UNIVERSITI PUTRA MALAYSIA

IMPACT OF LAND USE CHANGES IN SUNGAI PULAI MANGROVE ON SOCIOECONOMY OF THE LOCAL COMMUNITY

NOOR SHAILA SARMIN

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By

NOOR SHAILA SARMIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2017

DEDICATION

This thesis is dedicated to

my late father

Alim Uddin Chowdhury

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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August 2017

Chairman : Associate Professor Mohd Hasmadi Ismail, PhD
Faculty : Forestry

The importance of mangrove ecosystem to the community and environment cannot be underestimated. Local community largely depends on this natural endowment for their subsistence and commercial activities. The mangroves in Sungai Pulai and its surrounding areas in Johor, Peninsular Malaysia were reduced due to anthropogenic pressures mainly for land use/covers (LUCs) changes for developments which affected the local mangrove-dependent communities (mainly fishermen) livelihood. The objective of the present study was to assess the spatiotemporal changes of LUCs in and around Sungai Pulai mangroves during 2004 to 2014 with possible anthropogenic causes of mangrove change and socioeconomic impacts to local community's livelihood. The study integrated the application of remote sensing (RS) and geographic information system (GIS) with household survey data. Satellite RS data and GIS were used to assess LUCs changes during the study period. A cross-sectional household survey was conducted using a structured questionnaire with 360 respondents in order to identify local community's present socioeconomic status and their perception on mangrove change issue, causes and impacts of mangrove change to their socioeconomics. For the change detection analysis, three multi-temporal Landsat imageries (Landsat 5 TM for 2004 and 2009, and Landsat 8 OLI-TIRS for 2014) were used. Supervised classification technique with maximum likelihood classifier (MLC) was employed to categorize the LUCs into five classes such as mangrove, other vegetation, oil palm, built up and water body. The accuracies of the mapping of the satellite imageries were 96.09% (2004), 96.83% (2009), and 98.52% (2014). Annual change rates for each LUCs type were also calculated. The finding showed that LUCs of the study area changed and built-up area was increased resulting reduction of mangroves or other LUCs. Annual build up area increasing rate was 905.39 ha/year (7.44%) and reduction rate of mangrove area was 114.17 ha/year (-1.14%), oil palm area was 370.90 ha/yr (-1.56%), other vegetation area was 409.02 ha/yr (-7.75%) and water body area was 11.53 ha/yr. At *mukim* level study, except Sungai Karang, all the *mukim*s faced mangrove loss. In Malaysian perspective, though oil palm area has been increasing in recent days the change detection study found that oil palm coverage has been decreasing at the study area. Annually 155.06 ha, 27.69 ha, 468.56 ha, 117.68 ha, 112.99 ha and 23.33 ha of build up area increased in *mukim* Tanjung Kupang, Jelutong,

Pulai, Jeram Batu, Serkat and Sungai Karang, respectively. Therefore, annually 20.81 ha, 1.58 ha, 34.12 ha, 18.52 ha and 46.65 ha of mangrove area were reduced in *mukim* Tanjung Kupang, Jelutong, Pulai, Jeram Batu and Serkat, respectively.

Respondent's perceived urban development as the major cause of mangrove change followed by overharvesting/clear logging, coastal erosion, policy & management, accessibility to market & national highways, population pressure, migrant population pressure, farm size expansion, poverty rate, higher income from non-mangrove source, water & oil pollution, education level, agriculture expansion and aquaculture expansion. From the correlation analysis, urban development, population growth, migrant population growth, policy & management, coastal erosion, water & oil pollution, overharvesting and aquaculture were significantly related to mangrove change. However, the perceptions differed by *mukims* as the LUCs, pressures and drivers were different. Different ongoing mega development projects opened job opportunities at different employment levels which resulted an increase of population and migrants in the study area. *Mukim* Pulai and Tanjung Kupang faced huge infrastructural developments which directly affected mangrove coverage. *Mukim* Serkat also faced a drastic mangrove loss which resulted from the combined effect of the mixed development, shoreline erosion and oil pollution from the ship harboring at the port.

As negative impacts the respondents' perceived species and habitat loss as the highest priority followed by increase of coastal erosion, mangrove production reduced, mangrove income reduced, biodiversity threatened, increased migrants and increased risk of livelihood. However, as positive impacts respondents perceived new infrastructures developed for useful purpose replacing mangroves as number one followed by improved communication system and increased the overall quality of living standards. The study concluded that the area under investigation was facing a rapid development during the study period and conversion of mangroves and other LUCs to built-up areas impacted the local communities' livelihood both positively and negatively.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

IMPAK PERUBAHAN GUNA TANAH DI HUTAN PAYA BAKAU SUNGAI PULAI TERHADAP SOSIOEKONOMI MASYARAKAT SETEMPAT

Oleh

NOOR SHAILA SARMIN

Ogos 2017

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Kepentingan ekosistem hutan paya bakau terhadap masyarakat dan alam sekitar tidak boleh di pandang remeh. Sebahagian besar masyarakat tempatan bergantung kepada alam semulajadi bagi menyara kehidupan dan aktiviti komersial. Hutan paya bakau di Sungai Pulai dan kawasan sekitarnya di Johor, Semenanjung Malaysia telah berkurangan disebabkan oleh tekanan antropogenik terutamanya perubahan guna tanah/liputan untuk pembangunan yang memberi kesan kepada sumber pencarian masyarakat tempatan terutama nelayan. Objektif kajian ini dilakukan adalah untuk menilai perubahan guna tanah mengikut ruang-tempoh di dalam dan sekitar hutan paya bakau Sungai Pulai dari 2004 hingga 2014 yang berlaku disebabkan oleh kesan antropogenik kepada perubahan hutan paya bakau dan impak sosioekonomi terhadap kehidupan masyarakat tempatan. Kajian ini diintegrasikan dengan aplikasi penderiaan jauh dan sistem maklumat geografi (SMG) g melalui data isi rumah. Satelit penderiaan jauh dan SMG telah digunakan untuk melihat perubahan guna tanah sepanjang tempoh kajian dijalankan. Survei rentas bagi data isi rumah telah dijalankan di kawasan kajian dengan menggunakan soal selidik berstruktur kepada 360 responden bagi mengetahui status sosioekonomi masyarakat tempatan dan persepsi terhadap isu, sebab dan impak perubahan hutan paya bakau ke atas sosioekonomi mereka. Analisis pengesanan perubahan diperoleh melalui imej Satelit Landsat bagi tiga siri tempoh yang berbeza (Landsat 5 TM bagi tahun 2004 dan 2009; dan Landsat 8 OLI-TIRS bagi tahun 2014). Teknik pengkelasan berselia secara pengkelasan ke tahap maksimum (MLC) telah digunakan dalam mengkategorikan litupan guna tanah kepada lima kelas iaitu hutan paya bakau, vegetasi lain, kelapa sawit, tepu bina dan badan air. Ketepatan pemetaan pada imej satelit adalah 96.09%(2004), 96.83%(2009) dan 98.52%(2014). Kadar perubahan tahunan bagi setiap jenis LUC juga diambil kira. Penemuan ini menunjukkan bahawa litupan guna tanah di kawasan kajian telah berubah terutama kawasan tepu bina telah meningkat dan memberi kesan kepada pengurangan keluasan hutan paya bakau dan litupan yang lain. Kadar tahunan di kawasan tepu bina meningkat kepada 905.39 ha/tahun (7.44%) manakala hutan paya bakau mengalami penurunan kepada 114.17 ha/tahun (-1.14%), kawasan kelapa sawit sebanyak 370.90

ha/tahun (-1.56%), kawasan vegetasi lain 409.02 ha/tahun (-7.75%) dan kawasan badan air 11.53 ha/tahun. Kajian di peringkat *Mukim*, semua mukim kecuali Sungai Karang mengalami kehilangan hutan paya bakau. Dari perspektif Malaysia, kawasan kelapa sawit meningkat saban hari dan kajian menunjukkan perubahan terhadap litupan kelapa sawit berkurangan di kawasan kajian. Setiap tahun, keluasan tepu bina mengalami peningkatan iaitu sebanyak 155.06 ha, 27.69 ha, 468.56 ha, 117.68 ha, 112.99 ha dan 23.3 ha di mukim Tanjung Kupang, mukim Jelutong, mukim Pulai, mukim Jeram Batu, mukim Serkat dan mukim Sungai Karang. Namun begitu, kawasan hutan paya bakau berkurangan setiap tahun sebanyak 20.81 ha, 1.58 ha, 18.52 ha dan 46.65 ha iaitu di mukim Tanjung Kupang, mukim Jelutong, mukim Pulai, mukim Jeram Batu dan mukim Serkat.

Responden berpendapat bahawa pembangunan bandar merupakan punca utama kepada perubahan hutan paya bakau diikuti oleh pembalakan berlebihan, hakisan pantai, polisi dan pengurusan, ketersampaian kepada pasaraya dan lebuhraya utama, pertambahan penduduk, pertambahan penduduk asing, pencemaran dan sebagainya. Berdasarkan persepsi kajian, pembangunan bandar, pertumbuhan penduduk, pertumbuhan penduduk asing, polisi dan pengurusan, hakisan pantai, pencemaran air dan minyak, pembalakan dan akuakultur merupakan hubungan yang signifikan terhadap perubahan hutan paya bakau. Namun, persepsi yang berbeza bagi beberapa mukim terhadap litupan guna tanah yang menjadikan tekanan dan panduan adalah berbeza. Perbezaan ke atas projek pembangunan mega yang berterusan membuka peluang pekerjaan di pelbagai peringkat dan menjadikan kepada pertambahan penduduk dan migrasi di kawasan kajian. Mukim Pulai dan Tanjung Kupang menghadapi pembangunan infrastruktur yang pesat dan secara langsung memberi kesan kepada litupan hutan paya bakau. Mukim Serkat juga mengalami kehilangan hutan paya bakau yang ketara akibat daripada pembangunan, hakisan pantai dan pencemaran minyak dari kapal dagang di pelabuhan tersebut.

Responden berpendapat bahawa kehilangan spesis dan habitat merupakan impak negatif yang tinggi diikuti oleh peningkatan hakisan pantai, pengurangan pengeluaran dan pendapatan hutan paya bakau, ancaman biodiversiti dan peningkatan warga asing. Namun begitu, responden berpendapat bahawa impak positif adalah infrastruktur yang baru dapat dibangunkan bagi kegunaan menggantikan hutan paya bakau sebagai yang pertama diikuti oleh sistem komunikasi yang lebih baik dan peningkatan kualiti taraf hidup. Kesimpulan kajian ini mendapati kawasan kajian menghadapi pembangunan yang pesat dan perubahan hutan paya bakau serta litupan guna tanah yang lain ke atas kawasan tepu bina yang memberi impak terhadap kehidupan masyarakat tempatan secara positif dan negatif.

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I certify that a Thesis Examination Committee has met on 22 August 2017 to conduct the final examination of Noor Shaila Sarmin on her thesis entitled "Impact of Land Use Changes in Sungai Pulai Mangrove on Socioeconomy of the Local Community" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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AA	Accuracy assessment
AIM	Amanah Ikhtiar Malaysia or incentives for old group of people
AirSAR	Airborne SAR (Synthetic Aperture Radar)
CA	Cronbach's Alpha
CLUEs	Conversion of Land Use and its Effects at Small regional extent
CM	Confusion matrix
DF-C	Driving forces-Change
DID	Department of Irrigation and Drainage
DIP	Digital image processing
DOA	Department of Agriculture
DOSM	Department of Statistics Malaysia
DPSIR	Driver-Pressure-State-Impact-Response
DV	Dependent variable
EEA	European Environment Agency
ENVI	The Environment for Visualizing Images
EPUM	Economic Planning Unit Malaysia
ERTS	Earth Resource Technology Satellite
ETM+	Enhanced Thematic Mapper Plus
FAO	Food and Agricultural Organization
FCC	False colour composite
FDPM	Forestry Department of Peninsular Malaysia
FR	Forest Reserve
GIS	Geographic Information Systems
GPS	Global Positioning System
GT	Ground truthing
IM	Iskandar Malaysia
IMP	Integrated Management Plan
IR	Infra red
IRS	Indian Remote Sensing
IV	Independent Variable
JAKOA	*Jabatan Kemajuan Orang Asli*/ Department of Indigenous people development

JB	Johor Bahru
JKM	*Jabatan Kebajikan Masyarakat* (State welfare Department)
JNPC	Johor National Parks Corporation
JSFD	Johor State Forestry Department
JUPEM	*Jabatan Ukar dan Pemetaan Malaysia* (Department of Survey and Mapping Malaysia)
Kg.	*Kampung* or Village
Landsat TM	Landsat Thematic Mapper
LDCM	Landsat Data Continuity Mission
LUC	Land use/cover
Malakoff	The Malakoff Corporation Berhad
MIR	Medium Infrared
MLC	Maximum Likelihood Classifier
MOSTE	Ministry of Science, Technology and The Environment
MPJBT	*Majlis Perbandaran Johor Bahru Tengah* (Johor Bahru Tengah Municipal Council)
MSS	Multispectral Scanner
NASA	National Aeronautics and Space Administration
NCES	National Coastal Erosion Study
NEP	National Ecotourism Plan
NFA	National Forestry Act
NIR	Near Infrared
NRE	Ministry of Natural Resources and Environment
NTFPs	Non-timber forest products
OECD	Organization for Economic Cooperation and Development
OLI	Operational Land Imager
PCC	Post Classification Comparison
Pixel	Picture elements
PRF	Permanent Reserve Forest
PSR	Pressure-State-Response
PTP	Port of Tanjung Pelepas
RBV	Return Beam Vidicon
RGB	Red-Green-Blue
RM	Ringgit Malaysia
ROI	Region of Interest

RS	Remote Sensing
SAR	Synthetic Aperture Radar
SD	Standard Deviation
SEZ	Special Economic Zone
SFM	Sustainable Forest Management
SJCRMP	South Johor Coastal Resources Management Plan
SPM	Sungai Pulai Mangroves
SPMFR	Sungai Pulai Mangrove Forest Reserve
SPOT	Systeme Pour d' Observation de la Terre
SPSS	Statistical Package for Social Science
SS	Social Science
SWIR	Short wave Infrared
TCC	True colour composite
TIR	Thermal Infrared
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United State Geological Survey
UTM	Universal Transverse Mercator
VAG	Village action group
VJR	Virgin Jungle Reserve
WGS84	World Geodetic System 1984
XS	Multispectral

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Mangrove forest, status, and function: Mangrove forests may be defined as the forests located between the land and the sea, being inundated twice daily and having salt tolerant species with special characteristics (Giesen et al., 2007). Mangroves are the highly productive ecosystem located in intertidal tropical and subtropical regions. Presently mangroves occupy about 181,000 km^2 of tropical and subtropical coastlines (Jusoff, 2013). It is a salt tolerant and swamp ecosystem. Mangrove forests have special characteristics which help them to survive in the salty intertidal zone. Mangrove trees have specific characteristics or adaptations to survive to the salty, swamp ecosystem. For example, the trees have stilt root or pneumatophores. Stilt roots give support to the tree in the swampy soil while pneumatophores help them for respiration. The mangrove tree has a special germination process which increases both the germination and survival percent of seedlings in the muddy soil.

Being a valuable ecological and economic resource, mangrove ecosystem serves as nursery grounds and breeding sites for many important birds, fish, crustaceans, shellfish, reptiles, and mammals. Mangroves are a renewable source of wood; accumulation sites for sediment, contaminants, carbon and nutrients; and offer protection against coastal erosion (Jusoff, 2013). Mangrove ecosystem acts as a buffer zone between the terrestrial and marine ecosystem, stabilizes coastlines and river banks, and therefore play an important role in the protection of coastlines from storms and tides. Mangrove forests can reduce the impact of natural disasters such as hurricanes, cyclones, and tsunamis. Thus, mangrove forests provide a variety of environmental, economic and social benefits to the local, national, and global communities.

Malaysia is endowed with vast mangrove coverage. Malaysian mangrove represents 3.7% of the global total mangrove. In the Southeast Asia, it represents 11.7% after Indonesia which represents 60% of the global total mangroves (Giri et al., 2011). Most of the mangrove forests in Malaysia are concentrated to Sabah having 59% followed by Sarawak (23%) and Peninsular Malaysia (18%). In Peninsular Malaysia, the mangrove forest is dominant throughout the west coast. The Matang mangrove in Peninsular Malaysia is sustainably managed for over 100 years and identified as the best-managed mangrove forest in the world (Rahman & Asmawi, 2016).

Malaysian mangrove forest supports extremely rich biodiversity. The dynamic mangrove ecosystem serves many productive and protective functions both ecological and economical points of view. It supports over 60 different tree species, many animals, birds and fisheries. Mangroves are important nursery grounds and breeding sites for many important species. It provides timber, fuelwood, poles, firewood and charcoals. It is an important carbon stocks and protects the coastal shoreline and habitat from the strong wave.

The Sungai Pulai Mangrove Forest Reserve (SPMFR) covering 9,126 ha is the largest mangrove area in Johor and the second largest in Peninsular Malaysia. The SPMFR and surrounding mangroves have diversified flora and fauna including 24 true mangrove species, 21 mangrove-associated species, 7 amphibians, 12 reptiles, 55 birds, 26 mammals and 111 fish species (Ramakrishna et al., 2001; Mohd Hasmadi et al., 2011). The plant species composition of the Pulai mangrove is comparatively higher than the other mangroves of Peninsular Malaysia, for example, Ayer Hangat or Kisap forest reserve in Langkawi and Matang mangrove in Perak (Norhayati et al., 2005). These mangrove forests are managed by the Johor State Forestry Department (JSFD) in supplying forest products, especially wood for pole and charcoal making. In Johor, total mangrove forest area has been classified as (48%) production forest mainly for timber and the remaining 52.4% for other functions including protection, conservation, recreation, research and education (Che Hashim et al., 2005). About 80% of the mangrove species are less than 20 years because the trees are felled in a 20-year rotation for commercial wood production (Mohd Hasmadi et al., 2011). The mangrove ecosystem has played a vital role in the socioeconomic well-being of the traditional coastal communities by providing a range of products for their livelihood. The mangrove change has an effect on the local communities' livelihood.

Remote sensing and forest monitoring: Remote Sensing (RS) is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. It has been demonstrated as a powerful tool for studying such a place where it is difficult to reach or difficult to penetrate. Satellite RS is an effective tool for natural resources assessment from land to ocean.

RS along with Geographic Information System (GIS) serve many applications in monitoring and management of natural resources such as mapping, species identification, biodiversity monitoring, deforestation monitoring, vegetation dynamics monitoring, land cover change monitoring and change detection. (Ramachandran, 1993; Ramachandran et al., 1997, 1998; Mohd Hasmadi et al., 2011). It provides a timely and complete coverage for mangrove mapping where accessibility is difficult (Mohd Hasmadi et al., 2011). Thus, RS provides various guidelines and applications for sustainable coastal environment monitoring and management (Ramachandran, 1993; Ramachandran et al., 1997, 1998; Mohd Hasmadi et al., 2008; Havemann, 2009; Mohd Hasmadi et al., 2011; Hamdan et al., 2011; Heumann, 2011).

Two types of space-borne data used for mangrove mapping or monitoring are optical, and radar. Optical sensors rely on reflected sunlight whereas Synthetic Aperture Radar (SAR) satellites actively can emit microwave energy to their targets. Jusoff (2008) conducted an experiment to demonstrate the capability of National Aeronautics and Space Administration's (NASA) airborne SAR (AirSAR) data to classify and map the tropical forest of Pulau Tioman, Malaysia and suggested that optical satellite remote sensing technology has great potential in Pulau Tioman to be further tested for forest mapping, monitoring and inventory purposes.

Optical sensors such as Landsat and Systeme Pour d' Observation de la Terre (SPOT) imageries have been applied to mangrove studies through visual interpretation (Gang & Agatsiva, 1992), vegetation index (Blasco et al., 1986; Chaudhury, 1990; Jensen et al., 1991), classification (Dutrieux et al., 1990; Aschbacher et al., 1995) and band ratioing (Ranganath et al., 1989; Kay et al., 1991; Long & Skewes, 1994). Multi-temporal Landsat data have been using to assess the historical changes in mangrove forests in many countries (Rasolofoharinoro et al., 1998; Kovacs et al., 2001; Muttitanon & Tripathi, 2005; Beland et al., 2006; Akingbogun et al., 2012). Mohd Hasmadi et al. (2011) reported that optical sensors (Landsat or SPOT) provide appropriate resolutions for studying changes in mangrove canopy extent and condition.

The importance of community's perception and socioeconomic study: Socioeconomic status refers to the assets and owning goods of a household as well as the status of household members in the community (Krieger et al., 1997; Brady & Matthews, 2002). The study of population demography and socioeconomics are very important as it reflects the quality of living standard and strength of a nation (Banerjee et al., 2002). Socioeconomic factors are considered as one of the main causes of deforestation and the pace of deforestation depends on the socioeconomic condition of associated community (Turner & Meyer, 1991; Primavera, 2000; Liu et al., 2007a; FAO, 2010; Szantoi et al., 2012; Gong et al., 2013; Jusoff, 2013; Miyamoto et al., 2013). The change of socioeconomic status combined with other drivers have been reported to lead the deforestation or other environmental change (Allen & Barnes, 1985; Amelung & Diehl, 1992; Cropper & Griffiths, 1994; Ehrhardt-Martinez, 1998; Mather & Needle, 2000; Lin & Ho, 2003; Tanrivermis, 2003; Gong et al., 2011; Tian et al., 2013). Uses of household socioeconomic data combining with RS data have already been proved useful in many previous studies (Fox, 2003; Rindfuss et al., 2004, 2008; Overmars & Verburg, 2005; De Souza Soler & Verburg, 2010).

Integration of RS and social science (SS): The study of integrating RS and GIS with household survey or census data is gaining popularity in many interdisciplinary studies as it improves understanding of the processes along with the causes of land use/cover (LUC) changes (Geoghegan et al., 1998; Lambin et al., 1999; Mertens et al., 2000; Taubenböck et al., 2009; Bagan & Yamagata, 2012; Herrmann et al., 2014). This combined procedure can provide rapid information more accurately and in a cost-effective way, can handle vast quantities of spatial and non-spatial data which were previously impossible (De Andrade et al., 2010).

This technology is being applied in urban planning or urban development (Xu et al., 2000), monitoring the growth of settlements (Thomson & Hardin, 2000), environmental or forest monitoring, information on natural disasters like flooding, earthquake or tsunami. Socioeconomic data are strongly related to the biophysical environmental data (Lo & Faber, 1997; Bagan & Yamagata, 2012) thus population and economy can also be integrated (Xu et al., 2000) with remotely sensed data. Multi-temporal Landsat data combined with socioeconomic data can be used for identification of factors of deforestation and to understand the complex interrelationships between LUC change and human population (Sydenstricker-Neto, 2012; Bagan & Yamagata, 2012; Badar et al., 2013). For the socioeconomic study, RS data can assist by giving the exact coordinate of the studied household or land use. RS and GIS help to analyze and to present the survey data more easily and more attractively. On the other hand, survey data can be used to validate the RS data. Thus, the combined study of the application of RS and GIS with SS make the survey convenient for the researchers.

1.2 Problem statement

During 2000 to 2012 Malaysia has lost 4.5 million ha of forests i.e. 14.4% of its forest cover, which represents world's highest rate of deforestation at that time. Meaning, between these periods only Malaysia has lost forest cover equivalent to a football pitch in every 1.5 minutes (Yong, 2014). Mangrove forests are also included with this deforestation record. This deforestation is occurring on a quarterly basis. About 80% of the tropical forests in Malaysian Borneo have been heavily impacted by a logging operation. The logging is mainly done for construction of road and transportation and for timber and oil palm production (Yong, 2014). According to Samat et al. (2014), in Penang, urbanization and the new construction caused a massive migration of population and foreign workers to the newly built-up area which has put high pressure on the existing social services, increase pollution and other social problems. The authors reported that this urbanization also brings ecological and socioeconomic effects to the local community.

Currently, the southern coast of Peninsula Malaysia is in a transitional stage between the commercialization of coastal life (through the improved communications, new technologies, urbanization, and tourism development) and the isolated subsistence existence of rural 'Mangrove villages'. Since 1980, Johor Mangrove Forest has been experiencing a major decline in the Peninsular Malaysia. Hamdan (2012) reported that during 1990-2010 state Johor has lost about 6120.70 ha of mangroves from 29,797 ha in 1990 to 23,676 ha in 2010. In south Johor only the Iskandar Malaysia (IM) region lost 33% of mangrove coverage from 1989 to 2014 with annual deforestation rate 1.32% (Kanniah et al., 2015).

The mangroves of this area are under substantial pressure from large-scale development projects for infrastructure, urban development, industries, and harbour, as well as small-scale agriculture projects (Che Hashim et al., 2005). For example, many forest areas have been cleared for the development of Town Nusajaya as the new administrative centre of Johor state which affects the total mangrove coverage of this area. The development of the Tanjung Bin power plant and Port of Tanjung Pelepus (PTP) are additional examples of mangrove deforestation and causing erosion to the surrounding mangrove areas. Many forest areas have been cleared to make room for these development processes. The development of Puteri harbour is another cause because the dynamics of the water hydrology has been changed and thus the ecosystem has been altered. They impact directly on the mangrove ecosystem, causing coastal erosion and water pollution from associated dredging and reclamation works and traffic. The Ramser site is under threat from the rapid development in the surrounding area. A large part of the forest reserves have been degazetted and much more on the way (Che Hashim et al., 2005).

All these developments lead to mangrove deforestation by reducing both the mangrove coverage and biodiversity. Both flora and fauna of this mangrove ecosystem are being affected by the rapid development. Loss of biodiversity may lead to the extinction of an important plant or animal species. The indigenous peoples and local forest communities of the adjacent 38 villages depend on the mangrove ecosystem for their livelihoods, income generation, socio-cultural, and spiritual link (Yong, 2014). The deforestation of mangroves also affects their livelihood, income source, socio-cultural and spiritual activities.

The Sungai Pulai mangroves (SPM) is a reserve forest only not protected and parts of this forest already converted to other land use like port development, power plant development, aquaculture, charcoal making industry, residential area and coastal road development (Hashim & Kadir, 1999; Giesen et al., 2007). There are also some ongoing development projects like Iskandar Malaysia (IM) and Forest City project. For sustainable management of this endowment, it is demanded to know the status of this forest, associated threats, and impacts of the change to the socioeconomics of local communities' livelihoods along with the responses taken by the managers or planners.

Recently, a number of studies have been conducted to know the current land use status, monitoring mangroves and change detection at the southern Johor (Azlan & Othman, 2009; Abd & Alnajjar, 2013; Deilami et al., 2014; Kanniah et al., 2015). Unfortunately, no comprehensive study has done yet on LUC changes and their impacts. There is a little information about the socioeconomic impacts of mangroves change in the study area. As mangrove status may differ spatiotemporally due to the combined action of different direct and indirect factors. Thus, an update of knowledge about the mangrove status of the study area is necessary that can support the managers, planners, environmentalists, or researchers by providing up to date information of the current land uses. Hence, this study has been planned to detect the changes of mangroves with other LUCs at the study area with associated anthropogenic factors and impacts of changes to the socioeconomy of the local community.

1.3 Research questions

i) What is the current LUCs status in and around the SPMFR and how much mangroves area has been cleared for the last decade (2004 to 2014) and what is the rate of change within the 10 years period?

ii) What anthropogenic factors (land use and socioeconomic factors) are mainly responsible for mangrove reduction?

iii) Does the mangrove change have any socioeconomic impact to the local community?

1.4 Objectives of the study

The general objective of the study is to assess the spatiotemporal changes of LUCs and mangroves area using remote sensing technique and its impact to the socioeconomic of the local community near the SPMs, Johor, Malaysia. The specific objectives are as follows:

i) To detect land use/cover (LUC) and mangroves changes in and around the Sungai Pulai Mangrove Forest Reserve (SPMFR) area for the year 2004, 2009 and 2014;
ii) To determine the anthropogenic factors contributing to the mangrove change in the study area and;
iii) To determine the impacts of mangrove changes on the socioeconomic status of the local community.

1.5 Hypothesis

Hypotheses are statements of assumption and/or predictions of concerning research problems. For conducting a research we need to develop hypotheses that can guide and give the direction of the study (Karim, 2001). For this study, regarding the mangrove change and its effect on local communities socioeconomic, following hypotheses are developed:

i) There is a change (reduction) of the SPMFR and surrounding LUCs during the last 10 years (between 2004 to 2014);
ii) There is a relationship between the mangrove change/loss and associated anthropogenic factors;
iii) There are impacts (both positive and negative) of mangrove changes/loss to the socioeconomic condition of the local community.

1.6 Significance of the study

SPMFR and surrounding mangroves support a rich biodiversity dependent on mangrove including many rare species of plants, animals, and birds. The local community living in the surrounding area greatly depend on mangroves for their livelihood both subsistence and commercial.

The findings of this study are useful in several ways. Firstly, the mangrove change study (using multi-temporal satellite RS data) would provide information about the land use change dynamics of the SPMFR and surrounding area for the years 2004, 2009 and 2014. Land use maps for the studied area would become available for the mentioned years. Secondly, the household survey data would serve socioeconomic and livelihood information including their perception on mangrove change issue, awareness about deforestation, its causes and impacts on their socioeconomic condition. Thirdly, the combined study of applying RS and socioeconomic study would identify the potential land use and socioeconomic factors of mangrove change. It would supply available information about the drivers associated with the change with their magnitude of effect for the study area and also it would give a hint about the factors of mangrove change in the Peninsular Malaysia or whole Malaysia. Overall it would provide an understanding of change trend with a time of the socioeconomic condition.

Finally, information obtained from this study can be used as a baseline for mangrove forest monitoring and management for the studied area. These may help the environmentalists, researchers or managers. The policy makers may use the information to formulate better policies.

1.7 Scope of the research

This study is an initiative to combine two disciplines. RS data and socioeconomic data have been tried to combine at *mukim* level (census tract unit). It makes information available for *mukim* level LUC status for the studied period along with the socioeconomic information which gives information on current land use pressures of the studied area and also an indication of future study. Due to financial and time limitations, more detail study on the smallest unit integration could not be done. For example, integration of RS data with household-level socioeconomic data using higher spatial resolution RS data, for instance, Quick bird data (spatial resolution 0.65m) is able to record coordinates for every household with household-level socioeconomic and land use information.

Model simulation can be studied using RS data with socioeconomic data through different modeling for instances, Conversion of Land Use and its Effects at Small regional extent (CLUE-s), Cellular automata, Markov chain modeling, which will make a better integration of RS and socioeconomic data at household level or village level data and will give a projection of future change of land cover and land use of study area. If available fund, resource manpower and time can be ensured then advanced study for model simulation would be studied for a complete integration of these two disciplines.

1.8 Limitations of the study

The study area is situated in the tropical humid region and optical Landsat data were used hence cloud problem was faced. Moderate resolution RS data and socioeconomic census data (*mukim* level) were used for this study. Hence integration at fine spatial level (at household level or village level) could not be conducted.

Another important issue is a selection of factors. Though many factors and underlying causes are related to the mangrove change, only a few anthropogenic factors (some spatial and socioeconomic factors) have been considered for this study due to limitations of time, finance, and manpower. The factors those are included in the study have been recorded from the analysis of previous literature, household survey and census reports.

For the survey, data were collected at specific time frame using the cross-sectional survey approach due to the above-mentioned limitations (time, fund and manpower) which may not completely be able to give a clear picture of the real situation. Another limitation for the survey data collection is the income data provided by the household heads by assumption as some of them haven’t any record of their exact income.

1.9 Organization of thesis

There are 6 chapters in this thesis. Chapter 1 is the Introduction describing the background of mangrove forests and its role to the community. It also discusses about the application of remote sensing technology for LUC change detection. The problem statement, significance and objectives of the study are also presented in this chapter. Chapter 2 comprises the literature review which discusses previous related studies using remote sensing for forest change study. It also discusses the anthropogenic factors (both drivers and pressures) of mangrove change along with impacts of mangrove change to the communities' socioeconomic condition. The materials and methods have been described in Chapter 3. Chapter 4 describes the results of the study. Chapter 5 is the discussion of the findings obtained in chapter 4. Chapter 6 is the summary, implications, conclusion, and recommendation of the study including hints of future research.

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