COMPARATIVE STUDIES OF FORESTED AREAS ON BIODIVERSITY AND LAND-USE CHANGE (LUC) IN PENANG ISLAND

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by

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LIST OF ABBREVIATION

CBD	Convention on Biological Diversity
cm	Centimeter
dbh	Diameter at Breast Height
FG	Tropical Fruit Garden
HFR	Government Hill Forest Reserves
GIS	Geographical Information System
ha	Hactare
HR	Penang Hill Reserves
LST	Land Surface Temperature
LUC	Land-use Change
m	Meter
MV	Mixed Vegetation
NASA	National Aeronautics and Space Administration
NP	Penang National Park
no.	Number
OLI	Operational Land Imager
PHF	Private Hill Forest
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RP	Rubber Plantation
SAP	Penang Hill Draft Special Area Plan
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
TR	Taman Rimba Teluk Bahang
UNDP	United Nations Development Programme
UN-REDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation

PENGAJIAN PERBANDINGAN KAWASAN BERHUTAN PADA BIODIVERSITI DAN PERUBAHAN PENGGUNAAN TANAH DI PULAU PINANG

ABSTRAK

Penilaian Pengurusan Hutan Sejagat 2015 telah melaporkan pertambahan pemilikan tanah secara persendirian pada skala global. Walau bagaimanapun, aktiviti penebangan hutan sangat aktif dilaporkan berlaku di kawasan hutan-hutan bukit milik persendirian di Malaysia. Pulau Pinang telah dipilih kerana ia telah mengalami perubahan penggunaan tanah yang sangat pesat dan radikal disebabkan perkembangan kawasan bandar sejak tiga dekad yang lalu. Dalam kajian ini kesan daripada perbezaan pengurusan hutan terhadap perubahan penggunaan tanah (LUC) dan biodiversiti telah dianalisis. Analisis penggunaan perubahan tanah telah dijalankan dengan menggunakan PCI Geomatica melalui perisian paparan Landsat dari tahun 1991 hingga 2015 dan arah aliran untuk masa hadapan dinilai melalui perisian EXCEL Forecas Function. Kesan terhadap biodiversiti telah dilakukan di tiga hutan simpan berbukit (HFR) dan tiga hutan persendirian (PHF) di Pulau Pinang. Dalam kajian ini, variasi biodiversiti diukur melalui struktur komuniti bagi kedua-dua tumbuhan vaskular dan spesies avifauna bersama dengan pembolehubah persekitaran mikro. Kepelbagaian tumbuhan vaskular dan avifauna dipilih kerana telah terbukti sebagai petunjuk kepada pemantauan biodiversiti. Akhir sekali, implikasi pemuliharaan telah dicadangkan mengikut keadaan semasa penebangan hutan di PHF. Kajian LUC mendedahkan bahawa kadar penebangan hutan tahunan adalah sebanyak 1.4% di Pulau Pinang sejak tahun 1991 sehingga 2015 dengan kadar urbanisasi tahunan sebanyak 3.29%. Arah aliran analisis ini telah meramalkan kawasan hutan berkemungkinan menjadi lebih kecil daripada rizab hutan semasa pada tahun 2039.

LUC ini juga telah mendedahkan faktor utama dalam kemerosotan biodiversiti yang pesat adalah disebabkan peningkatan kejadian tanah runtuh, aliran lumpur, pencemaran air, banjir kilat, dan ancaman terhadap kesihatan. Komuniti tumbuhan dan analisis avifauna mendedahkan bahawa kawasan HFR adalah lebih pelbagai dan lebih sihat daripada PHF juga dengan keadaan kesamarataan yang lebih tinggi. Kekayaan spesies antara HFR dan PHF menunjukkan perbezaan yang signifikan bagi spesies tumbuhan tetapi bukan untuk spesies burung. Analisis kepelbagaian avifauna mencatatkan bilangan burung yang lebih tinggi di PHF walaupun HFR mempunyai kepelbagaian biodiversiti yang tinggi. Secara keseluruhannya kepelbagaian dan interaksi alam sekitar mendedahkan bahawa PHF telah menjadi habitat yang penting bagi menyokong kepelbagaian burung dengan menyediakan sumber makanan yang mencukupi. Oleh itu PHF berperanan sebagai zon penampan untuk kepelbagaian avifauna bagi rizab HFR. Tetapi kadar semasa bagi penebangan hutan di PHF didapati lebih tinggi berbanding dengan kadar penebangan hutan-hutan di seluruh Malaysia. Oleh itu sebarang perubahan terhadap litupan hutan bukit perlu dipantau dengan lebih dekat dengan penjagaan rapi bagi PHF sehingga ada kemungkinan untuk pelaksanaan program pengurusan bersama. Tambahan pula, aktiviti manusia di dalam HFR juga perlu dikawal kerana gangguan begitu jelas dilihat berlaku di HFR.

COMPARATIVE STUDIES OF FORESTED AREAS ON BIODIVERSITY AND LAND-USE CHANGE (LUC) IN PENANG ISLAND

ABSTRACT

The Global Forest Resources Assessment 2015 reported an increasing rate of privately owned forests on a global scale. However, deforestation was found to be very active in privately owned hill forest areas of Malaysia. Penang State was purposively chosen as it has been experiencing rapid and radical changes due to urban expansion over the last three decades. In this study, effect of differential management on land-use changes (LUC) and biodiversity were analysed. Analyses of land-use changes (LUC) were done by PCI Geomatica using Landsat images from 1991 to 2015 and future trends of LUC were assessed using EXCEL forecast function. Effect on biodiversity were studied in three hilly forest reserves (HFR) and three adjacent privately owned hill forests (PHF) in Penang State. In this study variations in biodiversity were measured using community structure of both vascular plants and avifauna species along four micro-environmental variables (canopy coverage, canopy height, elevation and disturbance). Vascular plants and avifauna species diversity was chosen since these have been proven as good indicator for biodiversity monitoring. Finally, implications for conservation were proposed considering the current state of deforestation in privately owned hill forests (PHF). LUC study revealed an annual deforestation rate of 1.4% in Penang Island with an annual urbanization rate of 3.29% since 1991 to 2015. Trend analysis forecasted a forest area that most probably be smaller than the current forest reserves by 2039. This LUC has already exposed major role in biodiversity loss with increasing landslides, mudflows, water pollution, flash flood, and health hazard. Plant community and avifauna analysis revealed that HFR

were more diverse and healthier than PHF also with higher evenness. Species richness between HFR and PHF showed significant difference for plant species but not for avifauna. Avifauna diversity analysis recorded higher abundance of birds in PHF though HFR was richer in species richness and diversity. Overall variability and environmental interaction finally revealed that PHF was providing important habitat service of abundant food resource for the bird diversity. Hence its role appeared as buffer zone for the avifauna diversity of HFR reserves. But the current rate of deforestation in PHF was comparatively higher than the deforestation rate of tropical forest Malaysia. Thus any alteration to hill forest cover should monitored closely with intensive care to the PHF with the possibility of the implementation of co-management program. Moreover human activities inside the HFR should also be controlled as conspicuous disturbance were also found inside HFR.

CHAPTER 1

INTRODUCTION

1.1 Research Focus

Biodiversity is the foundation of ecosystem services upon which all people fundamentally depend (Sala et al. 2000; Secretariat of the Convention on Biological Diversity 2010). The economy of a country depends largely on its biological resources, ecosystem and mineral wealth. On a broader note, these resources are part of the world stock of biodiversity, which have significant social and ethical replications (Newmark 2002). But it is now recognized that the global biodiversity situation is vulnerable much higher than at any time of its history (FAO 2015; Secretariat of the Convention on Biological Diversity 2014). The magnitude of biodiversity change is so large that it is now considered an important global change (Sala et al. 2000). A range of forces including land use change (LUC), overuse of natural resources, environmental pollution and the spread of invasive species are responsible for the loss of biodiversity (Akber and Shrestha 2013; Foley et al. 2005; Martinez et al. 2009; Masum et al. 2016). The threat to biodiversity in during the next century will be caused mainly by changes of land use and resulting deforestation (Akber and Shrestha 2013; Martinez et al. 2009).

LUC is a process that is highly interlinked and has widespread range of effects on livelihood and biodiversity through land surface process (Masum et al. 2016; Trisurat et al. 2010). LUC, such as alterations in cropland, intensification of farming, tropical deforestation, pasture extension, urbanization, and so on, occur in the tropical region because of complex interactions among different factors of changes, such as (1)

increased production pressure owing to resource scarcity, (2) changes in market prospects, (3) outside policy involvement, (4) lack of adaptive capacity and increased susceptibility, and (5) changes in social organization (Lambin et al. 2003). Thus LUC have the largest prominent effect on terrestrial ecosystem (Sala et al. 2000). LUC modifies the temporal variability of ecosystems and this will have repercussions for biodiversity and ecosystem functioning (Beierkuhnlein and Nesshöver 2006). Of the major categories of land-use change, the clearing of forests for use as cropland accounted for the largest fraction of CO_2 emissions. This phenomenon is largely responsible for the loss of floral diversity directly and for the loss of faunal diversity by reducing their habitat as well as by changing the local environment (Foley et al. 2005; Masum et al. 2016; UNDP 2008).

Over the past 25 years (1990-2015) the largest forest area converted to other land uses was in the tropics (FAO 2015). According to Miettinen et al. (2011), the highest deforestation rate amongst all tropical regions of world is taking place in insular Southeast Asia since 1990. Particularly, Malaysia is experiencing higher rate of deforestation than any other tropical country in the world (Butler 2013; Malaymail 2015; Miettinen et al. 2011). Malaysia is estimated to harbour some 185,000 species of fauna and 12,500 species of flowering plants (CEMD 2006). Owing to exceptionally high biodiversity in its forest ecosystem and huge amount of carbon in living forest biomass (3,212 million metric tons), deforestation in Malaysia has the potential to cause serious regional and global consequence. A total of 8.6% of its forest cover has been removed by 1990-2010 which was equivalent to 1.92 million ha of forest land with an annual deforestation rate of 96,000 ha (Programme 2016). According to UN-REDD this reduction was mainly driven as a result of rapid industrial and economic growth in Malaysia. Clearing of land in the name of development is occurring in most

of the Malaysia's densest hill forests, those with tree cover exceeding 50 percent, which generally store most carbon and are richest with wildlife, including endangered orang-utans, pygmy elephants, Sumatran rhinos and clouded leopard (Butler 2013). Forest Research Institute of Malaysia (FRIM) in 2013 has identified that 417 plant species, 48 land mammals species and 132 bird species under threat in Peninsular Malaysia and also recognized habitat degradation and fragmentation as major threat for biodiversity and ecosystem conservation in Malaysia (Mohmod 2014).

1.2 Problem Statement

Forest ownership and management are considered as vital for sustainable management of forest and its associated biodiversity. Global Forest Resources Assessment 2015 assessed an increasing rate of forest owned privately at the global scale with less certainty of remaining these private forest land as forest. The amount of private forest land in Malaysia is still less than 10 percent of its total forest area (FAO 2015). But deforestation was found very active in these privately owned hill forest area (Wyn 2013).

For a clear understanding of the effects of deforestation, Penang State has been chosen as it is an island based state of Peninsular Malaysia that has been experiencing a quick and radical change in urban extension over the last three decades. This island was identified as one of the deforestation hotspot in the Peninsular Malaysia by National Aeronautics and Space Administration- NASA (Mongabay 2013). Moreover islands provide a record of humanity's interactions with biological diversity in contained areas, and of the consequences of those interactions (Vitousek et al. 1995). Because of geographic isolation, the current epidemic of anthropogenic extinctions has hit primarily on the oceanic islands (Osvaldo et al. 2005). Island ecosystems would

appear to be particularly useful for studies of diversity as invasions and extinctions are widespread on islands, and they can be used to evaluate the effect of the management practices on species diversity (Vitousek et al. 1995).

Conversion of hill forest for agriculture and settlement through burning is now conspicuous in privately owned hill forest area of the island. Increasing amount of landslide now become very prominent in these barren land (Basith et al. 2010; Chan 1998; Pradhan and Lee 2010). As privately owned hill forests are solely affected by the phenomena of LUC, the effect on differential management hence signify the effect of LUC as well.

However, while the effects of land use on biodiversity are well-established for some taxa [ground foraging ants (Bestelmeyer and Wiens 1996); agricultural crop (Reidsma et al. 2006); macro invertebrates (Azrina et al. 2006); grassland species (Garnier et al. 2007)], there is limited knowledge on its effect on others, as well as how genetic versus species diversity responds to LUC. Also, we often do not know how the diversities of different taxa are interrelated, whether particular taxa can serve as indicators of biodiversity change, and to what extent LUC can have cascading effects across trophic levels (Fischer et al. 2010). Moreover the complexity of interactions between ecological and societal processes over time and space has challenged attempts to understand the linkages between change in biodiversity and land degradation. LUC analyses provide an entry into understanding these linkages and associated processes (STAP 1999). At this time, our understanding of the interactions among LUC and biodiversity globally is rudimentary. In addition specific research work was not found to explore biodiversity-LUC relationship in the tropical forest of Malaysia.

LUC detection using remote sensing and GIS has been conducted through a number of studies such as; in Gua Musang district, Kelantan by Jusoff and Senthavy (2003), impact of land surface temperature in relation to LUC by Tan et al. (2010); LUC detection for landslide risk area identification by Pradhan and Lee (2010) and Basith et al. (2010), effects of habitat disturbance on mammals by Laidlaw (2000), anthropogenic disturbance on invertebrates by Azrina et al. (2006) and Al-Shami et al. (2011). Thus the contribution of this research will provide baseline information for the policy maker to formulate adaptive plan for reducing forest degradation and fragmentation in all over Malaysia. As Penang state government had proposed a plan to make it 'Tax-Free World Trade Centre' in late 1990, all mega-scale development project started to activate from that year. So, this study will provide a new avenue of knowledge on LUC trend in Penang after 1990 and its effects on biodiversity and vice-versa will help pragmatic researcher in this field to accept the challenge of the millennium, and ultimately help relevant agencies to rearrange the conservation strategy according to the situation and to propose necessary amendment of the prevailing act that can really be put into action.

1.3 Objectives of Study

Vascular plants and birds are widely considered as indicator taxa for monitoring of biodiversity change (Elzinga et al. 2001; Gibbons et al. 1996; Nic Lughadha et al. 2005a; Pereira and Cooper 2006). As such diversity of vascular plants are one of the most important predictor of other taxa and thus used in representing Biodiversity hotspots (Myers et al. 2000; Osvaldo et al. 2005). On the other hand birds are ease of census and feasible to monitor as well as likely to be influenced by the habitat degradation (Elzinga et al. 2001; Gibbons et al. 1996; Gregory et al. 2005). As

a consequence, effect of LUC on biodiversity was studied in hill forest of Penang Island gathering vascular plant and avian species data in both government and privately owned hill forest area. Government owned forest land includes Penang Hill Reserved Forests (HR), Penang National Park (NP) and Taman Rimba Teluk Bahang (TR). Privately owned forest land composed of Fruit Garden (FG), Rubber Plantation (RP) and Mixed Vegetation (MV).

1.3.1 General Objective

The overall objective of this study is to assess the rate and trend of LUC in Penang Island as well as to assess the effects of differential forest land management on this island's biodiversity.

1.3.2 Specific Objectives

The specific objectives of the present research are:

1. To estimate the rate and trend of forest degradation in Penang Island since 1991 to 2015 through Satellite Landsat Image analysis.

2. To assess the effects of differential forest land management on diversity and abundance of vascular plant species in Penang Island.

3. To assess the effects of differential forest land management on diversity and abundance of avian species in Penang Island.

4. To relate avifauna abundance with micro environmental variables and vascular plant traits in Penang Island.

1.4 Significance of Research

Information obtained from the LUC provide quantitative information of forest degradation over a period of 24 years that can be used for sustainable forest management planning. Vegetation data assessed in this study include height, diameter class distribution, density, basal area, abundance, floristic distribution pattern, species diversity, canopy height, canopy cover with elevation aspect of both government owned and privately owned hill forest area. Avian data will provide abundance, species diversity in relation to habitat variable expressed in vegetation data for both government owned and privately owned hill forest area. This information would generate a better understanding about the effect of forest LUC and create consciousness among the policy makers to handle the privately owned hill forest land so that these land can remain forested on a sustainable basis. Thus my PhD study findings will help to educate mass people about the causes and negative impacts of forest land use change so as to stand against this degradation and to play significant role in Reducing Emissions from Deforestation and Degradation (REDD+) movement of United Nations. Moreover, this work will enable researchers to design management tools to control the drivers of land change and could be a predictive tools to foresee biodiversity pattern at different landscapes and disturbances in other deforestation hotspots of Malaysia.

1.5 Structure of Thesis

The thesis is organized into six chapters. Chapter 1 provides an overview of the research. It has research focus, problem statement, objectives and significance of the research. Chapter 2 reviews previous studies related to LUC assessment as well as effect of differential management on biodiversity with special focus on island

biodiversity. Discussion on the different methodologies that are used to conduct this research is presented in Chapter 3. Chapter 4 evaluates the results of the study. Discussion on the assessed results is made on Chapter 5. Finally, Chapter 6 conclude the research, provides recommendations and suggestions for possible future research. References and appendices are presented at the end of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 State of Tropical Rainforest and Biodiversity

Rapid population growth, widening of economy, globalization of trade, revolutionary advances in technology, as well as political changes, are some of several potential indicators of global change (Biermann and Siebenhüner 2009; Martino and Zommers 2007). On the same issue, industrial revolutions of different phases created their own impacts on the global environment (Ellis 2011). In addition, anthropogenic impacts on environment cause further changes resulting in complex feedbacks and interactions (Zavaleta and Heller 2009). Global change is now conspicuous in several phenomena or processes such as changes in climate, increasing of atmospheric pollution and rapid LUC (Beierkuhnlein and Nesshöver 2006). Eventually effect of global change has now reached a global dimension that are continuously affecting the components of the Earth system (Figure 2.1) as a whole altering the habitat and ecosystem for ecological communities (Assessment 2005; Sala et al. 2000; Zavaleta and Heller 2009). The alteration of habitat and ecosystem include the habitat loss and degradation, exotic species invasion, pollution and finally altering the dominance structure of species (Hooper et al. 2012).

Biodiversity, an indispensable part for a sustainable world, is both, a response variable affected by global change drivers and a factor governs the extent and efficiency of ecosystem processes and services that are essential to human well-being (Gamfeldt et al. 2008). Alteration of habitat and ecosystem has led to evolutionary

changes in the species and caused extinctions of species (Secretariat of the Convention on Biological Diversity 2010; Mace et al. 2005).

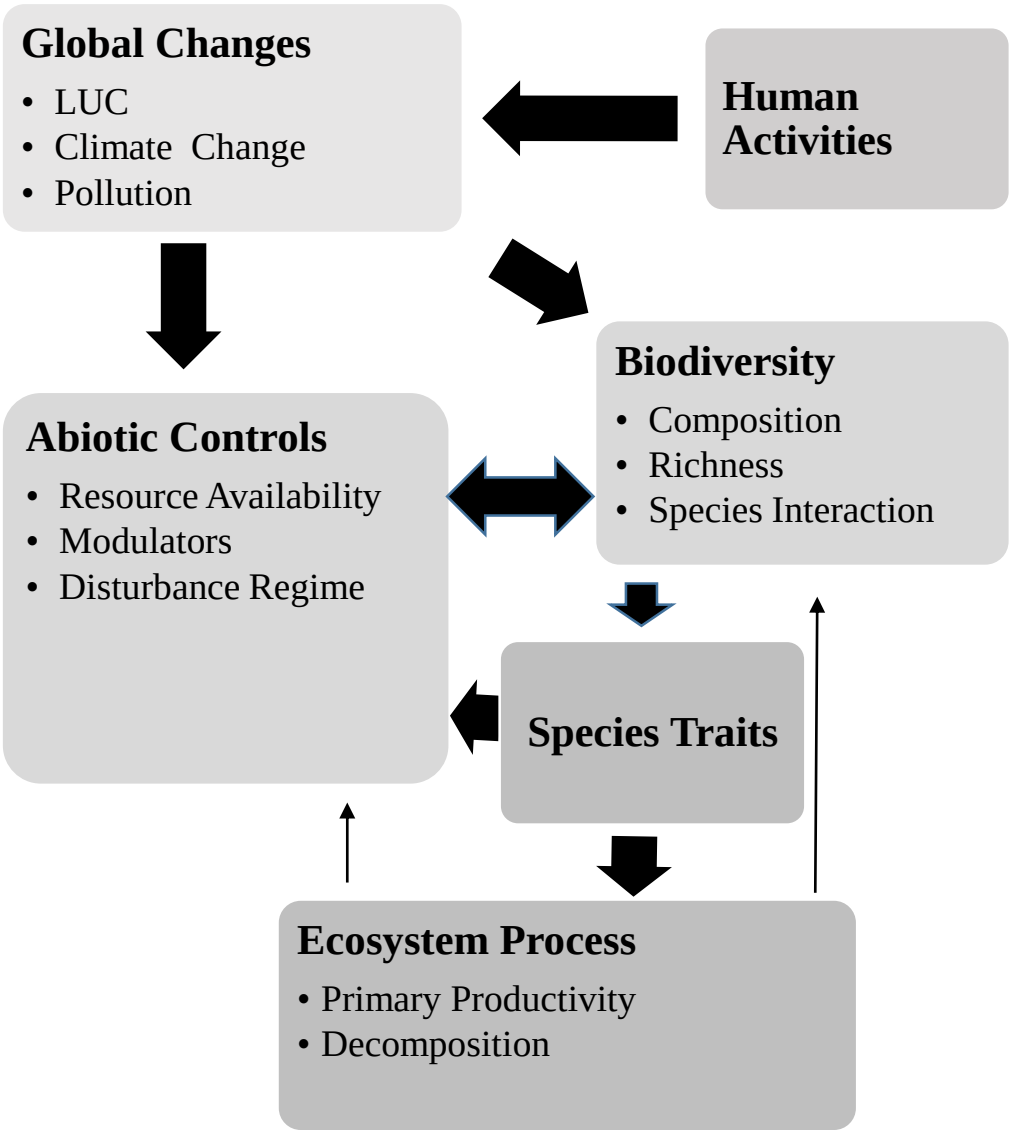

Figure 2.1 Feedbacks and interaction between human activities, global change, and biotic and abiotic controls on ecosystem processes. Modified from (Beierkuhnlein and Jentsch 2004; Chapin III et al. 2000; Hooper et al. 2012).

A variety of global changes are driving rates of species extinction up to 1000 times that greatly outpace background rates in the fossil record (Baillie et al. 2004). If these trends continue, projections suggest that within 240 years Earth may face the sixth mass extinction (Barnosky et al. 2011).

Nature and extent of anthropogenic impacts specify that a degraded ecosystem might never return and thus leading to an irreversible loss of terrestrial biodiversity (Mora and Sale 2011). Some 10-30% of the mammal, bird and amphibian species are now threatened with extinction, due to human actions (Assessment 2005).

Tropical rainforests habitat supports the greatest diversity of living organisms on Earth (over 50% of the earth's flora and fauna) and thus critically significant for carbon sequestration and energy cycles (Sodhi 2008). Despite their monumental role, tropical forests are restricted to the small land area between the latitudes 23.5° North and 23.5° South of the equator, or in other words between the Tropic of Capricorn and the Tropic of Cancer. But these mega diversity area are decreasing rapidly due to forest conversion (FAO 2015). Tropical rainforests have always been suffering from destructive natural calamities (storms, landslides, volcanic eruptions, floods, mud flows, fire, high winds, drought and fluctuated local climatic condition). These issues have been overpowered by continuous anthropogenic forces as rainforests are being deforested everywhere at a very high rate (Fund 2014). Presently rainforests covered about 6% of the Earth's land surface which is less than half the area they covered in the near past (Moore 2016). Thus a biodiversity crisis is conspicuous in the tropical rainforest ecosystem (Brook et al. 2003; Sodhi 2008).

Southeast Asia, West and Central Africa and Central and South America are three main regions consisting the tropical rainforest. Among them Southeast Asian

rainforest (Malay archipelago) is under serious threat and has the highest rate of deforestation compared to other tropical region (Laurance 2007; Mayaux et al. 2005; Miettinen et al. 2011). Due to the presence of high biodiversity and huge amount of carbon, deforestation in Southeast Asian region have the potential to cause severe global consequences (Miettinen et al. 2011). Habitat conversion, degradation and fragmentation were recognized as the process responsible for forest habitat degradation in this region (Braimoh et al. 2010; Masum et al. 2016). Based on the latest Global Forest Resources Assessment (FAO 2015), South and Southeast Asia exhibited the largest amount of partial canopy cover loss, with over 50 million ha detected. Thus based on current deforestation rates of 1.0 % per year (Mayaux et al. 2005; Miettinen et al. 2011), it is projected a total loss of rainforest in the Asian region by 2100. Currently about 30% of all species across various habitats were found threatened in Southeast Asian region (Bickford et al. 2012). If underlying factors for habitat degradation remain active it will cause the extinction of 13% - 85% of all species in the region by the end of this century (Brook et al. 2003; Sodhi et al. 2010). The small geographical ranges together with high levels of endemism, and other species related physiological and biographical characteristics have also made the Southeast Asian biome more vulnerable to a number of extinction drivers (Fordham and Brook 2010).

According to United Nations' Reducing Emissions from Deforestation and Forest Degradation initiative (UN-REDD), Malaysia has experienced higher deforestation rate than any other tropical country of the world for the year 2013 (Kamlun et al. 2016; Mongabay.com 2013). Using satellite image, Hansen et al. (2013) explored the world's highest rate of forest loss between 2000 and 2012 for Malaysia and discovered that Malaysia's total forest loss during the period amounted to 14.4

percent of its year 2000 forest cover. Miettinen et al. (2011) revealed that Malaysian forests were decreasing at the rate of 1.4% per year within the period of 2000-2010.

Land clearing was found prominent in Perak, Pahang, Kelantan, Sabah and Sarawak. In Peninsular Malaysia deforestation hotspots also comprise the state of Terengganu, Johor and Penang (Figure 2.2). Effects of deforestation was found prominent on the status of both flora and fauna of Malaysia. Presently, 9.3% of its total known species of amphibians, birds, mammals and reptiles are threatened (Kamlun et al. 2016; Mongabay 2016).

More than one third of vascular tree species are in the face of threatened condition due to clear felling (Table 2.1) (Mohmod 2014). Habitat loss forced at least 17% species for both mammals and bird species of Malaysia into the status of threatened (Table 2.1). According to WWF-Malaysia, clearing rainforests for oil palm plantations in Malaysia has ruined critical habitat of endangered mammals like orang-utans, elephant, rhinos, and tigers and have been pushing them to the verge of extinction.

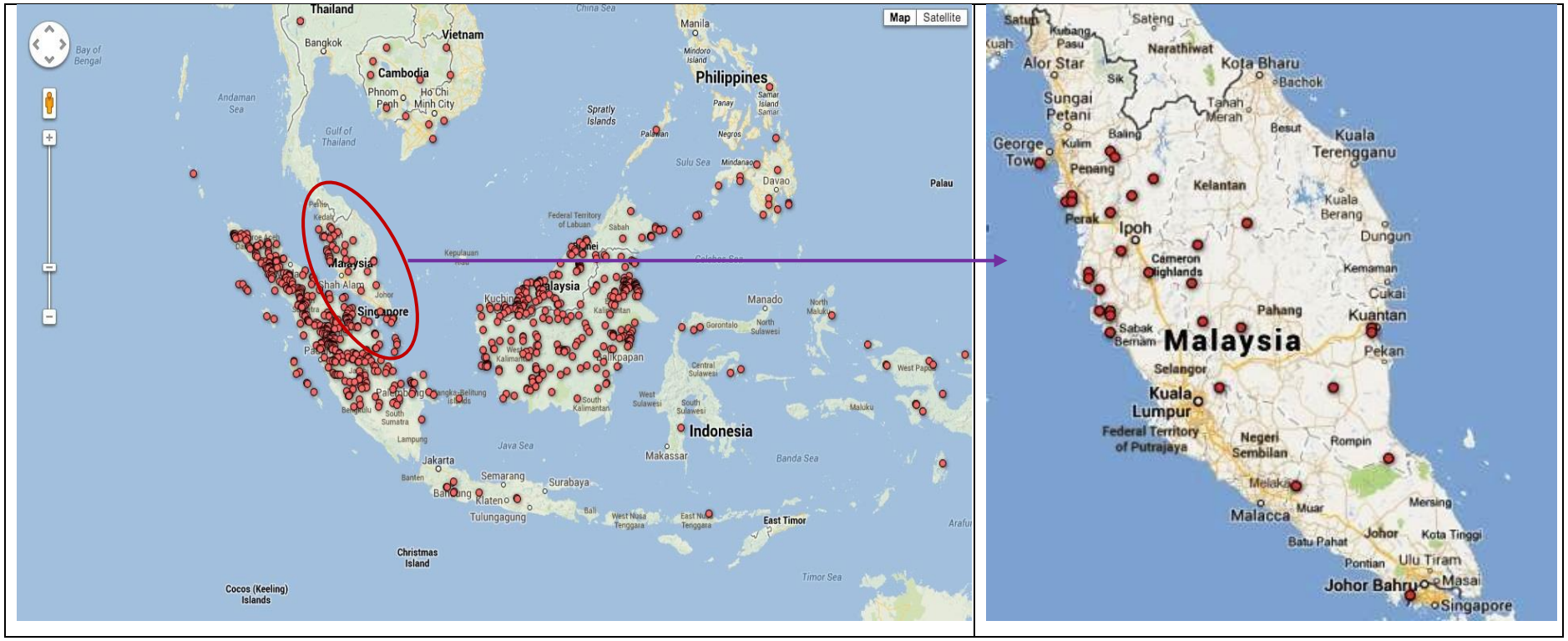

Figure 2.2 Deforestation hotspot of Southeast Asia and insular Malaysia [Adapted from Mongabay (2013)]

Table 2.1 Status of selected Flora and Fauna in Malaysia

Category	No. of known species	No. of threatened species	Threatened species %
Common Vascular Tree	1132	417	36.8
Land Mammal	292	50	17.1
Bird	736	137	18.6

(Source: Adapted from Mongabay 2016; CEMD 2006; DWNP 2010; Perumal and Sharma 1998; Baillie et al. 2004; Mohmod 2014)

Penang Island, a rapidly developing state in Malaysia (Basith et al. 2010; Tan et al. 2010) also faces massive deforestation in the name of development. Penang is industrialising at an average economic growth of more than 8 per cent since 1991 (Weng 2000). Urbanization is going on to support the process but exceeded the capacity of its plain low land and thus development of Penang is progressing totally at the expense of environment (Basith et al. 2010; Weng 2000). Forest cover of Penang has diminished over the years, caused by approved as well as illegal clearing of forests. As a consequence many common flora of Penang Island has become uncommon and rare (Go et al. 2011).

Biodiversity conservation requires immediate practical efforts for conservation reinforced by strong political will, area specific ordinance, backing from civil society, including industry and environmental groups (Bennett 2011; Clements et al. 2010; Masum et al. 2016).

2.2 LUC in Tropical Rain Forest

Most of the LUC in the last two centuries has been done to produce ‘wealth’ which puts land into the class of a ‘producer good’(Farmar-Bowers 2003). In

economics, goods manufactured and used in further manufacturing, processing, or resale are ‘producer good’. But limited resources create pressure on ‘producer good’ with dynamic application of science and technology (like genetic engineering and gene patenting) leading world to a new paradigm. This global paradigm is generating the development of specific landscapes, so that forest and woodland is converted to arable land or grazing land (Farmar-Bowers 2003; Golüke 2002).

Primarily LUC began when since human starts to manage the environment. But an intense LUC has occurred during since 1970 for rapid urbanization globally (Metzger et al. 2006). Natural disturbance like hurricanes, tsunamis, floods, landslides, volcanism and especially wildfires fire also trigger LUC with significant worldwide share (Lepers et al. 2005; Platt and Connell 2003; Thom and Seidl 2015). Hence LUC becomes a dire form of global pressure that are affecting the biodiversity, structure and composition of natural communities, finally ecosystem functioning and services (Metzger et al. 2006; Newbold et al. 2015; Poschlod et al. 2005; Reidsma et al. 2006). It is continuously creating impressive force to nature and leading to substantial shifts in ecosystem by modifying the major biogeochemical cycles of the earth (Chemini and Rizzoli 2003). The natures, rate and spatial scale of LUC are increasing and resulting in an imbalance to the functioning of the earth systems and permanent changes in biodiversity through degradation, fragmentation and elimination of the habitat of biodiversity (Bjørke and Ahmed 2011; Chemini and Rizzoli 2003).

More than 55% of new agricultural land of the tropical area has been developed by clearing the intact forest and another 28% of new agricultural land from disturbed forest during the period of 1980 to 2000 (Gibbs et al. 2010). Tropical forest ecosystem, sustaining 65% of the world’s 10,000 endangered species has already lost 21% of its

forest since 1980 while its human population has nearly doubled (Bawa et al. 2004). Rapid economic development in the form of urbanization, industrialization are exacerbating forces on continuous basis to the tropical forest ecosystem (Bawa et al. 2004; Rudel et al. 2005).

The original causes of tropical deforestation was identified as the prominent influence from economic factors, institutions, national policies, and remote influences while agricultural expansion, wood extraction, and infrastructure extension were recognized as immediate causes (Geist and Lambin 2002). Currently, ther are very few really undisturbed tropical forests present, whereas those reduced by repeated logging and fires, as well as secondary and plantation forests, are rapidly increasing (Bawa et al. 2004; Gibbs et al. 2010).

Tropical forest ecosystem are particularly climate-sensitive. Small changes in climate could affect timing and intensity of flowering and seeding events, with negative effects on forest biodiversity and ecosystem services. LUC in the form of fragmentation and deforestation significantly reduce the species mobility which lead to the risk of species extinction. A large decline in tropical forest biodiversity is thus anticipated because of rapid LUC (and hence climate change) in the tropical area (FAO 2010). Large forest animals and indigenous species of fauna that are distributed sparsely and intolerant of the vegetation neighbouring fragments, are susceptible to local extinction particularly in tropical rain forest (Turner 1996).

Tropical rainforest of Malaysia, which store a big share of global carbon and support a diverse ecosystem, are being degraded by logging, largely due to timber or oil palm production. During the period of 1975-2005 Malaysia lost 5 million hectare of forest (20% reduction in forest) only for palm oil plantation (Wicke et al. 2011).

Besides logging, illegal removal of forest products, forest encroachment, hill development project all around Malaysia also lead to habitat alteration in the tropical rainforest of Malaysia (Hashim and Yaacob 2007; Weng 2000). Moreover land development through the expansion of town and industrial areas leaves no opportunity for sheltering natural heritage site. According to World Bank report, Malaysia is among the more urbanized countries of East Asia. During the period of 2000 to 2010, urban area of Malaysia raised from about 3,900 square kilometres to 4,600 square kilometres with an average annual growth rate of 1.5% (Bank 2015) (Figure 2.3) which has exceeded the annual deforestation rate of 1.4% (Miettinen et al. 2011). Different aspect of LUC research in Malaysia by deforestation is listed in Table 2.2.

Penang is the third largest urbanized state (annual growth rate of 2% urban area) of Malaysia with highest density of population (4200 people per square kilometre) in 2015. It population is increasing from 2000 to 2010 at an annual rate of 4.3% (Bank 2015). This rapid development increasingly creating pressure on forest covered hilly areas which results in forest and biodiversity loss with the increase of soil erosion, landslides, water pollution and flooding hazard (Weng 2009). LUC from natural vegetation creates urban, industrial, commercial, housing and agricultural land use (Chan 1998). LUC study was on Penang Island predicted the effect on land surface temperature and found that urban areas have significantly higher temperatures (one to three degree higher) compared to forested areas (Sin and Chan 2004; Tan et al. 2010). LUC in the way of deforestation has now become a frequent event in Penang. A list of media coverage regarding deforestation in the hill forest area of Penang has been added in Table 2.3.

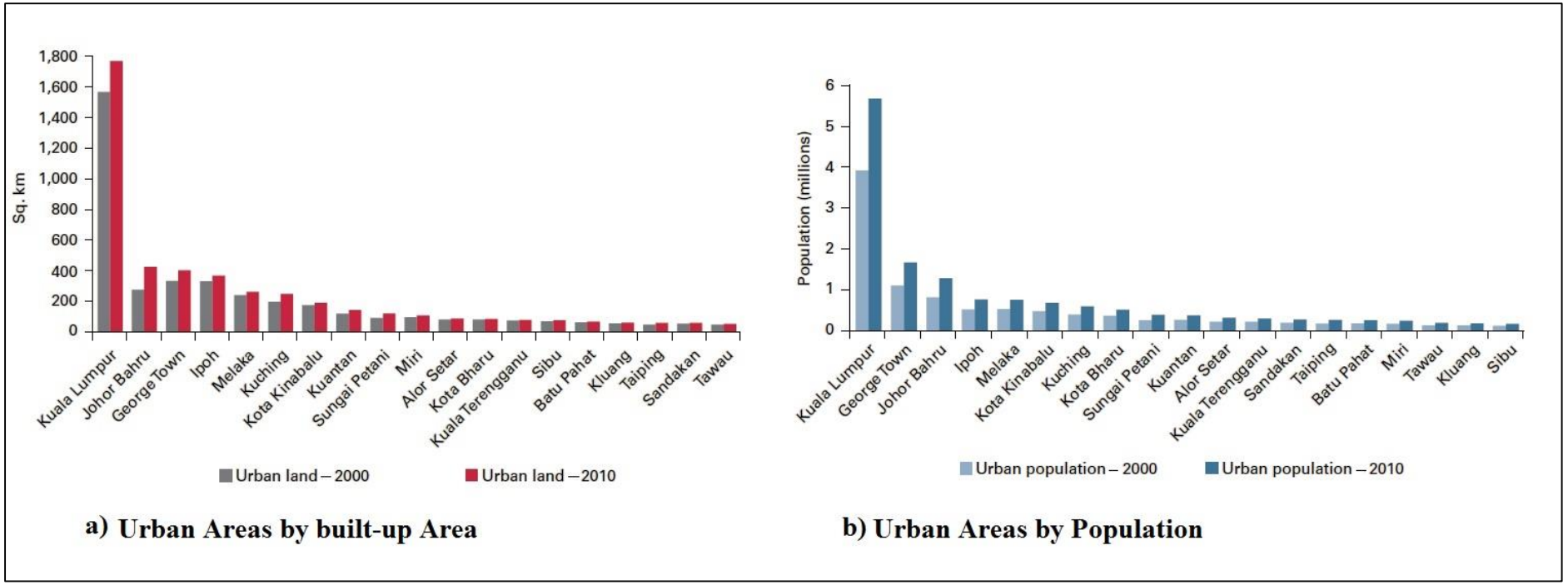

Figure 2.3 Status of major urban areas by built – up area (a) and by population (b) in Malaysia during 2000 and 2010 (Source: Bank 2015)

Table 2.2 LUC research in Malaysia with their objectives and findings.

Contributors	Research objectives and findings
(Abdullah and Nakagoshi 2007)	The study examined how anthropogenic LUC is related to forest fragmentation. Using state of Selangor as a case study they found that human induced LUC as an important determinant of forest fragmentation
(Jusoff and Senthavy 2003)	The study assessed the LUC due to the pressure from development in northern part of Gua Musang district, Kelantan from 1990 to 1997. It revealed an increase of shrub cover, palm oil plantation, rubber plantation, mixed horticulture, diversified crops, urban and paddy area with significant decrease in undisturbed and disturbed forest area.
(Marzuki, Masron, and Rofe 2012)	This paper recognises how changes in land use patterns influence the evolution of beach resort development along Batu Feringghi Beach in Penang Island from 1982 to 2009. Study revealed that about 100 acre area of reserved forest has been transformed into transportation, open space, recreational/vacant land, business/residential land uses by this time period.
(McMorrow and Talip 2001)	The inquiry measured the decline of forest and established its relationship to state policies, land code and land capability. Study identified commercial estate agriculture, especially oil palm as the major cause of forest loss, aided by Sabah's land tenure code and the ethnic equality and modernisation agendas of national and state agriculture policy.
(Nik 1988)	The work examine the effect of forest land conversion (to agriculture land) on water yield changes in three catchment of Tekam River, Pahang from 1977 to 1986 and found a significant increase in water yields.
(Norazhar et al. 2013)	They investigated the LUC and its impacts towards the soil stability on the sediment loading in Padas River sub-catchment using satellite images. Study showed that the conversion of forest and rubber areas to palm oil and urbanized area around the sub-catchment area have increased the sediment contribution to Padas River by 10.07% from 1991 to 2010.

Table 2.2 Continued

Contributors	Research objectives and findings
(Olaniyi et al. 2012)	The study assessed the drivers of coastal land use change in Malaysia using land use map. Results indicated that agricultural practises were particularly responsible for coastal land use change. The impact of urbanization was also identified as a rising factor of coastal land use change.
(Phua et al. 2008)	The research work detected deforestation from multitemporal Landsat data in and around the Kinabalu park, Sabah. It revealed a slower rate of deforestation in Kinabalu area and relatively less deforestation inside the Kinabalu Park area compared to outside.
(Samat, Hasni, and Elhadary 2011)	This paper integrated geographical information system (GIS) with Markov Cellular Automata Model to evaluate land use changes and forecast land use pattern until the year 2020 for Seberang Perai region of Penang State which experience significant land use transformation since the 1970s. It assessed significant changes of LUC since 1990s and predict the continuity of same urban growth pattern toward southern districts.
(Tan et al. 2010)	The paper investigate and evaluate the impact of land surface temperature (LST) with respect to land use changes in Penang Island using Landsat satellite images captured in 1999 and 2007. Study revealed an increase of urban area in Penang by 13.63% annually. Impacts of urbanisation did not result in a great deal of variety of LST with a temperature because of high annual humidity.
(Wicke et al. 2011)	The study analyses national-level data on land use change (LUC) and its causes in Malaysia over the past 30 years and explores the role of palm oil on LUC. It also projected the growth of palm oil production that may lead LUC until 2020. It reveals of 20% reduction of forest land and also large changes in permanent cropland with an expansion projections for oil palm range from 0.06 to 5 Mha.

Table 2.3 Collection of some selected Penang hill forest deforestation news.

News Agency, Date	News summary
nst.com.my/news 13 December 2015	Soil expert and scientist Datin Dr Kam Suan Pheng told that development on the barren hilltop of Bukit Relau has not stopped and has actually worsened with major soil erosion. (Nambiar and Kaur 2015)
greatermalaysia.com 13 August, 2015	New Straits Times special probes team had revealed massive excavation works carried out in many hills on mainland (Lin 2015).
sg.news.yahoo.com 10 August 2015	Quarrying on mainland Penang were carried out by both licensed and unlicensed operators over the past 10 years, is fast changing the landscape of the northern state of Penang (Dermawan 2015)
themalaymailonline.com 5 June, 2015	A developer has stripped Bukit Laksamana in the Teluk Bahang forest reserve of 4.47 ha of trees and greenery for the construction of 36 chalets ignoring a court order obtained by the Southwest District and Land Office to stop the illegal project. (**a reserved forest**) (Afandi 2015).
therakyatpost.com 21 April, 2015	Sahabat Alam Malaysia (SAM) slams Penang government over forest reserve conversion. They claim that Penang government has come under fire for allegedly converting gazetted hill forest reserve lands into residential zones in many areas on the island. The affected areas were Paya Terubong in Air Itam, Sungai Ara and Sungai Batu in Bayan Lepas, Bukit Relau and Bukit Gambier. The environmental group also wanted the state government to stop the rampant conversion of hill forest reserves into housing development zones. (Noordin 2015).
themalaymailonline.com 16 March, 2015	Referring to the latest illegal hill-clearing incident on Bukit Gambir and similar past incidents, Penang Citizens Awareness Chant Group (CHANT) coordinator Yan Lee said the developers in Penang no longer fear flouting the law and became unafraid of Penang authorities, (Shankar 2015).

Table 2.3 Continued

News Agency, Date	News summary
themalaymailonline.com 14 February, 2014	The Sessions Court fined Bukit Relau landowner General Accomplishments (GA) RM30,000 under Section 70(A) of the Street, Drainage and Building Act after it was found guilty of carrying out development without permission from the local authorities and direct GA to rehabilitate the degraded hill forest (Kay 2014).
freemalaysiatoday.com 9 December 2013	The proposals in the Penang Hill Draft Special Area Plan (SAP) to promote tourism and develop tourist infrastructures will threaten the peace and tranquillity of this nature reserve and its ecology. (Idris 2013)
socialwatch.org 8 June, 2012	Penang's environment threatened by unsustainable development. Some 70 per cent of mangrove forests here have been destroyed to make way for development projects. High-rise buildings and development projects coming up around the island. The state Environment Department's reported last year that 10 rivers in Penang were classed as polluted (Watch 2012)

2.3 LUC and Satellite Image Application

LUC is a process of transforming the landscape through anthropogenic activities. The magnitude, pace, and spatial scale of human alterations of the Earth's land surface are unprecedented and hence LUC is the most immediate and obvious type of global change (Bewket and Abebe 2013). It is now considered as a basic factor in the operation of environmental and social systems at any scale from regional to global (Aspinall and Hill 2008; NASA 2012). Land use applications encompasses both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use, where does LUC is taking place, extent and over what time scale and how this changes vary from year to year (NASA 2012). This knowledge will help develop strategies to balance conservation, conflicting uses, and developmental pressures. Urban areas are warmer than the surrounding countryside because the greater extent of paved areas affects how water and energy are exchanged between the land and the atmosphere. This increases the exposure of urban populations to the effect of extreme heat event. Decisions regarding land use can thus affect how much our climate will change and what kind of hazards humans and natural systems will face as a result (Brown et al. 2014).

Government agencies have a functional need for land use monitoring, as it is within their target to manage the natural resources of their respective regions. In addition to facilitate sustainable management of the land, land cover and land use information may be used for planning, monitoring, and evaluation of development, industrial activity, or reclamation. Identification of long term LUC may reveal a solution to a shift in local or regional climatic conditions which is the basis of global monitoring for terrestrial resources (Brown et al. 2014). Monitoring LUC now days