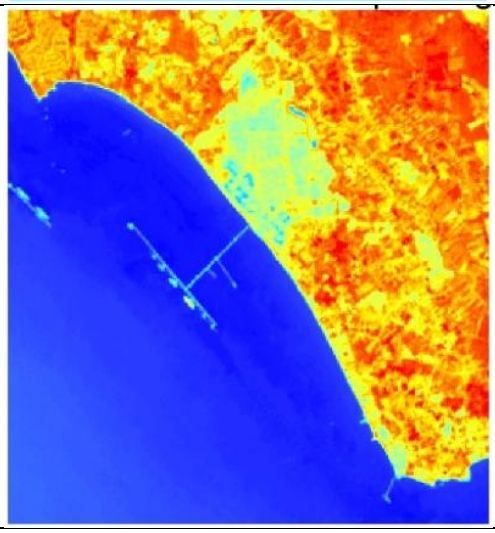
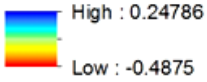


Figure 4: Illustration of baseline approach (Source: USGS, 2014).

RESULTS AND DISCUSSIONS

There are four (4) implied automated and semi-automated remotely sensed coastline detection techniques involved in this study. These techniques are band ratio, tasselled cap transformation, NDWI and unsupervised classification (ISODATA). In this study, the Landsat 8 (21 June 2014) image is used. Thus, on 21 June the mean tide recorded by Malaysia Surveying and Mapping Department (JUPEM) is 289.6 which are near to total mean of one month. Overall the mean tide recorded on 21 June is normal. Figure 5 shows the result of coastline detection by using ISODATA, Tasselled cap, NDWI and Band Ratio techniques.

	ISODATA  The accuracy recorded for this technique is 83.33% while overall Kappa Statistics recorded is 0.7458.
	TASSELLED CAP  The average maximum and minimum value is between -42736.5 and 3961.03. The highest value represents blue colour while the lowest value represents red colour.
	NDWI  The positive values are assumed to be water while vegetation or terrain has the negative values. The coastline is classified as sandy coast (<0), while other coastline types such as bed rock coast (> 0.26) is not coastline.

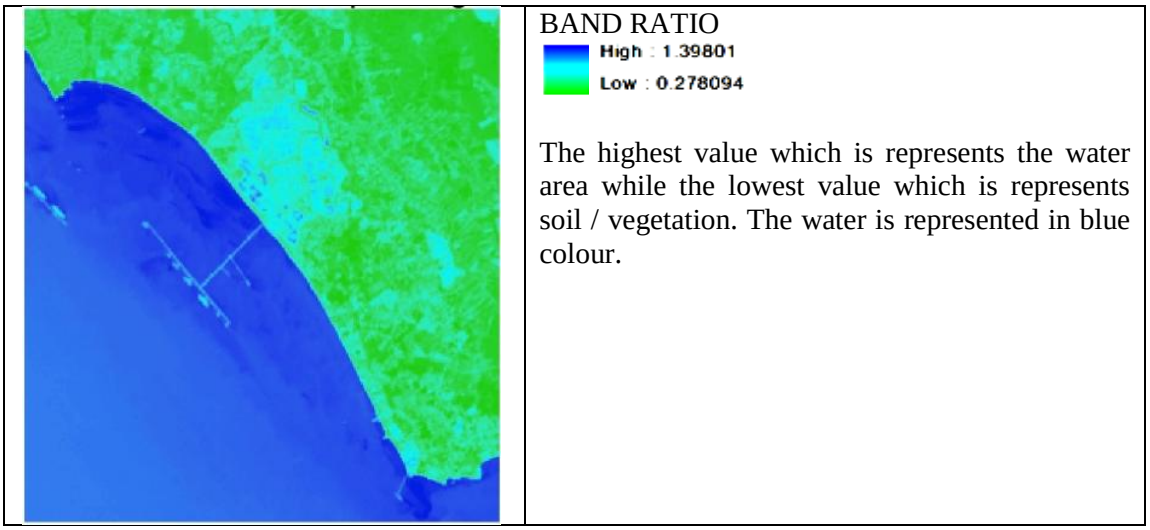


Figure 5: The Coastline Maps

The lowest mean and standard deviation of the calculation obtain is considered as the most accurate when referred to reference line. From the Table 1, the lowest mean and lowest standard deviation is band ratio technique. Band ratio technique recorded the lowest mean distance with 169.68m and standard deviation 29.15.

Figure 6: The Construction of Transect and Baseline of the Case Study

Table 1: Transect Summary

Statistic	Tasselled Cap Transformation (m)	Band Ratio (m)	Unsupervised (ISODATA) (m)	NDWI (m)
Minimum	156.10	105.54	115.37	176.67
Maximum	266.54	212.89	221.92	295.22
Mean	203.85	169.68	173.59	242.68
Median	192.37	165.42	171.93	240.11
Standard deviation	33.01	29.15	29.23	35.15

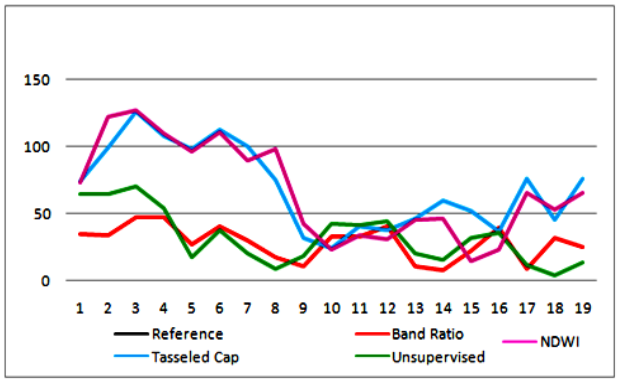


Figure 7: Coastline Extraction Method

Figure 7 shows graph of coastline extraction method. From this graph, the purple line is indicates the reference line which is recorded zero value. The x axis is indicates the transect point while the y axis is indicates the distance of four techniques from reference line. This graph shows that the band ratio method which represents red colour line is the closest to the reference line. The second close from reference line is Unsupervised Classification method which represents green colour line. This method also is nearest to the band ratio method. The blue line which is tasselled cap transformation method is quite far from reference line while the farthest method from reference line is NDWI method represents pink colour line.

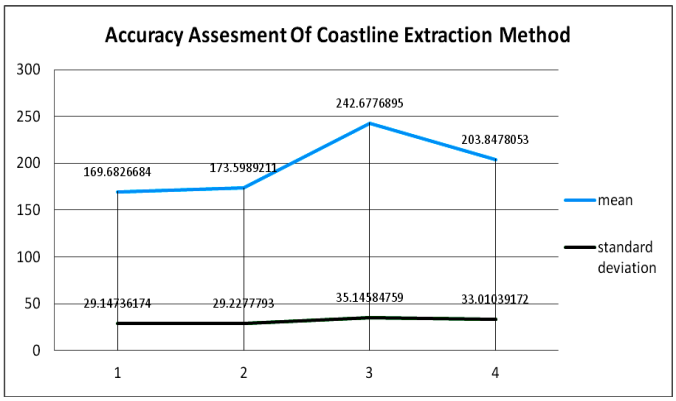


Figure 8: Accuracy Assessment of Coastline Extraction Method

Figure 8 shows the graph of accuracy assessment of coastline extraction method. This graph shows mean and standard deviation which represent line of blue colour and black colour. The x –axis shows the 4 technique involves which is method 1 is Band Ratio technique, method 2 represents Unsupervised Classification method, method 3 represents NDWI and method 4 represents Tasselled Cap transformation technique. Hence, it shows that the lower the mean values, the lower the standard deviation values as Band Ratio technique has the lowest mean and standard deviation value.

CONCLUSIONS

Based on the comparison of four (4) remotely sensed techniques to separate the water and land with refer to the baseline data acquired from JUPEM. Four remote sensing techniques (Tasselled cap transformation, Band Ratio, ISODATA and NDWI) were successfully used to extract the same coastline area. The results from this study exhibited that Band Ratio method for coastline extraction offers more accuracy. The fundamental principle in extraction of coastline is the accuracy. Thus, the spatial resolution of the source of data is important. Data that was used in this study is Landsat 8 OLI with 30 meter resolution for visible, NIR and SWIR while 15 meters for panchromatic. Using semi-automated techniques extraction of coastline, the processes can be conducted smoother and faster, hence, saving time, cost and maintenance as compared to the traditional method of coastline mapping techniques.

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