Journal of Engineering and Applied Sciences 11 (3): 441-445, 2016
ISSN: 1816-949X


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

Noor Shaila Sarmin, Mohd Hasmadi Ismail, Pakhriazad Hassan Zaki,
Khairil Wahidin Awang and Iqbal Putut Ash Shidiq
Universiti Putra Malaysia, Serdang, Malaysia

**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 km$^2$ 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

**Corresponding Author:** Mohd Hasmadi Ismail, Universiti Putra Malaysia, Serdang, Malaysia

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.

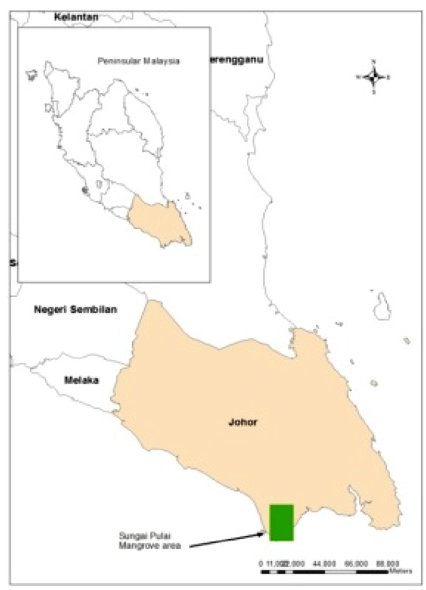


Fig. 1: Map showing the location of study area in Johor state in the P. Malaysia

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 |

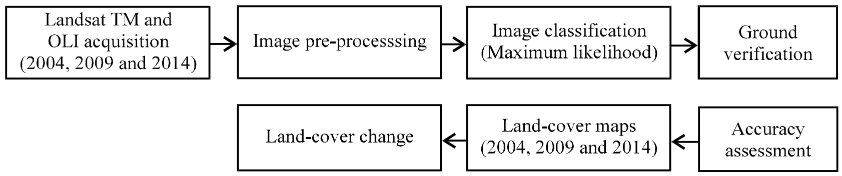


Fig. 2: Study flowchart

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

| | | No of ROI chosen | | |
|---|---|---|---|---|
| Land cover class | Associated class | 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).

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 |

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 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

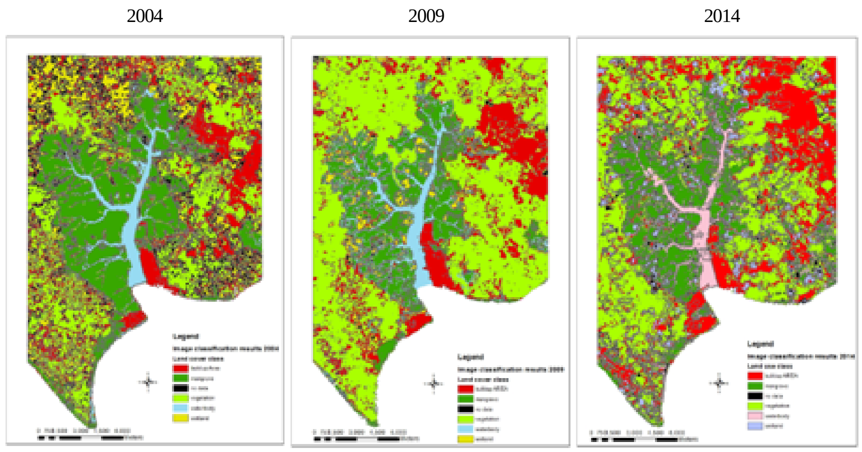


Fig. 3: Classification of land cover type for 2004, 2009 and 2014

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

| | 2004 | | 2009 | | 2014 | | Area change between |
|---|---|---|---|---|---|---|---|
| Land cover class | Area (ha) | Area (%) | Area (ha) | Area (%) | Area (ha) | Area (%) | 2004-2014 |
| 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.

## ACKNOWLEDGEMENTS

The reachers would like to thanks the funding body of this research, Organisation for Women in Science for the Developing World (OWSD) through its Postgraduate Training Fellowship programme.

## REFERENCES

Aschbacher, J., R. Ofren, J.P. Delsol, T.B. Suselo, S. Vibulsresth and T. Charrupat, 1995. An integrated comparative approach to mangrove vegetation mapping using advanced remote sensing and GIS technologies: Preliminary results. Hydrologia, 295: 285-294.

Blasco, F., F. Lavenu and J. Baraza, 1986. Remote sensing data applied to mangroves of Kenya coast. Proceedings of the 20th International Symposium on Remote Sensing of the Environment, December 4-10, 1986, Nairobi, Kenya, pp: 1465-1480.

Chaudhury, M.U., 1990. Digital analysis of remote sensing data for monitoring the ecological status of the mangrove forests of Sunderbans in Bangladesh. Proceedings of the 23rd International Symposium on Remote Sensing of the Environment April 18-25, 1990, Bangkok, Thailand, pp: 493-497.

Du, P., X. Li, W. Cao, Y. Luo and H. Zhang, 2010. Monitoring urban land cover and vegetation change by multi-temporal remote sensing information. Min. Sci. Technol., 20: 922-932.

Dutrieux, E., J. Denis and J. Populus, 1990. Application of spot data to a base-line ecological study of the mahakam delta mangroves (East Kalimantan, Indonesia). Oceanologica Acta, 13: 317-326.

FAO., 2007. The world's mangroves 1980-2005. FAO Forestry Paper No. 153, Forest Resources Division, Food and Agriculture Organisation, Rome, pp: 77.

Foody, G.M., 2002. Status of land cover classification accuracy assessment. Remote Sens. Environ., 80: 185-201.

Gang, P.O. and J.L. Agatsiva, 1992. The current status of mangroves along the Kenyan coast: A case study of Mida Creek mangroves based on remote sensing. Hydrobiologia, 247: 29-36.

Giesen, W., S. Wulffraat, M. Zieren and L. Scholten, 2007. Mangrove guidebook for Southeast Asia. Food and Agricultural Organisation and Wetlands International, Bangkok, Thailand, pp: 769.

Giri, C., E. Ochieng, L.L. Tieszen, Z. Zhu and A. Singh *et al*., 2011. Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecol. Biogeogr., 20: 154-159.

Grinand, C., F. Rakotomalala, V. Gond, R. Vaudry, M. Bernoux and G. Vieilledent, 2013. Estimating deforestation in tropical humid and dry forests in Madagascar from 2000 to 2010 using multi-date Landsat satellite images and the random forests classifier. Remote Sens. Environ., 139: 68-80.

Hamdan, O., F.M. Azahari, A.A. Hani and M.K. Azwan, 2012. Distribution and Extents of Mangroves. In: Status of Mangroves in Peninsular Malaysia, Hamdan, O., H.K. Aziz, I. Shamsudin and R.S.R. Barizan (Eds.). Forest Research Institute Malaysia, Kuala Lampur, Malaysia, pp: 59-88.

Hasmadi, I.M., H.Z. Pakhriazad and K. Norlida, 2011. Remote sensing for mapping RAMSAR heritage site at Sungai Pulai mangrove forest reserve, Johor, Malaysia. Sains Malaysiana, 40: 83-88.

Jensen, J.R., H. Lin, X. Yang, E. Ramsey III, B.A. Davis and C.W. Thoemke, 1991. The measurement of mangrove characteristics in southwest Florida using SPOT multispectral data. Geocarto Int., 6: 13-21.

Kanniah, K.D., A. Sheikhi, A.P. Cracknell, H.C. Goh, K.P. Tan, C.S. Ho and F.N. Rasli, 2015. Satellite images for monitoring mangrove cover changes in a fast growing economic region in southern Peninsular Malaysia. Remote Sens., 7: 14360-14385.

Kasawani, I., J. Kamaruzaman and M.I.A.N. Nadhirah, 2007. Study of forest structure, diversity index and above-ground biomass at Tok Bali mangrove forest, Kelantan, Malaysia. Proceedings of the 5th WSEAS International Conference on Environment, Ecosystem and Development, December 14-16, 2007, Spain, pp: 9-9.

Kay, R.J., P.T. Hick and H.J. Houghton, 1991. Remote Sensing of Kimberley Rainforest. In: Kimberley Rainforests, McKenzie, N.I., R.B. Johnston and P.G. Kendrick (Eds.). Survey Beatty and Sons, Chipping Norton, pp: 41-51.

Long, B.G. and T.D. Skewes, 1994. GIS and remote sensing improves mangrove mapping. Proceedings of the 7th Australasian Remote Sensing Conference, March 1-4, 1994, Melbourne, pp: 545-550.

Mohd Hasmadi, I., H.Z. Pakhriazad and J. Kamaruzaman, 2008. Mangrove canopy density of Sungai Merbok forest reserve, Kedah from Landsat TM. J. Malaysian For., 71: 67-74.

Ramachandran, S., S. Sundramoorthy, R. Krishnamoorthy, J. Devasenapathy and M. Thanikachalam, 1998. Application of remote sensing and GIS to coastal Wetland ecology of Tamilnadu and andaman and nicobar group of islands with special reference to mangroves. Curr. Sci., 75: 101-109.

Spalding, M., M. Kainuma and L. Collins, 2010. World atlas of mangroves. Nagoya, pp: 319. https://www.cbd.int/cooperation/pavilion/nagoya-presentations/2010-10-21-session1-mangroves-en.pdf.

UNFCCC, 2007. Investment and financial flows to address climate change. Climate Change Secretariat, Bonn, Germany. http://unfccc.int/resource/docs/publications/financial_flows.pdf.

Valiela, I., L. J.L. Bowen and J.K. York, 2001. Mangrove forests: One of the world's threatened major tropical environments. BioScience, 51: 807-815.