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RESEARCH ARTICLE

MAPPING MANGROVE DEGRADATION IN PAHANG RIVER ESTUARY, PEKAN PAHANG BY USING REMOTE SENSING

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ABSTRACT

This study examined the mangrove degradation in Pahang River Estuary, Pekan sub-district, Pahang between 1990 and 2017 using supervised classification. Landsat 8 OLI and Landsat 5 TM images of Pahang River Estuary have been analyzed using supervised classification and field survey. Based on the accuracy assessment, the confusion matrix for supervised classifications ranged from 77% to 81%. Kappa coefficient (K) for supervised classification ranged between the value of 0.67 and 0.72. The total mangrove covers in 2017 was 1,535.40 ha, decreased by 43.7% or 670.80 ha from its total area of 2,206.20 ha in 1990. The expansion of development area was observed in the past 27 years. Several other causes of mangrove degradation were identified during field survey, including sand mining activities along riverbank, mangrove clearing for aquaculture and agriculture. The rapid development within the coastal area and estuary had suppressed the mangroves propagation over the years. Long term monitoring of mangrove distribution is crucial to ensure the sustainability of the mangrove ecosystem.

KEYWORDS

mangrove degradation, Pahang river estuary, unsupervised classification.

1. INTRODUCTION

Mangrove is defined as a group of shrubs and trees that have special adaptation to grow within high salinity, strong tides, high temperature, destructive wind and muddy soils of estuary areas, the intermediate between land and sea, at tropical and sub-tropical climates. Mangrove also can be found in saline condition of intertidal water, which include palms and ferns [1,2]. According to a researcher, there are 60 species of mangroves available in Malaysia with mangrove forest cover about 577, 500 ha [3]. Another researcher stated that the humid tropical region and the geomorphological structure of Malaysia contribute to the extensive coverage of mangrove forest in Malaysia [4]. Malaysia mangrove forests are lies under the jurisdiction of the various management levels at the federal, state and local. For example, Pahang is the largest state in Peninsular Malaysia with 9,000 ha mangrove forest cover. Yet, only one third of the mangrove forest have been gazette as Forest Reserve that lies under the jurisdiction of Department of Forestry [5].

Coastal development in Malaysia has increased to meet the high demand of coastal properties. Even though mangrove abundantly distributed in South and Southeast Asia, but this ecosystem also considered as the most disturbed, distinguish and cleared out due to the anthropogenic activities and climate change [6]. The mangrove areas were cleared to give space for these developments such as human settlements, aquaculture farms, commercial and private properties. As mentioned by a previous researcher, mangrove forest is valuable economically and the degradation of mangrove forest mainly caused by the development in coastal area [7]. The land by the river is reported has low value and affordable thus attract the developer to develop within the area and lead to severe destruction to mangrove forest [8].

The similar phenomenon occurred in the Pahang state. Pahang is located within the coastal range and these development and urbanization undergoing within the coastal area lead to major stress toward the coastal habitat particularly mangrove ecosystem. Thus, monitoring the mangrove expansion or degradation considered importance in preserving and managing this ecosystem. In recent years, remote sensing found to be one of the most reliable methods to map the distribution of mangrove. The multispectral imagery data is the current remote sensing technology that help users to map coastal development with supporting data library from Geographical Information System (GIS) which make the mapping process easier and improved [9]. The application of remotely sensed images for monitoring land cover considered as highly accurate since the remote sensing tools are advancing according to time as the urban areas are growing rapidly. Thus, the mangrove covers in year 2017 and 1990 was examined using remote sensing techniques based on supervised classification and field survey data. Mapping the mangrove distribution in Pahang River estuary is necessary in order to record the existing mangrove area while at the same time to monitor how the mangrove areas can be sustained in the future against potential threats of depletion due to uncontrolled development.

2. MATERIALS AND METHODS

2.1 Study site

Pahang river estuary is located in the east of Pahang state, in Pekan sub-district. The climate is equatorial, with uniform air temperature throughout the year, varying from 24ºC to 28ºC with 80% humidity [10]. This area prone to recurrence flood events, considered the huge size of Pahang River catchment area. Additional conditions include its low topography, monsoon season, river overflow, and tidal behavior, which are the natural causes of flood [11]. Economical activities and recent developments have also grown rapidly within the area. These assets are increasingly located on land exposed to hazards due to lack available space and rapid development, and thus, potential economic exposure has increased over time [12]. Furthermore, the impact of flooding become greater with mangrove degradation as mangrove acts as the natural barrier to reduce the water flow speed.

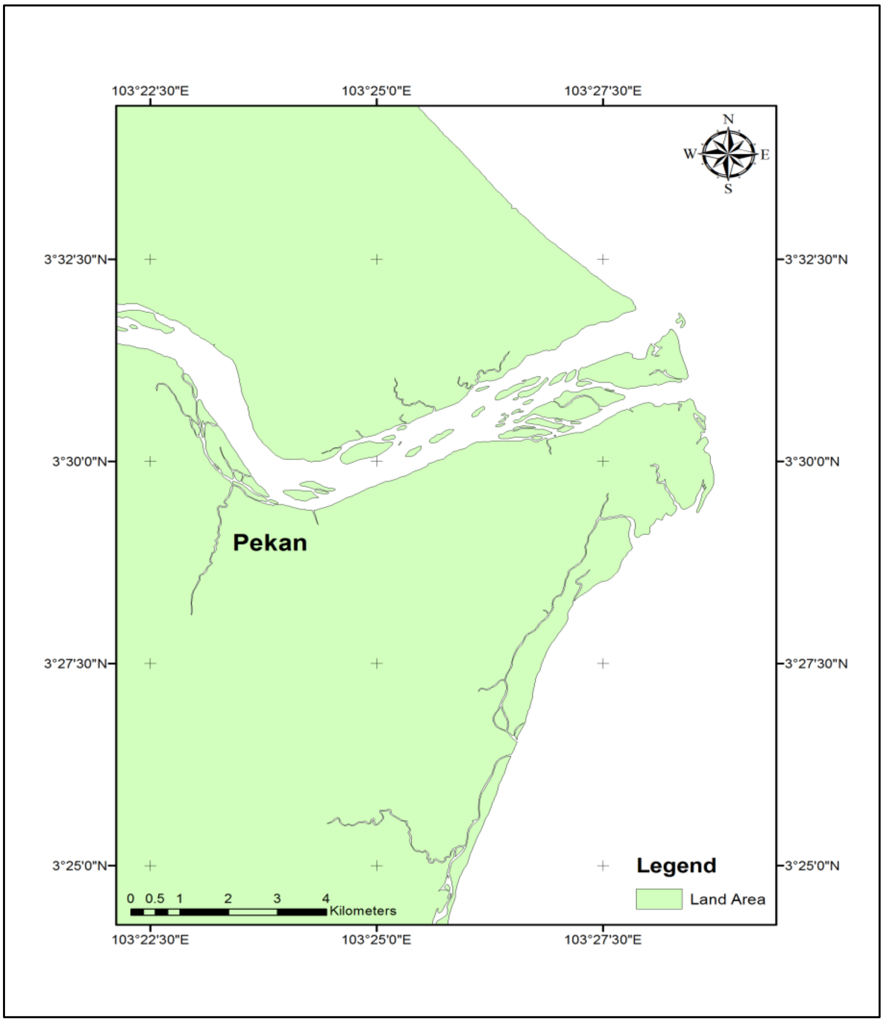

Figure 1: GIS Map of Pahang River Estuary

3. METHODOLOGY

3.1 Image processing and digitizing

Satellite images of Pahang River Estuary were obtained from USGS. Three satellite images were analyzed, which are: 9th July 1990 from Landsat 5 TM and mosaic images of 12th May 2017 from Landsat 8 OLI/TIRS (Path:126 Row:57; Path:126 Row:58). Operating land Imager (OLI) data performed better in vegetation and land cover classification due to higher quality data than TM within visible bands [13]. Landsat 8 OLI consists of 11 spectral bands including Thermal Infrared Sensor (TIRS) with narrower wavelength covered compared to Landsat 5 TM with 4 spectral bands but larger wavelength covered [14]. ENVI software was used to pre-process the satellite images. Standard atmospheric and geometric correction procedures have been applied to the images**.** The images processed with Normalize Difference Vegetation Index (NDVI) computation. NDVI will strengthen the difference between water bodies, land and urban from vegetation based on computation of similar pixels value into group with the same spectral signature.

Unsupervised classifications were conducted using Iterative Self-Organizing Data Analysis Technique (ISODATA) clustering. Supervised classification was conducted using Maximum Likelihood, based on identified Region of Interest (ROI) and Ground Control Point (GCP) from field sampling. Five (5) classes have been determined, which are: Vegetation, Mangroves, Land, Water, and Urban. Accuracy assessment based on Kappa coefficient (K) and confusion matrix percentage was performed on the classifications. The Kappa coefficient were used on both unsupervised and supervised classification to compare the error made between classifications generated by the producer and by the users. The Kappa coefficient expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification. Confusion matrix demonstrate a list of class values for the pixels in the classified image file and the class values for the corresponding reference pixels, mainly field data. Mangrove covers from the supervised images were digitized to observe the changes over the past 27 years. The simplified flowchart was shown in Figure 2.

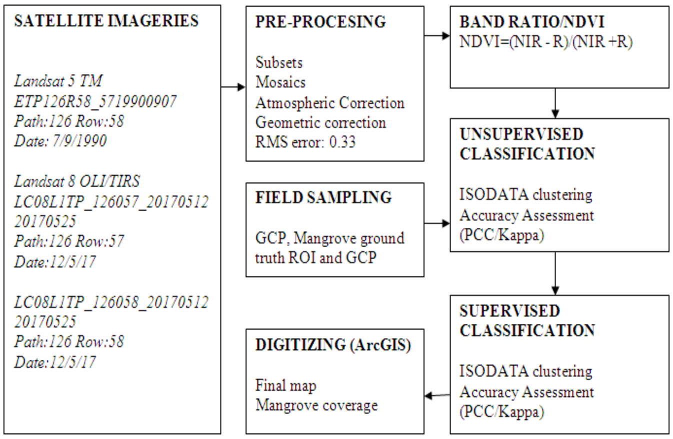

Figure 2: Flowchart of image processing and mapping.

3.2 Field survey

Several reference pixels have been identified on the unsupervised classified image Based on the pre-determined GCPs, ground truth stations coordinates have been identified at all five classified classes. Sixty-four (64) distributed random sampling stations were used as GCP for ROI identification and reference points. The locations of each station points and ground truth points have determined using Global Positioning System (GPS).

4.RESULTS AND DISCUSSIONS

4.1 Classification and Accuracy Assessment

Based on the combination of unsupervised and supervised analysis, the Kappa coefficient and the percent correctly classified pixels (PCC) in the forms of percentage was obtain for each of the maps were generated. The values of the Kappa coefficient and the PCC in the form of confusion matrix were listed in the Table 1. The accuracy assessments were reliable and the Kappa coefficient (K) for supervised classification for image in 1990, and 2017 are good. The confusion matrix for supervised classifications ranged from 77 percent to 81 percent. Kappa coefficient for supervised classification ranged between the value of 0.67 and 0.72. High resolution of Landsat OLI, selection of quality image with less than 10 percent cloud cover and numerous field survey data are the main factor for the reliable classification.

Table 1: The accuracy assessment based on the unsupervised and supervised classification.

	Unsupervised Classification		**Supervised Classification**	
IMAGES	**Confusion matrix**	**Kappa(K) coefficient**	**Confusion matrix**	**Kappa (K) coefficient**
1990 Landsat TM	*59.35%*	*0.4228*	*77.78 %*	*0.6667*
2017 Landsat 8 OLI (Mosaics 126/57 and 126/58)	*76.25%*	*0.6992*	*81.32 %*	*0.7155*

4.2 Mangrove cover

Mangrove cover in Pahang river estuary exposed to various types of anthropogenic activities such as sand mining along riverbank, residential/commercial developments, channel construction connecting Kuala Pahang jetty and Tanjung Agas jetty, agriculture, and aquaculture activities (Figure 3). The total mangrove cover in 2017 was 1,535.40 ha, decreased by 43.7% or 670.80 ha from its total area of 2,206.20 ha in 1990. Figure 4 shows the boundaries of mangroves have been shrinking between years 1990 and 2017. Based on a research, the total mangrove cover of Pahang state was 11,467.03 ha in the year 1990 and degraded by 123.06 ha per year due to various factors. Mangrove in Pahang River estuary represents 19.24% of the total mangrove in Pahang state in the year 1990 [15]. Latest study by a recent scholar using remote sensing analysis only show the current status cover of mangrove in Pahang state in the year 2014 which is 8,513.61 ha [16]. Thus, the exact mangrove coverage of Pahang river estuary over total Pahang state coverage is incomparable (Table 2).

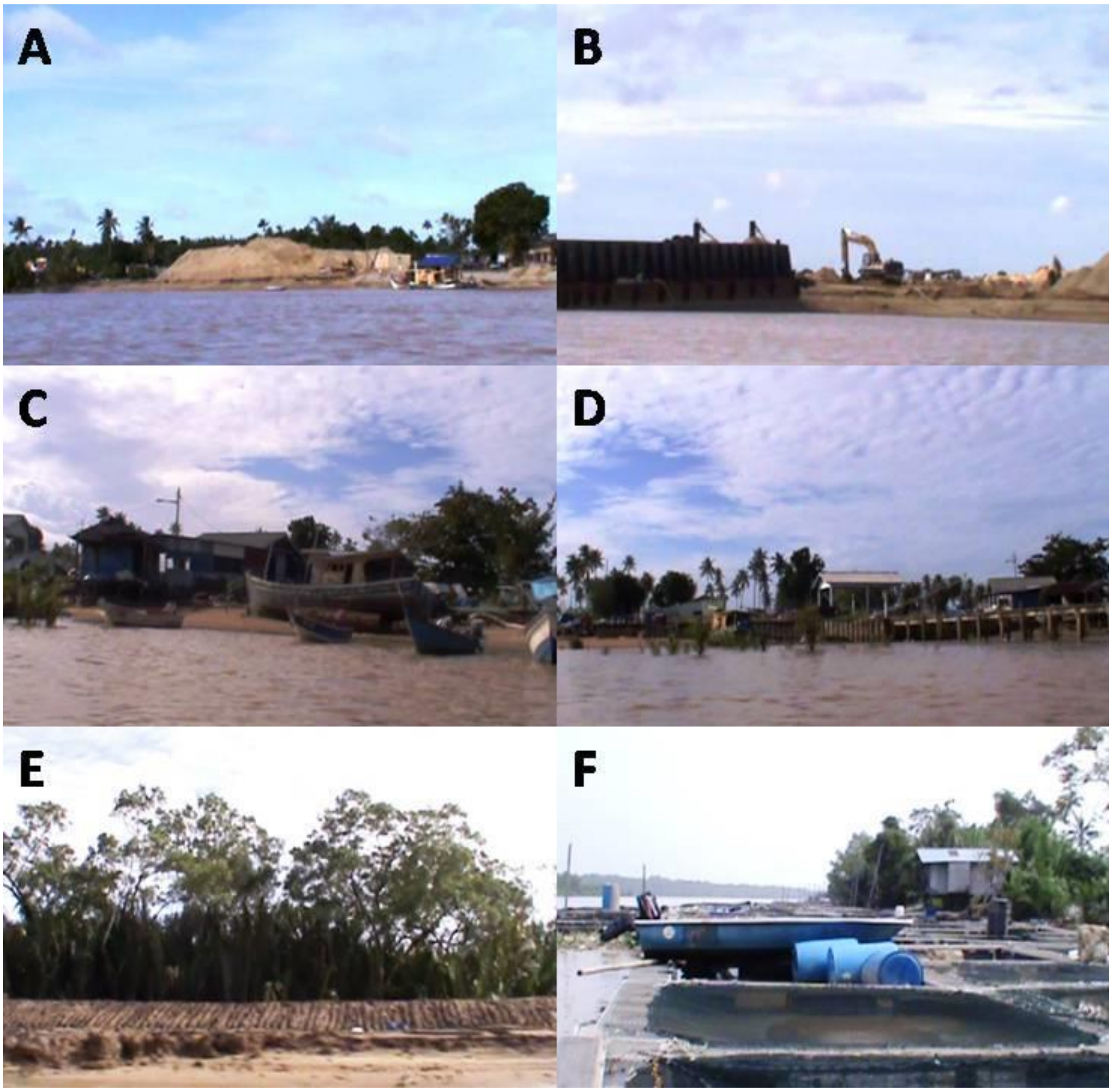

Figure 3: Anthropogenic activities in mangrove area: (A) Sand mining activities; (B) Sand mining activities; (C) Local community built houses and docking the boats in mangrove area; (D) Jetty Tanjung Agas with Nypa frutican seedling grow in front of the jetty; (E) Mangrove area have been cleared allowing channel construction connecting Kuala Pahang jetty and Tanjung Agas jetty; (F) Cage culture activities near mangrove area.

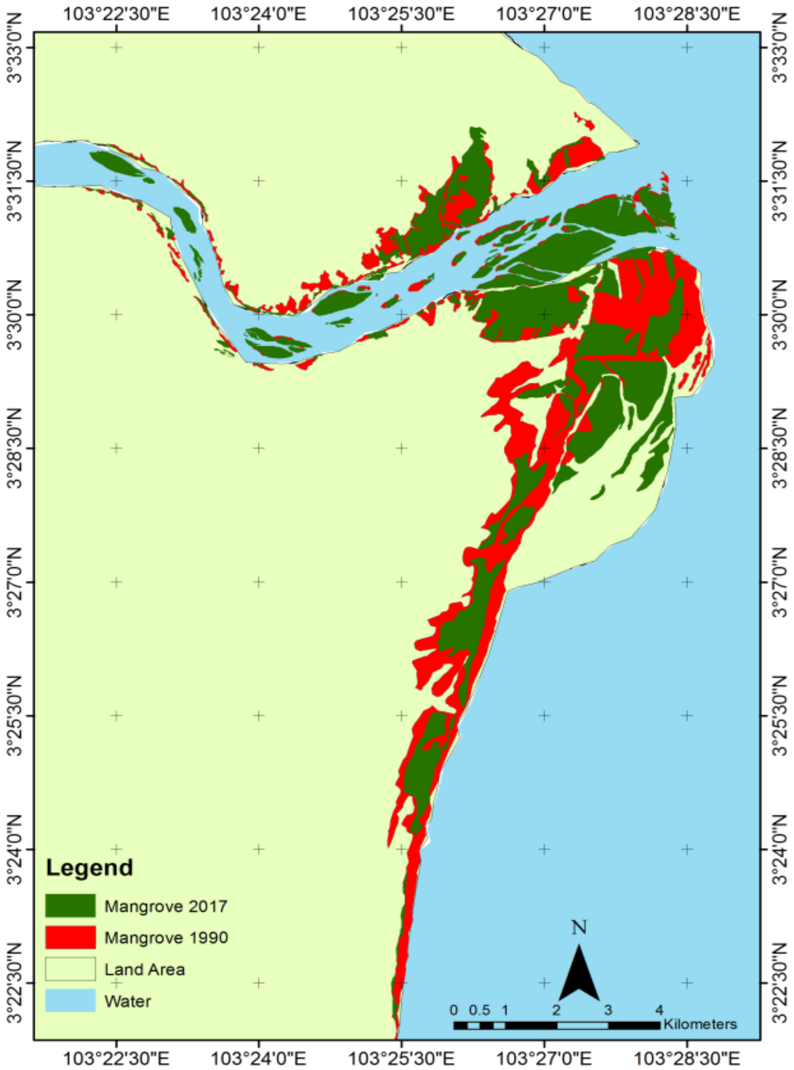

Figure 4: Map of mangrove cover changes from year 1990 to year 2017

Table 2: Summary of mangrove cover (Hamdan et al, 2012, Hamdan et al, 2016).

Year	Pahang State Total Area (ha)	Pahang River Estuary Total Area (ha)*	Percentage*
1990	*11,467.03*	*2,206.20**	*19.24%**
1995	*11,129.23*	-	-
2000	*10,791.42*	-	-
2005	*9,915.34*	-	-
2010	*9,039.26*	-	-
2014	*8,513.61*	-	-
*2017**	-	*1,535.40**	-

**results from this study.*

5. CONCLUSION

Development and aquaculture activities had reduced the mangrove cover in Pahang River Estuary. As the cover reduced by almost half its size in 27 years, better solutions is needed to manage the degradation problem. Public education and awareness campaign on the importance of conserving mangrove habitat and ecosystem is important, especially toward local community, developers, industry players, and government agencies. These efforts will help to conserve mangrove habitat and encourage development in a sustainable manner. It is recommended that continuous mangrove monitoring study being carried out in this area, as the degradation rate is alarming.

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