

Land Cover Dynamics of Sungai Pulai Mangrove Forest Using Remote Sensing and GIS-Preliminary Results

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Abstract: Nowadays, mangroves, the most diversified ecosystem facing anthropogenic threats from various development activities. Remote Sensing (RS) data can provide spatio-temporal information on mangrove status for monitoring and management. This study was conducted to monitor the land cover dynamics of Sungai Pulai Mangrove Forests (SPMF) in Johor, Peninsular Malaysia between 2004 and 2014. Satellite data such as Landsat TM and Landsat OLI were processed by using Envi and ArcGIS Software. A total of five land cover types were classified using supervised Maximum Likelihood (MLC) algorithm. Accuracy for the classification was assessed by using confusion matrix table. For 2004, 2009 and 2014 year's imageries, the overall accuracies obtained were 76, 87 and 85% and Kappa coefficient were 0.71, 0.85 and 0.82, respectively. Results showed a continuous mangrove cover reduction from 2004-2009 and from 2009-2014. Approximately, 2,498 ha of mangrove cover was reduced and 3,905 ha 'other vegetation' cover increased between the 10 years period.

Key words: Mangroves, forest change, land cover dynamic, remote sensing, GIS

INTRODUCTION

Mangroves can be broadly defined as woody vegetation types occurring in marine and brackish environments (Giesen *et al.*, 2007). Presently mangroves occupy about 181,000 km² of tropical and subtropical coastline (Kamaruzaman *et al.*, 2013). Mangroves are a valuable ecological and economic resource, being important nursery grounds and breeding sites for birds, fish, crustaceans, shellfish, reptiles and mammals; a renewable source of wood; accumulation sites for sediment, contaminants, carbon and nutrients and offer protection against coastal erosion (Kamaruzaman *et al.*, 2013). Mangroves act as buffer zones between terrestrial and marine ecosystems, stabilizing coastlines and river banks and therefore play an important role in protection of coastlines from storms and tides. Thus mangrove forests provide a variety of environmental, economic and social benefits to the local, national and global communities.

Malaysian mangrove represents 3.7% of the global mangrove (Giri *et al.*, 2011). The forest supply valuable timber species and also a source of food, materials for medicine or other non-wood products such as charcoal production, aquaculture activities, eco-tourism and recreation opportunities. The Johor state in peninsular

Malaysia is one of the most developing states during the last few couple of decades. The population is also increasing from 1, 600, 946 in 1980 to 3, 233, 434 in 2010. The development is on-going and causes the land use/land cover has changed for urbanization, industrialization, aquaculture, agriculture, tourism, erosion, etc (Kanniah *et al.*, 2015) and consequently reduces the mangrove coverage as well as biodiversity. Effective monitoring is urgently needed to manage this natural legacy properly and to prevent from further loss (Kanniah *et al.*, 2015).

Satellite Remote Sensing (RS) is an effective tool for natural resources assessment from land to ocean. It provides a timely and complete coverage for vegetation mapping especially in mangroves where accessibility is difficult (Hasmadi *et al.*, 2011; Kasawani *et al.*, 2007; Mohd Hasmadi *et al.*, 2008). Remote sensing is able to provide data rapidly and cost effective in gaining data over traditional ground surveying (Kanniah *et al.*, 2015). It provides various guidelines and information for mangrove monitoring and management (Ramachandran *et al.*, 1998). Those information can greatly assist in regular monitoring of mangroves, selection of new sites for coastal afforestation that drive to increase the forest cover as well as proper management of the existing forest ecosystem. Remote

sensing technology have been applied to mangrove studies through visual interpretation (Gang and Agatsiva, 1992); vegetation index (Blasco *et al.*, 1986; Chaudhury *et al.*, 1990; Jensen *et al.*, 1991), classification (Aschbacher *et al.*, 1995; Dutrieux *et al.*, 1990), band ratioing (Kay *et al.*, 1991; Long and Skewes, 1994), analysing mangrove canopy density (Mohd Hasmadi *et al.*, 2008) etc. Thus, the objective of this study is to monitor the land cover dynamics of sungai pulai mangrove forests in Johor, Peninsular Malaysia between 2004 and 2014.

MATERIALS AND METHODS

Study area: The Sungai Pulai Mangrove Forest (SPMF) reserve located at the South-West Johor was selected for this study. The study area is situated at the estuary of the Pulai river which has separated the Pontian and the Johor Bahru districts. The SPMF reserve occupied about 9,126 ha of area (Mohd Hasmadi *et al.*, 2008). The geographical location of the study area is lies between is 01°23'N to 01°24'N and 103°29'E to 103°32'E (Fig. 1). This mangrove is very rich with diverse flora and fauna including 24 true mangrove species, 21 mangroves associated species, 7 amphibians, 12 reptile, 55 birds, 26 mammals and 111 fish species (Mohd Hasmadi *et al.*, 2008).

Data used: Landsat TM for 2004, 2009 and Landsat OLI for 2014 were used for the study (Table 1). The images were downloaded from the United States Geological Survey (USGS) Earth Explorer of path 125 and row 59. Before download, the images with less cloud cover of the study area were given preference. A state wise shape file of Peninsular Malaysia and various maps were collected from the local government agencies, Majlis Perbandaran Johor Bahru Tengah (MPJBT), Department of Agriculture Malaysia, Jabatan Ukur Dan Pemetaan Malaysia (JUPEM).

All imageries were rectified and geo-referenced to the Universal Transverse Mercator (UTM) map coordinate system. Layer stacking, band combination and low pass filtering was done during pre-processing. The composite image was opened using 7-4-2 bands in envi (Version 4.5). Then, the study area was subset from the image. Land cover/land use classification was performed separately for

the mentioned 3 years images to identify different land uses of the study area. At first, seven land cover types were identified by using the unsupervised ISODATA algorithm. After ground truthing, supervised classification (using Maximum Likelihood Classifier (MLC) was performed. MLC used because of it's operational simplicity, easily applicability and good performance (Du *et al.*, 2010).

Accuracy Assessment (AA) was carried by using Confusion Matrices (CM) table. The CM tables were produced for each year classification results to assess the accuracy of selected training areas (Grinand *et al.*, 2013). Confusion matrix is the most commonly performed method for accuracy assessment in remote sensing application (Foody, 2002).

For accuracy assessment, a number of 30 Regions of Interest (ROIs) were chosen for each class. For ROI selection, information used from field visit data conducted in February 2015, land use map for 2008 provided by the ministry of agriculture, land use map 2003 collected from the Johor Bahru city council and other collected maps. After selection of ROIs a CM algorithm was chosen for the AA and a contingency table was produced for each year (2004, 2009 and 2014) images.



Fig. 1: Map showing the location of study area in Johor state in the P. Malaysia

Table 1: Detail ID of landsat data used for the study

Sensor type	Image ID	Acquisition date	Path/row	Projection system
Landsat 5 TM	LT51250592004362BKT00	27 December 2004	125/59	UTM WGS 48 N
Landsat 5 TM	LT51250592009199BKT00	18 July 2009	125/59	UTM WGS 48 N
Landsat 8 OLI	LC81250592014341LGN00	7 December 2014	125/59	UTM WGS 48 N

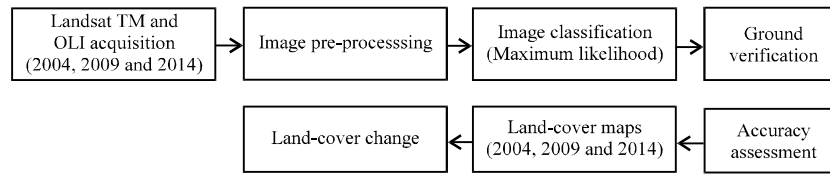


Fig. 2: Study flowchart

Table 2: Land covers classes with number of ROI for accuracy assessment

Land cover class	Associated class	No of ROI chosen		
		2004	2009	2014
Mangrove	Mangrove forest with different mangrove species	30/375	30/494	30/414
Water bodies	Rivers, lake, ponds, streams and canals	30/352	30/263	30/277
Cloud	-	30/352	30/349	30/331
Vegetation	Agricultural lands, grass land, evergreen forest land and all other vegetation except the mangroves	30/376	30/381	30/350
Build up area	All kinds of build-up area including residential, industrial, institutional, transportation etc.	30/415	30/473	30/456
Wetland	Vegetation in marshy land	30/227	30/197	30/156
Cloud shadow	-	30/239	30/266	30/202

Finally, those classes were merged to mangrove forest (different mangrove species), water body (river, streams, lakes, ponds and canals), vegetation (including all agricultural lands, grass lands, evergreen forest lands and all other vegetation except the mangrove), build-up area (all kinds of build-up area including residential, industrial, institutional, transportation etc.) and wetland (vegetation in marshy lands) and no data (cloud and cloud shadow covered area). Cloud has been reported as one of the major limitations for optical remote sensing. The list of different land cover classes with their associated features and number of chosen ROIs with pixel numbers for each class is shown in Table 2 and the study flowchart is shown in Fig. 2.

RESULTS AND DISCUSSION

The overall accuracies for 2004, 2009 and 2014 classified images were 75.60, 86.92 and 85.04%, respectively. Meanwhile, the Kappa coefficients were 0.71, 0.85 and 0.82 (Table 3).

Vegetation has been recorded as major land cover types for all the three years images followed by build-up area and mangrove area. Mangrove and wetland area shown a continuous reduction and inversely water-body, vegetation and build-up area were shown continuously increasing. Figure 3 shows the land cover classes for 2004, 2009 and 2014. The classes are buildup (red), mangrove (deep green), other vegetation (light green), waterbody (sky blue), wetland (yellow) and no data (black). Vegetation has been recorded as major land cover types for all the three years images followed by buildup area and mangrove area. Mangrove and wetland area shown a continuous reduction and inversely waterbody, vegetation and buildup area were shown continuously

Table 3: Overall accuracy and Kappa coefficient for 2004, 2009 and 2014

Years	Overall accuracy (%)	Kappa coefficient
2004	75.60	0.71
2009	86.92	0.85
2014	85.04	0.82

increasing. The main causes to the reduction of mangrove area are a land conversion to new build up area and agriculture plantation such as oil palm. About 7,246 ha mangrove area was recorded in 2004 which covers about 22% of the total land area at that year (Table 4). But at 2009, mangrove coverage reduced to about 17% covering 5,462 ha and at 2014 the mangrove coverage reduced to 4748 ha representing 14%. Between the 10 years 2,498 ha mangrove area has been reduced. Results showed that water body increased 1,737 ha from 2004-2014. Vegetation cover was recorded about 30% or 9,783 ha in 2004, 52% (16,981 ha) in 2009 and about 42% (13,688 ha) in 2014. In fact about 3,905 ha area for vegetation has been increased from 2004-2014. While build-up areas were increased about 591 ha and wetland area decreased about 1, 545 ha. Based on the results, an annual mangrove reduction is 249.8 ha (3.45%) which is higher than the world annual mangrove reduction. As (FAO, 2007) reported that every year the world mangrove area has been disappearing at the rate of 1%. Conversion of other land uses is reported as a major threat to mangroves (Spalding *et al.*, 2010) and in Asia <1.9 million ha has been converted to other land use such as aquaculture, agriculture, urban and industrial spaces (Hamdan *et al.*, 2012; UNFCCC, 2007). According to Kamaruzaman *et al.* (2013) and Valiela *et al.* (2001), globally about 50% of mangrove loss is due to aquaculture mainly for shrimp farming. In the study area shrimp culture in the sheltered coastline is expanding. The 1000 ha of mangrove area has been cleared to create artificial shrimp ponds (Hamdan *et al.*, 2012). As it

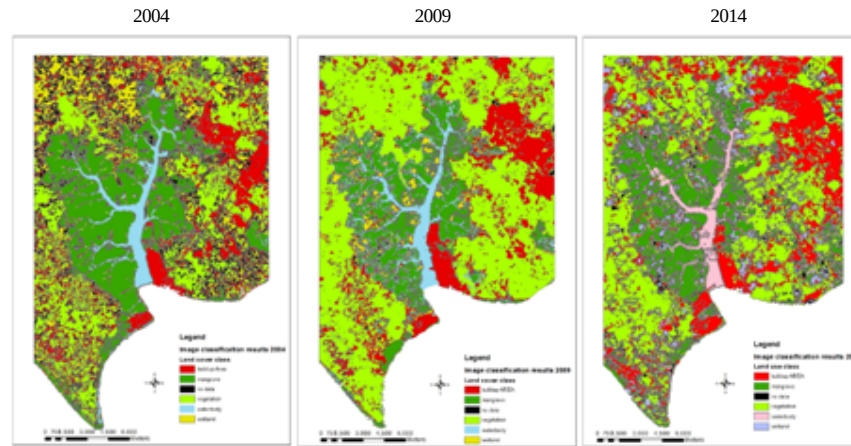


Fig. 3: Classification of land cover type for 2004, 2009 and 2014

Table 4: Land cover class, area extent and magnitude of change of the study area between 2004 and 2014

Land cover class	2004		2009		2014		Area change between 2004-2014
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	
Mangrove	7246	22	5462	17	4748	14	-2498
Water body	1329	4	2061	6	3066	9	1737
No data	4233	13	737	2	1946	6	-2287
Vegetation	9783	30	16981	52	13688	42	3905
Build-up area	7390	22	6096	18	7981	24	591
Wetland	3081	9	1539	5	1536	5	-1545

represents the water body, so it is also one of the reason for land cover class “water body” increase from 2004 to 2014. Mangrove area is also reducing for agricultural purpose (mainly oil palm plantation). In the study area, oil palm is a major plantation crop and is also a reason for vegetation cover increase. Increasing human population density is another major cause for mangrove reduction. As the population living near the coastal area increase, they clear the edge of the mangroves to create new settlements or to expand the existing one. As a most developing state in Peninsular Malaysia, population in Johor is increasing from 1, 600, 946 in 1980 to 3, 233, 434 in 2010. The livelihood of local people especially resides along the coastline depends on the mangroves ecosystem. However, the mangrove coverage is continuously decreasing in the study area.

CONCLUSION

Five land cover types, i.e., mangrove, water body, vegetation, build-up area and wetland have been identified for the study area. Mangrove forest area was reduced (2,498 ha) from 2004-2014. During this time vegetation cover was increased about 3,905 ha mainly due to oil palm plantation. About 1,737 ha of water body has been increased mainly for aquaculture development and about 591 ha of build-up area increased during the mentioned 10 years period. The loss of mangroves may

affect the local community livelihood. The limitation of the study is mainly on the presence of clouds that affect the classification process for land cover types. Future work should investigate the impact of the mangrove deforestation or reduction on mangrove biodiversity and socioeconomic of the local community by using high resolution satellite data. The research contributes information on current land cover trend for ten years of the study area. This information will be helpful to the natural resource managers, land use planners or decision makers for better management of the mangrove ecosystem for Johor state.

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