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Detection of Vegetation Losses in Shrimp Farming Area Using Remote Sensing Technique

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Abstract

The conversion of mangrove forest to aquaculture activity leads to the destruction of habitat diversity and ecosystem. Shrimp farming is a sector of aquaculture that has a high potential for poverty alleviation and rural development in Tumpat, Kelantan. However, the development of this activity induces changes that potentially have negative impacts on the environment, one of which is vegetation deterioration. Pulau Terendak, Tumpat has been through the phase of conversion area which established as a shrimp farming area at year 1989. Using remote sensing technique, this study was implemented to identify the current status and total ranges of shrimp farming area by comparing vegetation losses from year 1989 to 2017. Land use and land cover maps of study area was analyzed through a process called image classification. Supervised classification using Maximum Likelihood algorithm was utilized to assess vegetation losses of the 45 hectare of shrimp farm area. Four main land use classes were detected namely water, bare area, dense vegetation and small vegetation. Result showed that in 25 years, vegetation of the area had decline to 23.3% while bare soil or open area increased to 8.5%. Digital analyzed data was compared to field verification procedure, accuracy assessment in this study was recorded at 64.3%. There are many causes for vegetation or mangrove loss but in this case the conversion of mangroves to shrimp farms has caused considerable attention whereby vegetation losses was found at serious state. Output of this study could suggest the authorities to plan a good strategy to address this issue in cost effective with maximum benefits for the environment and society.

1. INTRODUCTION

Delta Tumpat is one of the most important ecosystems for mangrove due to its advantages for economic, socio-economic and environment with 83.7% relative humidity and mean temperature of 26.8°C (Kasawani, 2011). Mangroves are evergreen trees and shrubs that are well adapted to their salty and swampy habitat. They have breathing roots (pneumatophores) that emerge from the oxygen-deficient mud to absorb oxygen. Mangrove tree has developed an adaptation to the harsh condition of the environment. They have a strong and powerful root that helped them to stay standing proudly due to harsh and strong tidal waves. Besides that, the coastlines will be protected too by this ecosystem from high tides (Alex*et. al*., 2003). Other than that, mangrove forests also known as a favorite breeding place for faunas such as shrimp, fish and mollusks. Besides that, mangrove ecosystem also gives the hiding place for insects, birds and mammals like monkeys and rats. Mangrove ecosystem also gives high commercial values such as charcoal, timber, firewood and food resources (Somjai*et. al.*,2000).

Delta Tumpat consists of 10 islands which are Pulau Che Minah, Pulau Tengkorak, Pulau Bedal, Pulau Layang-Layang, Pulau Kambing, Pulau Terendak, Pulau Timun, Pulau Tongkang, Tanjung Duff and Pulau Rulah (Huda *et. al.*, 2013). All of these islands are covered with mangrove trees. Total area of the Delta Tumpat approximately reached 1200 hectare (Behara *et. al.*, 2011).The existence of the Delta Tumpat was in early 1960 due to the deposition of silt. In earlier existence, the area was roomy without any existence of mangrove colony (Huda *et. al*., 2013).

During 2000-2004, Kelantan State Forestry Department started to plant about 40 000 mangrove trees at Pulau Layang-Layang and Pulau Mas in order to add more mangrove colonies (Hapizah, 2015). Behar *et al.*, (2011) stated that mangrove trees covering for about 339.6 ha of Delta Tumpat and aquaculture activity that held 42.7 ha including Pulau Terendak. Since 1980 until 1990, Malaysia mangrove forest ecosystems were disturbed due to urban development, deforestation, conversion area to

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agriculture site and shrimp farming activity (Spalding *et. al.*, 1997).

Shrimp farming became one of the activities that were held at mangrove areas and no exception at Pulau Terendak. The development of shrimp farming at the mangrove area caused a disturbance of the original habitat of the flora and fauna besides caused the loss of the mangrove forest area.

In order to monitor the shrimp farming and the extended area, field measurement seem does not a professional way to acquire the good and accurate measurement. Therefore, satellite and sensors were used to gather more data for this research. Satellite Remote Sensing (RS) were used for monitoring and detecting the Earth area. RS also can be used to monitoring the mapping purposes, deforestation and aquaculture activity (Green *et. al.*, 1998). The data of the object that exists on the Earth can be achieved by the process of observations by the sensors such as radar, cameras and radiometers without any physical contact (Ramachandran, n.d.). There are various methods of RS, for examples are Landsat TM and SPOT XS (Green *et. al.*, 1998).

Remote Sensing (RS) data obtained through a space sensor and be able to provide reliable information. Recently RS has increased the enhancement of collecting the data such as IKONOS and Quick Bird (Prakash*et. al.*,2014). Remote sensing data have a lot of advantages due to be able to collect the data about the aquaculture activity, deforestation, mapping and forest plotting.

Landsat sensors are recorded by the emitted and reflected energy from the wavelengths of the electromagnetic spectrums which included radio waves, x-rays to the gamma rays. Landsat 5 was well known for the longest operating Earth satellite due to be functioned for about 30 years. Afterward, Landsat 5 believed had transmitted over 5 million images and orbited the Earth for about150 000 times (Jean, 2012). Landsat 5 consists of 120m resolution of thermal bands and near-infrared bands of 30m resolutions and was functioned from 1984 until 2013.

Currently, Malaysia mangrove forest had been converted into a land for an agriculture purposes, shrimp farming and urban development (Polpanich, *et. al.*,n.d). Shrimp farming activity has been increasing rapidly due to the high demand of the shrimp itself because of the limitation supply from the fisheries capture. Thus, shrimp itself is a high value product to the international market. The continuous use of the mangrove forest without a good management and control can lead to bad effects to the forest itself which will cause environmental impacts if there is no good planning and management to the farming site activity. Water quality will turned out really bad if the water not managed well. Information of mangrove forest is difficult to find out due to the physical conditions. While for shrimp farming activity at Pulau Terendak covered 45.0 hectare. Usually the shrimp farms are located near the shore line due to the advantage of the tides to collect post larvae, thus destroying large hectares of mangroves area. Shrimp farmers typically abandon their ponds after a few crop cycles in order to avoid disease outbreaks and declining productivity. So, they prefer to move to the new sites, and left the farming site itself without any incentive to take care of the already destroyed mangrove area. A few benefits of establishment shrimp farming are able to maintain the sustainability of seafood sources by a proper management of the farm itself. Other than that, shrimp farming activities are able to provide jobs to the community besides able to increases the country economic value and are able to reduce the pressure from commercial fishers.

2. MATERIALS AND METHODS

2.1. Study area

The shrimp farming area was located at Pulau Terendak, Tumpat Kelantan with latitude and longitude of 6˚12’35.4” N and 102˚11’4.8” E respectively (Figure 2.1). The area experience 83.7% of relative humidity and mean temperature of 26.8°C (Kasawani, 2011). The vegetation of this area is mostly from mangrove and associates-mangrove species such as Nypa fruticans, Avicenna alba, Rhizophora apiculata and Cocos nucifera (Behara et. al., 2011).

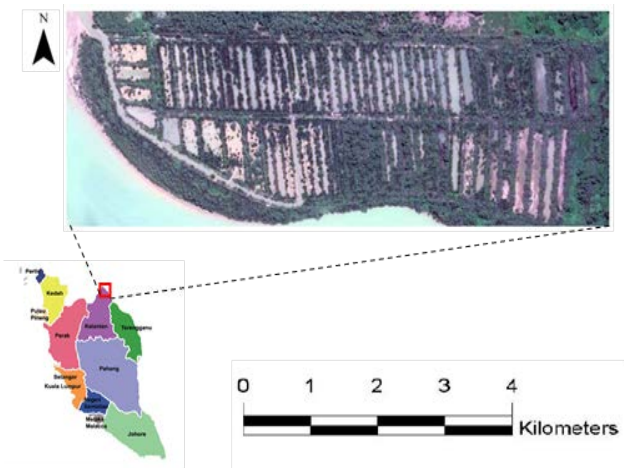

Figure 2.1: Location of shrimp farming area at Pulau Terendak, Tumpat, Kelantan.

2.2. Secondary data

Landsat TM images were used in this study due to the availability andcost-effective imaging solutions. The images were downloaded from USGS’s website. Image of study area for year 2017 and 1989 were acquired with the specifications given as in Table 2.1. Meanwhile, Figure 2.2 and 2.3 showed the original Landsat 5 (1989) and Landsat 7 (2017) that were used for analysis in this study.

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Table 2.1: Remote sensing image specifications

Details	2017	1989
Satellite name	Landsat 8	Landsat 5
Date of acquisition	23.8.2017	4.4.1989
Number of bands	8	7
Source	USGS	USGS

Figure 2.2: The Landsat 5 image of 1989

Figure 2.3: The Landsat 7 image of 2017

2.3. Ground verification

Field data collections were conducted in 2nd August 2018. A total of ten locations were selected randomly for ground verification work. However, due to accessibility of the area, only three locations were successfully visited. The actual condition of the land cover was compared with the classified images. The point of location of the ground verification area was recorded using hand-held Global Positioning System (GPS) device. The default projection setting of the GPS is set to Kertau RSO Malaya. These data were also used in accuracy assessment process (Amnaet.al. 2015). The observation data were recorded and ground photograph were taken on each visited location.

2.4. Satellite data analysis

2.4.1. Pre-processing

Image preprocessing was carried out to produce a better view of remotely sense data. Both TM Landsat images year 1989 and 2017 were go through geometric correction, image filtering and enhancement. The geometric correction was done to remove internal and external distortion (Philpot, 2001). Image pre-processed were carried out in ENVI 5.1 software. After the raw image was pre-processed, the area of interest (AOI) which is Pulau Terendak were selected and clipped within the area size required.

2.4.2. Image classification

Pre-processed images were then go through image classification process. First, the unsupervised classification was carried out to generate general clusters and assign land cover classes of the images. In unsupervised image classification, random classes were formed automatically to differentiate the land use class. Next, supervised classifications analysis were carried out to classify both images with pre-determined number of classes based on previous classification technique. In this analysis, the Maximum Likelihood (ML) algorithm was selected to classify the land cover of the images. Type of classes and description selected in supervised classification are shown in Table 2.2.

Table 2.2: Classes used in image classification process.

Class name	Description
Soil	Exposed soil of land area.
Water	Open water, river and shrimp pond
Vegetation 1	Dense vegetation or mangrove species
Vegetation 2	Small vegetation or shrubs

2.4.3. Image classification

Classification results and field observation were analyzed to determine the accuracy between ground data and digital image data. The assessment data were organized in confusion or error matrix from which both overall classification accuracy on the individual classes could be calculated in terms of the proportion correctly classified (PCC) sample points. Figure 2.4 show the flow of the study.

3. RESULTS AND DISCUSSION

3.1. Satellite image analysis

Both satellite images of 1989 and 2017 were pre-processed; filtered and enhanced to remove internal and external distortion. This was done in ENVI 5.1. After pre-processing stage, images were clipped to polygon shape file to get the AOI of shrimp farming area of Pulau Terendak. Next, the areas of shrimp farming at Pulau Terendak was measured. Figure 3.1 shows a total of 45.0 ha shrimp farming area extracted from selected AOI.

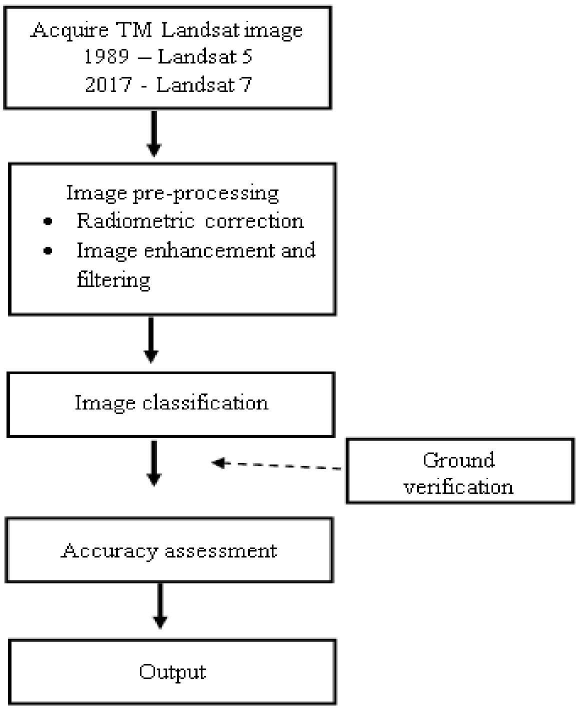

Figure 2.4: Flow chart showing method use in this study

Figure 3.1: Area occupied for shrimp farming at Pulau Terendak

3.2. Image classification

In unsupervised classification, ten classes were assigned to the algorithm. It groups pixels with common characteristics without providing sample classes. After examined the land cover classes from the prior analysis, supervised classification technique was carried out. Training data was provided 2 to classify pixel with the similar characteristics. Results showed that four main classes namely water, soil, vegetation 1 and vegetation 2 were produced (Figure 3.2). Vegetation 1 is determined by denser plant distribution of mangrove and non-mangrove species while Vegetation 2 described small vegetation in the area such as grass and shrubs.

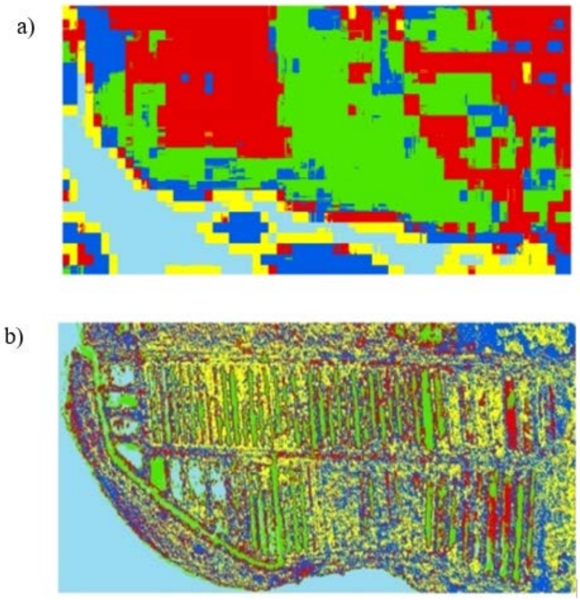

Figure 3.2: Image classification of a) 1989 and b) 2017 using supervised classification method.

3.3 Accuracy assessment

Accuracy of the analyzed data was accessed using commission and omission of user and producer accuracies. It was also calculated using Kappa coefficient. The results from accuracy assessment showed an overall accuracy obtained from the random sampling process for the image of 64.3% for 2017 and 46.6% for 1989 data (Table 3.1).

Supervised classification of both images showed a low accuracy classification, it might due to input features have noise and non-informative data (Sophia & Ndambuki, 2017) or training sample might not large enough. However, the classification result could give an overall view of the changes of shrimp farming area from 1989 to 2017 using four classes.

Percentage and area covering each class type are shown in Table 3.2. From the result, it explains that vegetation distribution of the shrimp farming area experience various changes by time. For nearly 30 years, percentage of vegetation cover decreased. Area cover by mangrove and associate species had reduced to 4.8% while the amount of shrub and grasses-type vegetation were also decreased 12.5%. The conversion from mangrove area to shrimp farming area was the main reason of this land use changes. Based on the interview with the surrounding villager at Tumpat delta, the shrimp farming area was established about seven years ago. At the opening of the shrimp pond, mangrove trees were majorly cut down. At the same time, due to the opening of land for shrimp farm open or bare soil area enlarged to 8.5 ha. In 2017, the abandoned shrimp ponds had decreased the amount of area covered with water. The shrimp pond was abandoned and it started to fill with soil instead of growing shrubs.

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Table 3.1 Accuracy assessment result for year 1989 and 2017.

Year	1989	2017
Overall accuracy (%)	46.59	64.3
Kappa coefficient	0.08	0.18

Table 3.2: Percentage and area (ha) covered by land use class types

Year	1989		2017	
	Percentage cover (%)	Area (ha)	Percentage cover (%)	Area (ha)
Water	16.87	7.59	21.27	9.57
Bare soil / open area	0.00	0.00	18.94	8.52
Vegetation 1	55.56	25.00	44.73	20.13
Vegetation 2	27.58	12.41	15.07	6.78

Previous study on shrimp pond abandoned in Asia indicated that shrimp farming activities commonly stopped due to disease attack. Without mitigation and restoration of the landscape, the pond is left disused and it could raise other issues such as loss of important ecological and socio-economic functions of mangrove ecosystems, changes in hydrology, salinization, introduction of non-native species and diseases, pollution from effluents, chemicals and medicines, use of wild fish for feed, capture of wild shrimp seed and loss of livelihoods and social conflicts (Ashton, 2003). Therefore, by applying the results of this finding, the authorities can strategize action plan which to be taken to address the issues. For example, either to sustain shrimp pond operation or the abandoned area can be used for another productive use such as salt ponds, rice paddy fields or fruit trees which is cost effective and give maximum benefits for society.

4. CONCLUSION

The utilization of remote sensing images in assessing vegetation losses in shrimp farming area at Pulau Terendak was analyzed using supervised classification technique. The maximum Likelihood algorithm used showed that four classes of land use and land cover could be map with medium accuracy. For 25 years, changes of vegetation distribution is the main concern. Vegetation such as mangrove and associates species as well as shrubs had decreased by 23.3% from total area of 45 hectare. The decreasing amount of vegetation was due to the conversion of the mangrove area to the shrimp ponds. The standing trees were cut off and the construction of the shrimp farm started to take place which also caused the bare soil or open area as well as water body area increased to 8.5 % and 2% respectively. This is an alarming situation if open area increases while vegetation in this area continue to lose by years. Action need to be taken to prevent the deterioration of mangrove ecosystem and habitat diversity in future.

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