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UNU-IAS Policy Report

Climate and Human-Related Drivers of Biodiversity Decline in Southeast Asia

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Climate and Human-Related Drivers of Biodiversity Decline in Southeast Asia

Ademola K. Braimoh

Suneetha M. Subramanian

Wendy S. Elliott

Alexandros Gasparatos

UNITED NATIONS UNIVERSITY

UNU-IAS

Institute of Advanced Studies

United Nations University Institute of Advanced Studies
6F, International Organizations Center
Pacifico-Yokohama 1-1-1 Minato Mirai
Nishi-ku, Yokohama, 220-8502 Japan
Tel: +81-45-221-2300 Fax: +81-45-221-2302
Email: unuias@ias.unu.edu
URL http://www.ias.unu.edu/

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Contents

Abbreviations

ASEAN	Association of Southeast Asian Nations
BOD	Biochemical oxygen demand
CBD	Convention on Biological Diversity
CI	Conservation International
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
ENSO	El Niño/La Niña-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistical Database
GBO	Global Biodiversity Outlook
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
ITCZ	The Intertropical Convergence Zone
LCA	Life Cycle Assessment
MA	Millennium Ecosystem Assessment
Mha	Million Hectares
POME	Palm Oil Mill Effluent
S. E. Asia	Southeast Asia
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
VOCs	Volatile Organic Compounds
WRI	World Resources Institute

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Message from the Director

The world is on the brink of a confounding crisis, which is brought about by a cumulating cascade of factors such as rapid changes in our natural climatic conditions, environmental degradation brought about by unsustainable production and consumption practices, depletion of environmental and biological resources, and a sharp decline in various indicators of well-being. While noting that it is our actions and, often times, inactions that have precipitated these impending crises, it is imperative that we the citizens of our planet should quickly come up with effective measures to mitigate the consequences and adapt to the changes in our natural ecosystems. This would require us to pay more attention to the enhancement and maintenance of natural resources and processes as well-functioning ecosystems with the diversity of resources contained therein so as to enable sustainable production, consumption, and related livelihood activities. Obviously, this would require inputs from various scientific, technological, and allied academic fields in terms of innovations and radically new ideas; from business communities by fostering best practices in the use and disposal of resources and transactions with others in the supply chain; from civil society in fostering responsible stewardship of natural resources and social concerns; and, from governments in terms of development and implementation of appropriate policies that are sensitive to the needs of the diverse sections of the society they govern. And the implications of actions by the various stakeholders need to be analysed in a timely, and, often, anticipatory manner, in order to draw attention to benefits and concerns related to decisions made at different levels.

In this context, I am pleased to state that the United Nations University Institute of Advanced Studies (UNU-IAS) has been actively contributing to advancing awareness of various concerns related to biodiversity and ecosystems among a variety of stakeholders. Our research has straddled areas in the interface between the natural world, human aspirations, and well-being consequences. We have focused especially on the notion of fostering equitable transactions between different stakeholders over the years.

This year, we are launching several new publications that are of particular relevance to the Conference of Parties (COP) to the Convention on Biological Diversity (CBD). The publications examine a diverse set of topics that include, among others, the effectiveness of implementation of national biodiversity strategies by different countries; the governance and management of bio-cultural landscapes such as *satoyama* and *satoumi*; the status of biodiversity in the South East Asian region; the impact of emerging biofuel technologies to the provision of ecosystems services; scoping the role of urban centres in green development; and underscoring the need for bridging epistemological divides between modern and traditional world views in securing development goals and conservation priorities – all of which are topics that are of keen import to the CBD's objectives as well as to the broader sustainable development agenda. I expect each of these publications will provide a basis to inform discussions and facilitate designing of implementable policies in their related areas.

I would like to take this opportunity to thank our partners and collaborators for their support in our research and capacity development activities. There are several expectations from the outcomes of this COP, and we hope to continue our work in the future informing and providing relevant inputs to policy-makers, academics, and practitioners alike.

Govindan Parayil,
Director, UNU-IAS and Vice-Rector, UNU
October 2010

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Executive Summary

Southeast Asia hosts diverse biological resources and cultural milieus that are under different degrees of stress from various factors. This report highlights the key underlying economic, political and natural factors that contribute to biodiversity decline in the region, and provides specific policy directions that could help address the decline.

The report documents the salient biophysical characteristics of Southeast Asia, the current state of biodiversity and the attendant climatic and anthropogenic drivers of biodiversity decline in the region. Specifically, the role of international trade and the expanding oil palm plantations to meet increasing biofuel demands, as well as impact of urbanization and land tenure management systems and changing climatic patterns on biodiversity are clarified.

Policy responses required to augment and maintain a rich biodiversity status in the region are highlighted in the last section. There is a need for periodic assessments, monitoring and appropriate regulation mechanisms as well as the use of innovative financial mechanisms to enhance adaptive capacity. Investments in collaborative research and information sharing and educational initiatives to raise awareness and foster better ties between science and policy networks are a priority.

1. Introduction

Southeast Asia has been recognized as a bio-cultural hotspot. The region hosts diverse biological resources that are under different degrees of stress due to a variety of factors. This report highlights the key underlying economic, political and natural factors that contribute to biodiversity[1] decline in the region, and provide some specific policy directions that could help address these underlying factors.

Section 1 documents concisely the biophysical characteristics of Southeast Asia. Section 2 gives an account of the current state of biodiversity in the region and presents a framework for analyzing biodiversity loss vis-à-vis climatic and anthropogenic drivers with special attention to deforestation and habitat loss. To improve our understanding of biodiversity decline, the framework integrates proximate and underlying factors with the processes of biodiversity loss. Section 3 further covers prominent anthropogenic influence on biodiversity including biofuel production, trade, land tenure systems and urbanization. The synergistic impacts of climate and its interaction with other drivers are discussed in Section 4, followed by policy responses that can curb biodiversity decline in the region in Section 5.

1.1 Background

Southeast Asia extends from Latitude 10° S and 30° N, and stretches between Longitude 90° W and 140° E (Figure 1). It comprises 11 countries with a combined population of over 565 million (Table 1).

The region exhibits marked variation in elevation ranging from 100 m below sea level to over 5000 m above sea level in the mountains of Southwest China[2]. Outstanding diversity in terms of land use, species and habitat can be found in the montane regions. These areas have most of the region's remaining forests, whereas the lower regions are composed of a mix of agroforestry landscapes.

About 72 percent of the population lived in the rural area in 2000, but due to rapid urbanization about half of the population is predicted to inhabit Southeast Asian cities by 2025. This growing urban population is to a large extent responsible for the rapid economic development in the region. However, this economic development is accompanied by considerable exploitation of natural resources, including forest resources, leading to significant environmental degradation.

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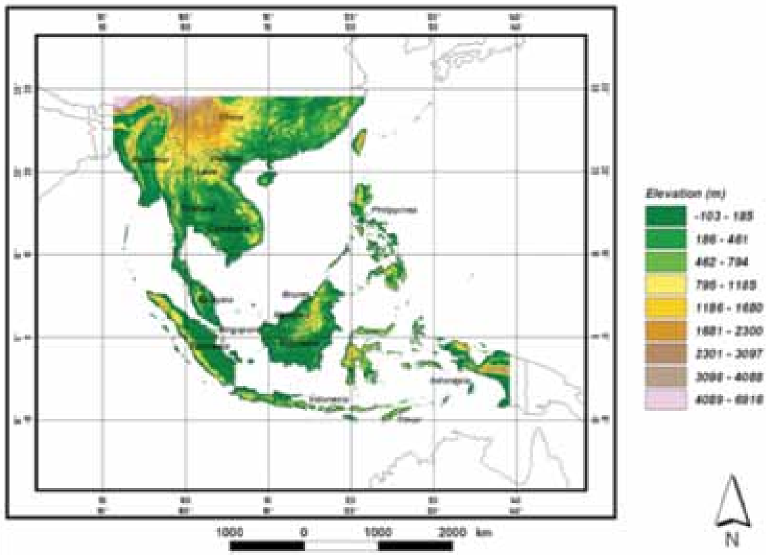
[1] In this report, biodiversity or biological diversity is defined as diversity in genetics, population, species and the ecosystem.

[2] Many studies include Southwest China as part of Southeast Asia. In this report we limit our definition of Southeast Asia to mainly the 11 countries in Table 1.

Figure 1: Physiographic map of Southeast Asia



Source: (Elevation data was obtained from http://glcf.umiacs.umd.edu/ (accessed on 2 May 2010))

Table 1: Land area and population of Southeast Asia

Country	Land Area (1 000 ha)	Forest cover (%)	Percent annual rate of forest change (2000-2005)	Population in 2006 (1 000)	Percent Urban population (2000)	Percent Urban population (2025)	Human Development Index rank (2006)
Indonesia	181 157	49	-2.0	228 864	42	51	111
Philippines	29 817	24	-2.1	86 263	48	55	105
Vietnam	31 007	40	2.0	86 205	24	41	116
Thailand	51 089	28	-0.4	63 443	31	42	87
Malaysia	32 855	64	-0.7	26 113	62	81	66
Myanmar	65 755	49	-1.4	48 379	28	44	138
Singapore	69	3	0.0	4 381	100	100	23
Cambodia	17 652	59	-2.0	14 196	17	26	137
Laos	23 080	70	-0.5	5 759	22	49	133
Timor-Leste	1 487	54	-1.3	1 113	24	36	162
Brunei Darussalam	527	53	-0.7	381	71	81	30
South East Asia	**434 495**	**47**	**-1.3**	**565 097**	**38**	**50**	**-**

Data sources: (FAO, 2009; UNDP, 2009; UN-DESA, 2009)

1.2 Climate Patterns and Variability

The high mountains and the complex land-sea configuration of Southeast Asia have a strong influence on weather and climate. Three distinct rainfall regimes can be identified across the Southeast Asian region (Kripalani and Kulkarni, 1998; Table 2). A substantial proportion of the annual precipitation over most of the region is received during the summer period of the northern hemisphere.

Table 2: Major characteristics of the three rainfall regimes of Southeast Asia in comparison to the northern hemisphere seasons

Rainfall regime	Description	Major characteristics	Countries/Areas
Asian Monsoon Region	Continentality with high mountains is the contributor to enhancement of summer monsoon	High precipitation (maximum of 1150mm in July) on the western slopes and along Myanmar-Thailand frontier as a result of orography and the Southwest monsoon laden with moisture from the Bay of Bengal. In areas 20 – 25 degrees N, appreciable rainfall (300 – 500mm) is observed during summer monsoon months due to the Inter-Tropical Convergence Zone (ITCZ). In the autumn, the Vietnam coast receives maximum rainfall of 550mm in October due to winter atmospheric circulation, whereas there is a marked decrease in rainfall from July to October over the Arakan coast.	Myanmar, Thailand, Vietnam, Laos, Cambodia
Equatorial Monsoon Region	This region is influenced by the North Australian-Indonesian monsoon regime. The continent ocean-heat contrast makes it the strongest component of the southern hemisphere circulation.	Areas around Malaysia, Brunei and Sulawesi receive more rain during northern winter, while for areas between Latitude 110° – 120°E, the northwest winds during the southern summer monsoon bring more rainfall (500 – 700 mm). The region lying between the Equator to Longitude 5°S between Sulawesi and New Guinea receives relatively high precipitation during the northern summer monsoon period in July. The movement of the ITCZ in the equatorial zone also causes rain to fall in spring (April) and autumn (October).	Singapore, Malaysia, Indonesia, Sumatra, Timor-Leste, Borneo and Brunei

Rainfall regime	Description	Major characteristics	Countries/Areas
Pacific Monsoon Region	This region is subject to the influence of Western North Pacific Monsoon regime with less significant continentality.	The maximum rainfall on the northwest coast is attained during the moisture-laden southwest monsoon in July, whereas the maximum rainfall of the east coast is attained during the northeast monsoon blowing from the Pacific.	Philippines

Source: (Synthesized from Kripalani and Kulkarni ,1998)

The primary source of inter-annual variability in climate in Southeast Asia is the El Nino-Southern Oscillation (ENSO) phenomenon. ENSO results from the interaction between large-scale ocean and atmospheric circulation processes in the equatorial Pacific Ocean. There is a correlation between ENSO and precipitation anomalies in Southeast Asia. Precipitation associated with warm ENSO events (El Nino) tend to be below normal with a larger range of variation, whereas that associated with cold events (La Nina) tend to be above normal with a smaller variation range (Xu *et al*., 2004; Kripalani and Kulkarni, 1997).

Recent studies indicate that between 1955 and 2007, annual mean, maximum and minimum temperatures increased by 0.17 degrees C per decade and 0.24 degrees C per decade respectively over the Asia Pacific region (Choi et al., 2009). These increases surpassed the warming rate of global mean surface temperature (0.13 ± 0.03 degrees C per decade) between 1956 and 2005 (IPCC, 2007). The rate of increase in minimum temperatures is generally greater than that of maximum temperatures (Table 3)

Table 3: Linear trends (degrees C per decade) in maximum and minimum temperatures in Vietnam, Thailand and Malaysia

Countries	Maximum temperature			Minimum Temperature		
	Winter	Summer	Annual	Winter	Summer	Annual
Vietnam	0.250	0.187	0.242	0.273	0.178	0.206
Thailand	0.161	0.203	0.164	0.559	0.261	0.361
Malaysia	0.192	0.162	0.157	0.236	0.255	0.230

All the trends are significant at the 95% level (Choi et al., 2009)

Significant changes in annual, seasonal maximum and minimum temperature means are associated with changes in frequency of extreme temperature events in the Asia Pacific Region (Choi et al., 2009). Between 1955 and 2007, average frequency of cool nights decreased by 6.4 days/decade, whereas that of cool days decreased by 3.3 days per decade. On the other hand, the frequency of warm nights increased by 5.4 days per decade whereas that of warm days increased by 3.9 days per decade over the same period. Further analysis by Choi *et al.* (2009) indicate that the rate of change of the frequency of warm and cool days and warm nights has accelerated considerably since the late 1980s, whereas the frequency of cool nights has decreased more or less linearly since the mid-1950s. The strongest changes in extremes are observed in northern tropical regions including Malaysia and Thailand, where the maximum decrease rate in annual frequency of cool nights amounts to -22 days per decade, and the maximum increase rate of annual frequency of warm nights rises to 25 days per decade.

Unlike temperature, seasonal and annual precipitation in Asia Pacific does not manifest spatially coherent trends. Whereas there are linear trends in annual and seasonal total precipitation between 1955 and 2007, these trends are not statistically significant. The increase in seasonal total precipitation is largely due to increases in intensity of rainfall events (Choi *et a*l., 2009). Summarily, the seasonal shifts in weather have exposed the region to annual floods and droughts.

1.3 Future Climate of Southeast Asia

Table 4 summarises the Intergovernmental Panel on Climate Change (IPCC) projections on the likely increase in seasonal surface air temperature and percent change in seasonal precipitation for Southeast Asia using 1961 to 1990 as the baseline period (IPCC). The data suggests an acceleration of warming and more uncertain changes in precipitation during the 21st century. An increase in the occurrence of extreme weather events including heat-wave and intense precipitation events is also predicted for South-East Asia (IPCC, 2007). Sea-level rise, floods and droughts will continue to impact the livelihood of the people. Knutson and Tuleya (2004) predict an increase of 10% to 20% in tropical cyclone intensities for a rise in sea-surface temperature of 2°C to 4°C relative to the current threshold temperature in East Asia, South-East Asia and South Asia.

Changes in climate directly affect material fluxes and the temperature regimes at which chemical transformations occur. In addition, changes in extreme temperature events as well as monsoonal shifts in climate patterns have begun to have dramatic effects on natural resource based economies of the region (Talaue-McManus, 2001).

Table 4: Projected changes in surface temperature and precipitation for Southeast Asia (IPCC, 2007)*

Months	**2010 – 2039**				**2040 – 2069**				**2070 – 2099**			
	Temperature (degree C)		Precipitation (%)		Temperature (degree C)		Precipitation (%)		Temperature (degree C)		Precipitation (%)	
	HFE	LFE	HFE	LFE	HFE	LFE	HFE	LFE	HFE	LFE	HFE	LFE
Dec – Feb	0.86	0.72	-1	1	2.25	1.32	2	4	3.92	2.02	6	4
Mar – May	0.92	0.80	0	0	2.32	1.34	3	3	3.83	2.04	12	5
Jun – Aug	0.83	0.74	-1	0	2.13	1.30	0	1	3.61	1.87	7	1
Sep – Nov	0.85	0.75	-2	0	1.32	1.32	-1	1	3.72	1.90	7	2

* HFE = highest future emission trajectory scenario; LFE = lowest future emission trajectory

2. Biodiversity in Southeast Asia: State and Drivers of Decline

2.1 Global Trends

Currently, global biodiversity is changing at an unprecedented rate and scale in response to human-induced perturbation of the Earth System. Fossil records indicate that the background extinction rate (that is Pre-Industrial value) for most species is 0.1 – 1 extinctions per million species per year. Over the past years however, the species extinction rate has increased to more than 100 extinctions per million species per year (MA, 2005a). There is a strong linkage between biodiversity loss and human-driven ecosystem processes from local to regional scales.

In spite of the commitment of Governments in 2002 to curtail the rate of biodiversity loss by 2010, virtually all regions of the world are currently experiencing alarming rates of biodiversity decline (GBO, 2010[3]). Notwithstanding some policy and management response successes, there have been severe declines in population trends of vertebrates, habitat specialist birds, shorebird populations, and extent of forest and mangroves as pressures on biodiversity increase across world regions (Butchart *et al*., 2010).

2.2 State of Biodiversity and Biodiversity Hotspots

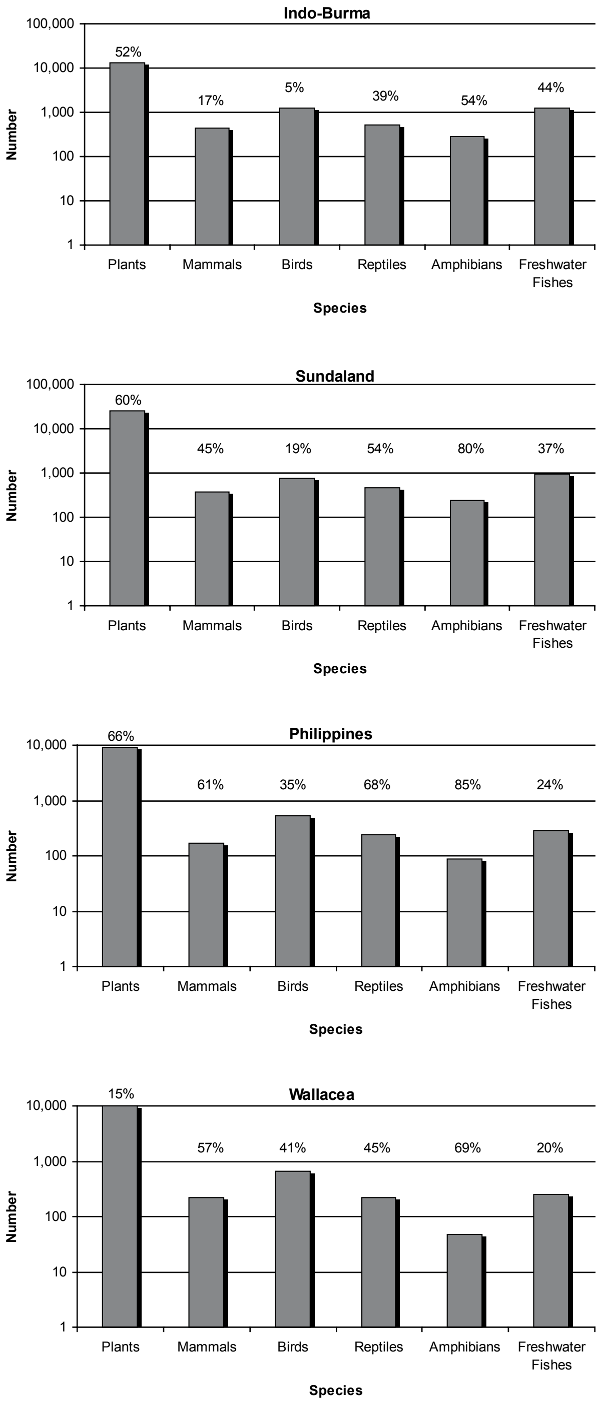
Southeast Asia is one of the most biodiverse regions of the planet. Even though the region occupies just 3 per cent of the world's surface, it accommodates about 20% of all plant, animal and marine species. Southeast Asia includes 3 mega diverse countries (Indonesia, Malaysia and Philippines) and contains 4 of the world's 25 biodiversity hotspots[4] as designated by Conservation International (CI) (Figure 2). Most of the countries in the region fall within the Indomalaysia/Melanesia landmass, categorized as one of the three core areas of biocultural diversity (Maffi, 2007). As such, communities hold a rich germplasm of landraces of various crops. For example, an on-farm/community diversity of crops survey found that rice richness in Vietnam varied from 9 to 74 varieties per community (Jarvis *et al*., 2008).

Endemicity of plants in these biodiversity hotspots varies from 15% for Wallacea to 66% for Philippines. For example, in the Philippines there are 9,250 vascular plant species with 65.8% endemism, 1000 species of orchids and 165 species of mammals (102 endemic and 47 threatened) as reported by the ASEAN Centre for Biodiversity.

[3] Secretariat of the Convention on Biological Diversity, 2010, Global Biodiversity Outlook 3, Montreal.

[4] A biodiversity hotspot is a biogeographical region rich in biodiversity but under anthropogenic threat. Biodiversity hotspot designation is developed to assess global conservation priority. It is based on the criteria that the region must contain at least 1500 species of endemic vascular plants and 70% of its original habitat must have been lost (Myers *et al*., 2000).

Figure 2: Total number of species and endemism in Southeast Asia



The bars represent the number of species, whereas the percentages correspond to endemism of each species (Data source: http://www.biodiversityhotspots.org, accessed on 28 April 2010)

The aforementioned biodiversity hotspots are not the only areas in the region that harbor high biodiversity and high numbers of endangered species. Montane ecosystems throughout the region are particularly noted for the diversity of species that they accommodate (refer to Box 1).

Box 1: Biodiversity of montane ecosystems in Thailand

Several of the upper and lower montane forest habitats in Thailand receive protection as national parks and sanctuaries where subalpine vegetation and varying dominant tree species and forest structure between the eastern and northeastern and southern peninsular regions can be found. Protected areas cover about 20% of land area. However, the ecological services areas face pressures from rural poverty and population migration to mountains, deforestation to cropland, overgrazing and degradation (Thailand 3rd National Report on the Implementation of the CBD, 2006). Overall, in Southeast Asia habitat loss has been characterized as particularly severe (Sodhi and Brook, 2006).

Thailand has 302 species of mammals of which 116 are considered threatened. There are 35 endangered species including the Asian tapir (*Tapirus indicus*) found only in the western and southern mountains of Thailand and the tiger (*Panthera tigrus*) of which only 75 are found in the mountain regions. There are also at least 66 endangered bird species including the Rufous-necked hornbill (*Aceros nipalnesis*) whose habitat in the evergreen forests is being destroyed. There are also about 1,424 threatened plant species with 94 endangered wild species of forest plants several of which are collected for sale and illegal trade (wild animals are also illegally traded) and also face habitat destruction (Thailand Third National Report on the Implementation of the Convention on Biological Diversity, 2006).

Even though a small number of species has actually become extinct from the region, the relatively recent deforestation history and the associated fragmentation of natural habitats is expected to accelerate biodiversity decline in the coming years (Sodhi et al., 2004). Several species native to the area are currently considered as vulnerable (VU), endangered (EN) or critically endangered by the International Union for the Conservation of Nature (IUCN, 2010).

2.3 Drivers of Biodiversity Loss

Sala *et al*., (2000) recognize five major drivers of biodiversity loss, namely land use, climate, nitrogen deposition, biotic exchange and atmospheric carbon dioxide. The importance of these drivers varies from one ecosystem to the other. Land-use change (especially deforestation) and climate change generally have the greatest impact for terrestrial ecosystems, whereas biotic exchange is more important for freshwater ecosystems (Sala *et al*., 2000; Table 5).

Table 5: Impact of a large change in each driver on the biodiversity of selected world biomes by 2100

Driver	Boreal Forest	Grassland	Savanna	Southern Temperate Forests	Tropical Forests
Land Use	5.0	5.0	5.0	5.0	5.0
Climate	3.5	3.0	3.0	2.0	3.0
Nitrogen deposition	3.0	2.0	2.0	3.0	1.0
Biotic Exchange	1.0	2.0	2.0	3.0	1.5
Atmospheric Carbon Dioxide	1.0	3.0	3.0	1.5	1.0

Note: Unit change of the driver was defined for land use as conversion of 50% of land area to agriculture, for climate as a 4°C change or 30% change in precipitation, for nitrogen deposition as 20 kg ha^{-1} $year^{-1}$, for biotic exchange as the arrival of 200 new plant or animal species by 2100, and for CO_2 as a 2.5-fold increase in elevated CO_2 as projected by 2100, Estimates vary from low (1) to high (5) impact based on scenario modeling and expert knowledge (Sala et al., 2000).

A suitable framework for assessing biodiversity decline in Southeast Asia is presented in Figure 3. The framework recognizes that the processes of biodiversity loss are driven by a combination of proximate factors and underlying drivers. Proximate causes are near final or final human activities (e.g. agricultural expansion) that directly affect the environment, whereas the underlying forces (e.g. population growth) are the root causes or fundamental factors behind the proximate sources. Proximate factors operate more at local scales, whereas underlying forces can operate at scales ranging from national to global (Turner et al., 1993). Attention is more often focused on proximate causes of biodiversity loss (e.g. Sodhi *et al*., 2004), but conservation actions that consider or address only proximate causes or single drivers of biodiversity loss are unlikely to be effective because most often drivers act synergistically in threatening biodiversity.

Of the various processes leading to biodiversity loss, the most notorious is habitat destruction (Primm and Raven, 2000), an environmental process that renders habitats unsuitable to support species. Considering that tropical forests are the key habitats, habitat loss due to deforestation is a major driver of biodiversity loss in the region. However, before discussing the key driving factors vis-à-vis their impacts on biodiversity in Southeast Asia (Sections 3 and 4), we first highlight the inextricable linkage between deforestation and habitat loss.

Currently, the proportion of land area occupied by forests in the region varies from 3 percent for Singapore to 70 percent for Laos, but the annual regional rate of deforestation (1.3 percent) is among the highest in the world (Table 1). In most Southeast Asian countries, forest area change has been negative despite implementation of afforestation and reforestation projects. For example, Thailand's forest resources including evergreen montane rainforests were markedly reduced between the 1960s and 1980s by conversion to agriculture, land resettlement, and dam and road construction. Indonesia also experienced high rate of deforestation between 1990 and 2005. In fact, after Brazil, Indonesia suffered the next largest annual forest loss between 2000 and 2005 at a rate of -1871 thousand ha/year (FAO, 2010a). This gives some support to predictions that in the absence of appropriate intervening policies, by 2100, a quarter of biodiversity in Southeast Asia may be wiped out by deforestation (Sodhi and Brook, 2006).

Figure 3: Driving forces and processes of biodiversity loss in Southeast Asia

Underlying drivers
- Human population growth
- Poverty
- Urban expansion
- Policy failures
- Institutional failures
- Trade and globalization
- Climate Change and other natural factors

Proximate factors
- Agricultural expansion
- Biofuel production
- Wood extraction
- Infrastructure development
- Biomass burning

Processes of biodiversity decline
- Habitat conversion
- Habitat degradation
- Habitat fragmentation
- Species introduction
- Overexploitation

Box 2: Linking forestry, agriculture, mining with deforestation in the Philippines

Historically, deforestation in the Philippines has been driven by commercial and community logging. Slash and burn agriculture and forest land conversion are also major proximate causes of forest cover loss (Kummer, undated).

Logging between 1969 and 1998 was at 2,000km^2 annually (CI, 2009). Illegal logging is still occurring in several provinces though logging and any commercial exploitation of old growth forests were banned in 1992 under the National Integrated Protected Areas Act. Even though the forestry sector has such a large impact on biodiversity and landscapes, in 2006 the forestry sector in Southeast Asia had only 0.4% of the total labour force whereas in the Philippines it captures 0.1% of the labour force with contributions of USD 560 million to the economy (FAO, 2009). There has been high export demand placed on timber, by importing countries such as Japan. In a critical analysis of the state of deforestation in Malaysia, Philippines and Indonesia, Dauvergne (1997) identifies the major drivers of forest loss as domestic forest policies aided by subsidies and loans and lack of political will to address deforestation and the associated environmental problems coupled with foreign aid, import tariff incentives from buyer countries and usurious private rent-seekers both from inside the country and abroad.

In the 1600s old growth forest that covered over 90% of the Philippines decreased to 7 percent by 1997, a decline considered as the most rapid and severe in the world (Heaney et. al., 1998). Forests in the Philippines are threatened by population pressure with a population density of 1000 persons to 83 hectares of forests in 2005 (FAO, 2009). The country also has a large rural population heavily dependent on natural resources and agriculture. In the Cordellia regions, 92 percent of the 1.3 million are indigenous peoples predominantly dependent on agriculture. In this region open pit mining and upper mossy forest conversion to small scale agricultural plots and lower elevation large-scale agriculture and overlapping land uses have tremendous impact on ecosystem services of the mountainous region and management of protected areas (Ga-ab, 2008). Mining activities are also an imminent threat to the Philippines forests as mineral resources are found often in areas rich in biodiversity, populated by indigenous peoples. In 1997, mining activities covered more than half of the remaining forests (CI, 2009).

Apart from its impact on biodiversity, deforestation can directly affect human wellbeing. Indeed, forest ecosystems provide important goods and services for human livelihoods and environmental health. Such goods and services include water, energy, landslide protection, agricultural/forest products and genetic material. At the same time forests are important biological reserves that can detect and modulate regional climate change patterns as well as moderate the occurrence of infectious diseases (Beniston, 2003 in IPCC, 2007; Foley et al., 2007). Forest ecosystems also store terrestrial carbon in biomass and soils interacting in the carbon cycle between air and land. Additionally, depending on the integrity of natural forests and how they are managed they can be a source of atmospheric carbon. The carbon density of Southeast Asian forest can be up to 500 Mg/ha but logging and conversion to agricultural land can reduce the carbon density to less than 40 Mg/ha (Lasco, 2002).

Forest degradation has resulted in increasing frequency and intensity of floods and droughts, erosion, landslides, siltation of coral reefs and decreased groundwater supplies (Heaney et. al., 1998). In 1993, 1995, and in 1997 the number of floods occurring in the Philippines were 26, 34, 38 respectively (ADB, undated). In mid-December of 2003, a series of landslides occurred in the Philippines province of Southern Leyte as hillside soils became saturated (NASA, undated). These events can be linked to deforestation.

3. Human Related Drivers of Biodiversity Decline

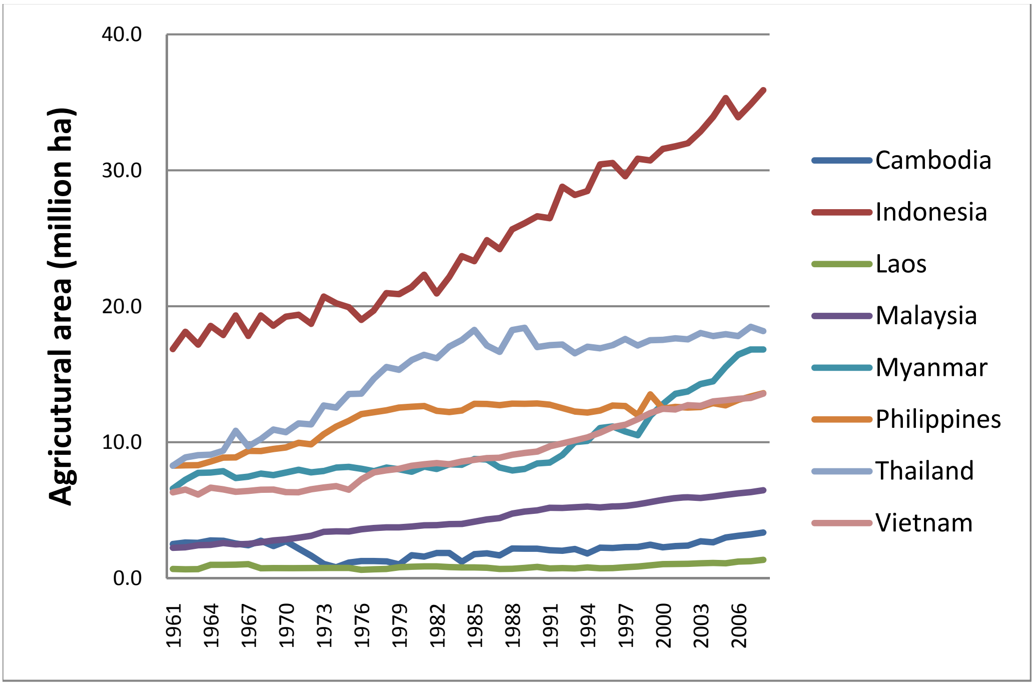
3.1 Agriculture

3.1.1 Agricultural Expansion

Agriculture contributes significantly to the GDP of most countries in the region, for example 33% of GDP in Cambodia and 11.4% in Thailand (FAO, 2006). Agricultural labour has been decreasing simultaneously with a decrease in rural populations in the region, for example, in Malaysia it decreased from 41% in 1979 to 16% in 2004 (FAO, 2006). Even so, several countries still have large rural populations largely dependent on agriculture (Zhai and Zhuang, 2009). Cambodia's rural population remained relatively high moving from 88% in 1979 to 81% of total population in 2004 (FAO, 2006).

At the same time the production and trade of agricultural commodities has increased significantly throughout the region since the 1960s. With the exception of Cambodia and the Philippines, all other countries have more than doubled their cultivated area (see Figure 4). This agricultural expansion is mainly at the expense of natural ecosystems and particularly primary forests.

Figure 4: Agricultural land use in S.E. Asia

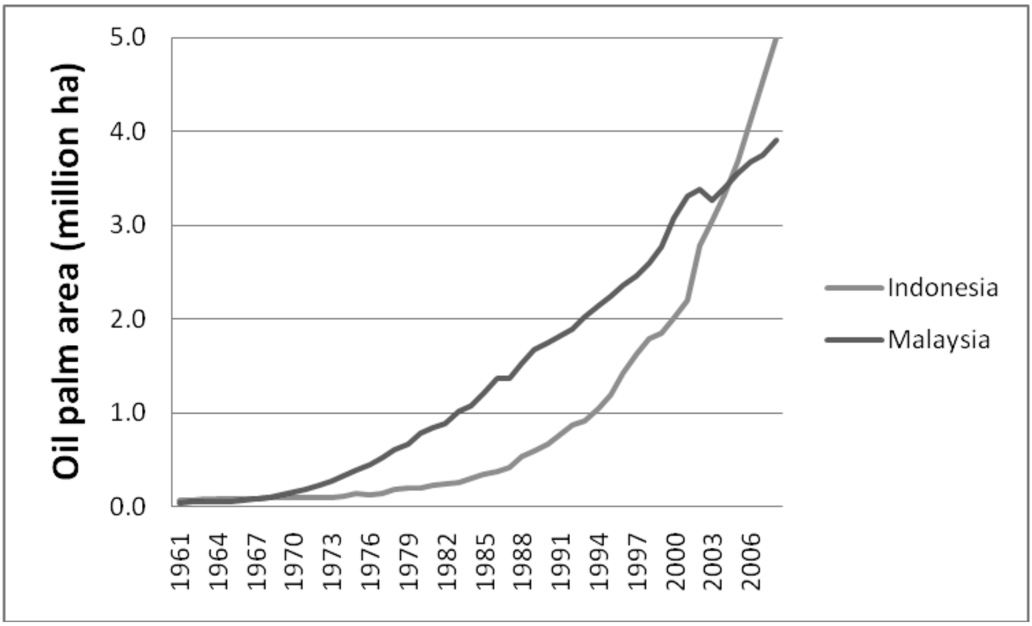


Source: (FAO, 2010b)

Even though this agricultural expansion is to be expected in a region that faces some of the highest incidences of malnutrition globally, it is interesting to note that the expansion happened simultaneously with an increase in the trade of agricultural commodities (see section 3.4). An interesting example is the case of oil palm cultivation in Indonesia and Malaysia[5]. Estimates indicate that both countries have increased their cultivated land area by 113.1% and 189.2% respectively between 1961 and 2007 (FAO, 2010b) with a significant fraction of this agricultural expansion being the result of oil palm expansion (refer to Fig. 5). In 2008, oil palm plantations, constituted 13.9% and 60.2% of the total agricultural land in Indonesia and Malaysia respectively. As a result, Indonesia and Malaysia have become the major oil palm exporters capturing more than 90% of the global market. In fact, Malaysia appears to have shifted its focus from rubber to palm oil exports in order to capitalize on the multiple demand of oil palm for food and energy (biofuel). However, this agricultural expansion did not come without any adverse environmental effects.

Agriculture, extensive monoculture in particular, is a significant driver of biodiversity decline (MA, 2005b). Sodhi *et al*. (2004) suggest that conversion of primary forest for agricultural uses has a particularly detrimental impact on biodiversity given the combined effects of habitat loss/fragmentation and the subsequent depletion of nutrients from the soils. Oil palm plantations are particularly hostile to biodiversity and are major agents of deforestation and other drivers of biodiversity loss (see Section 3.2 for more details).

Figure 5: Oil palm expansion in Indonesia and Malaysia



Source: (FAO, 2010b)

[5] Palm oil is the most produced and traded vegetable oil globally (FAO, 2010). As a result it has traditionally been an important part of the diet in several areas of the world. However, significant amount of palm oil is now used for the production of transport fuel (i.e. biodiesel), refer to Section 3.3.

3.1.2 Land Management and Tenure Systems

Disturbed lands broadly refer to any land that includes secondary, fragmented and selectively logged forests. Swidden lands can also be categorized as disturbed lands as swidden agriculture involves "cutting living vegetation in the dry season, letting it dry, burning it late in the dry season and then planting a crop in the ashes early in the wet season" (Fox and Volger, 2005). Swidden cultivation has been the predominant method of cultivation in Southeast Asia for centuries. Although it still comprises 25-33% of land use in the region, swidden cultivation has progressively decreased, giving way to settled and commercial cultivation of crops such as paddy, tree crops and oil palm, rubber and timber plantations. Swidden lands also go through a cyclical process of cultivation, fallow and secondary growth. Secondary growth in these tropical regions has been observed to be species diverse and useful to sequester carbon (Padoch *et al.*, 2007).

Swiddeners consciously cultivate a diverse set of landraces and varieties of a crop adapted to local conditions, which are increasingly lost during the process of commercialization. For example, in Vietnam, currently only five genetically engineered varieties of rice are cultivated on a large scale versus 20 traditional varieties commonly cultivated earlier (Cassellini, 2001). Similar reports from Thailand indicate that there has been a decrease in the number of rice germplasm collections in the country, as farmers have taken to planting new varieties, and paddy fields are giving way to urban development. This is the case of several indigenous varieties, which have been lost due to loss of natural habitats (Thailand Third National Report on the Implementation of the Convention on Biodiversity, 2006). The reduction in swidden cultivation is also a result of government policies to promote nature preserves, other development projects and encourage commercial cultivation of cash crops and plantations.

While some researchers call for a revisit of policies towards swidden farming, it is also noteworthy that the extent of this practice has not been properly documented and such land use is usually classified as 'other' types of forest/ degraded forests/ secondary growth, thereby obstructing efforts to monitor benefits from such land use practices. Community-led environmental governance is being increasingly recognized and mainstreamed into forest conservation policies such as Community Forest Programs. Such initiatives have led to a significant increase in forest regeneration and an improvement in diversity (Ravindranath et al., 2006). Most recently the direct impact of rural peoples on tropical forests appears to have stabilized and could even be diminishing in some areas (Butler and Laurence, 2008).

Other cultivation practices harmful to biodiversity include drainage, fertilizer run-off from the plantations and the use of agrochemicals (refer to Section 4.2). For example, approximately 25 different pesticides are deployed in oil palm plantations in Indonesia, which are not monitored as they are not controlled or documented (Down to Earth, 2005) Owing to government subsidies on pesticides and farm chemicals in Vietnam, pesticide applications by farmers on field crops and orchards exceeded the permissible limits by 2 – 45 times, leading to increased pest resistance along with other ecological impacts.

Land Tenure

Land tenure is highly diversified in Southeast Asia. A recent study of land tenure systems in the region indicates that neither state nor private/customary land allocation guarantees tenure security (Table 6). Land tenure problems in the region relate to fragmented policy frameworks that result in multiple laws and regulations that weaken the negotiating positions of landholders, increase land disputes, complicate co-ordination between different government departments concerned with land administration, and hinder adequate land financing opportunities (Guo, 2007). In countries such as Vietnam where liberalization allowed a free market whilst the state retained formal ownership, there has been a sharp increase in rural landlessness amongst the poor and the non-poor (Ravallion and van de Walle, 2008). The impact of the landless or "shifted cultivators" on biodiversity has long been recognized in the literature (e.g. Myers, 1985). Due to lack of alternatives, the landless shift to available unoccupied public land – usually forests. The lack of tenure security in the new found land also implies lack of incentive to invest in environment-conserving technology. Clearly, these are challenges that need to be overcome, within the political realities of a country, to ensure better land management and developing pragmatic land tenure systems is seen as an essential driver to this effect, whether they be in terms of clear title deeds, or clear terms of usufructory rights between different stakeholders.

In recent times, most governments in Southeast Asia have reworked tenure systems in forest areas and have reclassified previously community-held and managed lands as nature preserves belonging to the State. It is noteworthy that the degree of removal of non-wood forest products is very low in countries where state ownership is complete. Conversely, in Vietnam, where state control is mixed with private and other forms of control over forests, the forests continue to be accessed for non-wood requirements including food, medicine and cultural purposes (FAO, 2005a). Relocation of people from their native areas to new locations has triggered degradation in the new areas as they were observed to be less caring of their new environments than their culturally linked lands (Cassellini, 2001), apart from the population pressure on limited spaces in the new areas (Fox and Volger, 2005).

Table 6: Classification of land tenure systems based on land allocation and tenure security

	Greater role of private or customary allocation	Greater role of state land allocation	Greater security of tenure	Less security of tenure
Thailand	√		√	
Vietnam		√	√	
Laos		√		√
Cambodia		√		√
Philippines	√			√
Indonesia	√			√

Source: (Modified from Guo, 2007)

It is understandable that different countries have different approaches to secure land tenure systems for different stakeholders. It is imperative that the policies are pragmatic within the socio-political contexts, to allow conflict free use and management of lands for different production purposes. While in some cases, clear title deeds have been found effective, in some other cases as in Thailand, use of customary allocation of land and resources have been found effective. In either case, the terms of ownership and use are clear that allows decision making with minimal externalities.

3.1.3 Agriculture as a driver of climate change

Agricultural activities are significant emitters of global greenhouse gases (GHGs) and as such agricultural activity is a major driver of anthropogenic climate change. Emissions from agricultural sources was 14% of global GHG emissions in 2000 with developing countries accounting for three quarters of agriculture emissions in the case of rice (WRI, 2006; Stern, 2007). Climate change has been identified as a potentially significant threat to biodiversity in the region (refer to Section 4).

As forests are cleared in the region for agricultural purposes, crop residues are burnt, agriculture is intensified (e.g. through mechanization and increased fertilizer/agrochemical use) and livestock are raised, large quantities of GHGs such as CO_2, CH_4 and N_2O are emitted. Rice paddies, which have been increasing in productivity across Southeast Asia, are important emitters of CH_4 (IPCC, 2000). Apart from those primary agricultural activities, the associated land-use change also contributes significantly to CO_2 emissions (IPCC, 2007). This additional contribution from land-use conversion seems to further unbalance the annual net flow of CO_2 between agricultural lands and the atmosphere. Not only are these emissions contributing to enhanced greenhouse effect, they also represent a loss of useful carbon and nitrogen which are potential energy sources for crop and plant production.

3.2 Biofuel Expansion

First generation biofuels[6] currently constitute one of the most controversial energy sources. Despite initially being heralded as environmentally friendly energy options there is currently significant evidence about their negative impact on the environment (e.g. SCOPE, 2009), biodiversity (Fitzherbert *et al*., 2008) and the climate (Fargione *et al*., 2008)**.** Several countries in Southeast Asia are currently increasing their biofuel production capacity. The main factors behind this boost in biofuel production include energy security, climate mitigation and socioeconomic issues such as rural development, poverty alleviation, increased employment and foreign exchange savings (Yan and Lin, 2009).

The major biofuel producers in the region are Indonesia, Malaysia, Thailand, the Philippines and China. According to Zhou and Thomson (2009), the adoption and proliferation of biofuel policies in the region are a result of energy security concerns and other socioeconomic issues (refer to Table 7). On the other hand, environmental considerations do not seem to have influenced significantly the production of biofuels given that these countries are not required to reduce their GHG emissions under the prevailing United Nations Framework Convention on Climate Change (UNFCCC) agreements.

[6] e.g. bioethanol from food crops (sugarcane, corn, cassava etc) and biodiesel from oil seeds (e.g. from oil palm, soybeans etc).

Currently both biodiesel and bioethanol are pursued as alternative transport fuel options in the region but the availability of biofuel feedstocks is the main limiting factor for their production (refer to Table 8).

Table 7: The main determinants of biofuel production in Southeast Asia

	Security	Economy			Social		Environment	
	Energy security	Trade balance	Price of petroleum	Economic development	Increase agricultural employment	Rural development	Climate change	Air pollution
China	√	√			√	√		√
Malaysia		√	√	√			√	
Indonesia	√			√	√	√		
Philippines	√	√		√				√
Thailand	√	√		√	√	√		

Source: (Zhou and Thomson, 2009)

Table 8: Biofuels and feedstocks for the main Southeast. Asia producing nations

	Main option	Feedstock	Secondary option	Feedstock	Comments
China	Bioethanol	Corn (mainly) and wheat (secondarily)	Biodiesel	Animal fats and waste vegetable oil	Cassava and sweet sorghum are used for bioethanol in an experimental basis. Assess the potential of rapeseed, Jatropha, sunflower seeds, sesame seeds and several types of beans and nuts for biodiesel production.
Malaysia	Biodiesel	Palm oil			
Indonesia	Biodiesel	Palm oil (mainly), Jatropha (secondarily)	Bioethanol	Cassava and sugarcane	

	Main option	Feedstock	Secondary option	Feedstock	Comments
Philippines	Bioethanol and biodiesel	Sugarcane (for bioethanol) and coconut oil (for biodiesel)			Research and development is conducted in order to assess the feasibility of using Jatropha for biodiesel and cassava for bioethanol
Thailand	Bioethanol	Sugarcane and cassava	Biodiesel	Palm oil and Jatropha	

Source: (Zhou and Thomson, 2009)

Oil palm is the major feedstock cultivated in the region, particularly in Malaysia and Indonesia, for biofuel production purposes. Currently these two countries account for more than 90% of world production while both countries are significant exporters of this commodity (FAO, 2010b)[7]. Concurrently, these two countries contain a significant portion of the planet's remaining tropical forests, which harbor several endangered species - indeed, Sundaland and Wallacea, two of the world's twenty-five biodiversity hotspots (Figure 2). It is feared that the oil palm expansion spurred by biofuel production within the two countries and for feedstock exports can have significant impacts on biodiversity. In fact large scale oil palm cultivation can influence directly and indirectly three key drivers/processes of biodiversity loss, namely habitat destruction, pollution and climate change.

Koh and Wilcove (2008) suggest that palm oil plantations in Malaysia and Indonesia have replaced to a great extent primary and secondary tropical forests and to a lesser extent pre-existing cropland. According to their calculations, 55-59% of oil palm expansion in Malaysia and at least 56% in Indonesia occurred at the expense of primary forests. Fitzherbert *et al.*, (2008) estimate that between 1990 and 2005, oil palm expansion resulted in a net loss of 1 million hectares and 1.7 to 3 million hectares of forest in Malaysia and Indonesia respectively. The overall impact on biodiversity could be quite substantial.

Oil palm plantations harbor fewer species of birds (Peh *et al.*, 2005) and butterflies (Hammer et al., 2003; Dumbrell and Hill, 2005) than primary forest, logged forest and rubber plantations (Fitzherbert *et al.*, 2008; Danielsen *et al.*, 2009). In fact, in most cases the majority of forest species was lost after the conversion to oil palm plantations and was replaced by smaller numbers of non-forest species, mainly generalist species of low conservation value (Danielsen *et al.*, 2009). The loss of biodiversity in oil palm plantations

[7] Note here that energy security and environmental concerns (i.e. climate change mitigation) in developing nations might be responsible for the phenomenal oil palm cultivation expansion in Southeast Asia. Indeed the EU is a major importer of palm oil from the S.E. Asia with an increasing quantity of this palm oil used for biodiesel production purposes. Both energy security and climate change concerns are high in the agenda of the European Commission with significant policies being adopted (most notably Directive 2009/28/EC).

is due to the fact that such habitats are structurally less complex than primary forests, have a shorter life time and are major landscape fragmentation factors (Fitzherbert *et al*., 2008; Danielsen *et al*., 2009).

Oil palms, like all other plants, emit Volatile Organic Compounds (VOCs). There are concerns that oil palm expansion might result in greater VOC emissions (Royal Society, 2008; Hewitt et al., 2009). In fact, Hewitt et al. (2009) have shown that VOC and nitrogen oxides (NOx) emissions[8] are greater from oil palm plantations than from surrounding primary rainforest. Additionally, land that is appropriated for oil palm cultivation is sometimes cleared through the use of fire (e.g. van der Werf et al., 2008), also refer to Section 4.1. Biomass burning has been identified as a major source of atmospheric pollution affecting significantly biogeochemical cycles (Bytnerowicz *et al*., 2008; Crutzen and Andreae, 1990).

The palm oil industry has been in the past a major source of pollution in Malaysia (Muyibi, *et al*., 2008). Palm oil mill effluent (POME) is characterized by high levels of Biochemical Oxygen Demand (BOD). At the same time palm plantations consume large amounts of fertilizers – the largest amount of fertilizers than any other crop in Malaysia (FAO, 2004; FIAM, 2009), while they are the third highest consumer of fertilizers in Indonesia (FAO, 2005b). High BOD and nutrient runoff from fertilizer application have been associated with severe environmental problems such as eutrophication and hypoxia and as a result can significantly affect aquatic biodiversity.

Life Cycle Assessment (LCA) studies have shown that biodiesel from palm oil has generally lower GHG emissions than conventional fossil fuels (e.g. Zah *et al*., 2007; RFA, 2008). However in some cases these studies do not take into consideration the GHG emitted as a result of direct and indirect land-use change. Oil palm plantations are expected to be net carbon sinks only if they are established in crop/grassland and not on forested areas (Danielsen *et al*., 2009). Depending on the forest clearing method used, it would take 75-93 years[9] for an oil palm plantation to compensate the carbon lost during the loss of the initial forest and 692 years if that happens on peatland. On the other hand, if the oil palm is cultivated on grassland it would take just 10 years to compensate for the carbon lost during land-use change. Similar findings have been reported in the literature (e.g. Fargione *et al*., 2008; Germer and Sauerborn, 2008; Gibbs *et al*., 2008), leading to the conclusion that oil palm biodiesel might in fact produce greater amounts of GHGs than conventional fossil fuels if direct and indirect land use impacts are considered.

3.3 Trade

Trade in agricultural commodities and endangered species have been two major underlying and interlinked drivers of biodiversity loss in S.E. Asia (Schipper et al., 2008). In fact agricultural activities constitute one of the most important causes of biodiversity loss globally (e.g. MA, 2005b) given that agriculture is a major driver of habitat loss and fragmentation

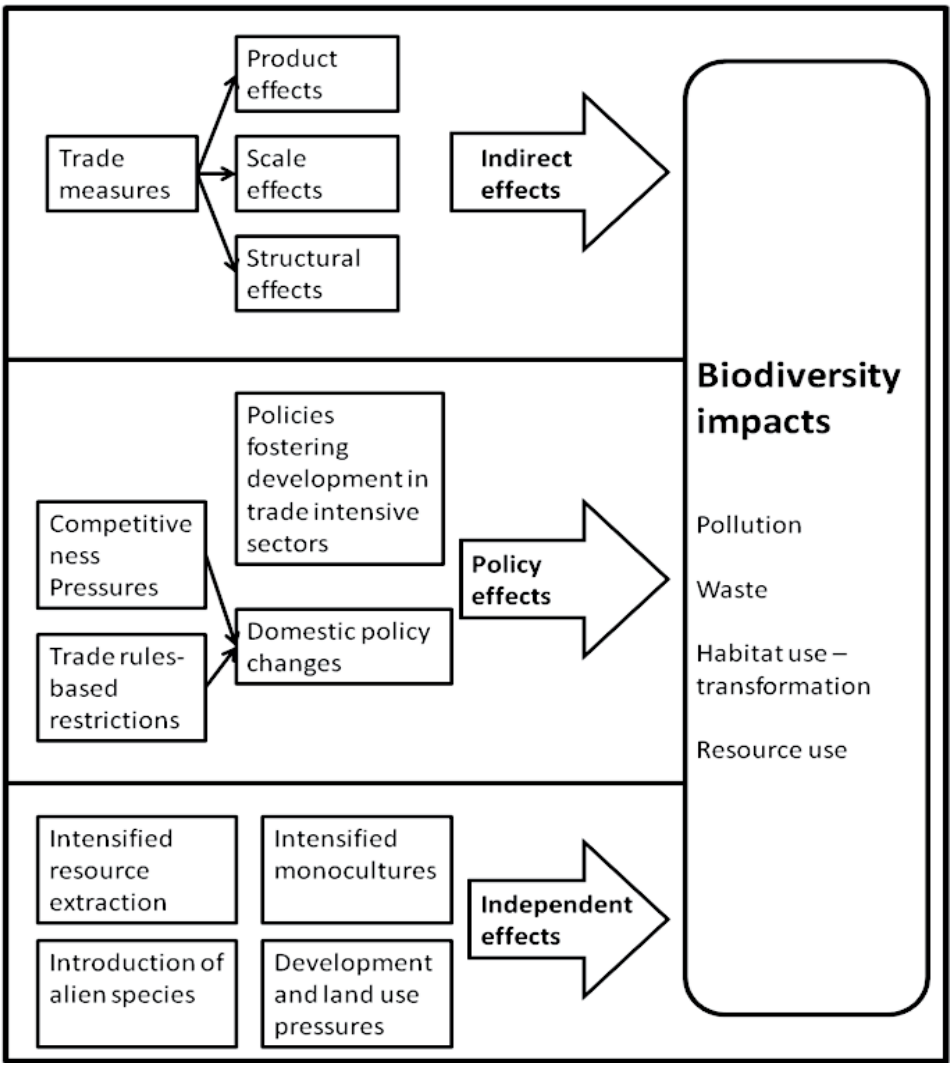
[8] VOCs and NOx are tropospheric ozone precursors (O_3) which is both a potent GHG and can affect animals and plants.

[9] The higher estimate corresponds to when fire use as a land clearing method.

as discussed in the previous sections. On the other hand trade can be directly linked with other direct drivers of biodiversity loss such as species overexploitation and introduction of species.

Despite the almost universal understanding that increased consumption and trade activities can negatively affect biodiversity, the mechanisms through which this happens are difficult to delineate. According to Conway (1998) trade can have indirect, policy and independent effects on biodiversity as summarized in Figure 6. The independent effects are the most straightforward to assess and have therefore received the greatest attention from academics and practitioners.

Figure 6: Effects of trade on biodiversity



Source: (Redrawn from Conway, 1998)

Conway (1998) suggests that there is significant evidence indicating that trade liberalization in Indonesia has affected biodiversity through:

- product effects (e.g. rattan, wildlife trade);
- structural effects (e.g. fisheries, mining);
- intensified extraction of natural resources for export (e.g. shrimps, frogs);
- intensification of monoculture (e.g. oil palm);
- policies encouraging trade development in trade intensive sectors (e.g. forest products, agricultural products, oil and gas).

It is no wonder that there are different multi-lateral institutions and programmes to understand and regulate the trade of agricultural commodities and endangered species for the benefit of biodiversity. For example, between 2005 and 2009, the United Nations Environment Programme (UNEP) established an Initiative on Integrated Assessment of Trade-Related Policies and Biological Diversity in the Agriculture Sector. The primary goal of the initiative is to enhance capacity in developing countries to develop and implement policies that safeguard biological diversity whilst maximizing sustainable development gains from trade liberalization in the agriculture sector[10]. Perhaps the first major programme concerned with the linkage between biodiversity loss and trade is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)[11] that regulates the trade of threatened and endangered animals in order to assure their conservation. Currently there are approximately 900 species included in Appendix I (most threatened by trade) and about 33,000 species in Appendix II (not necessarily threatened with extinction but that may become so if trade is not controlled properly). Populations of a large number of these species are found in or are endemic to Southeast Asia.

In fact, wildlife trade is a booming business in the region conducted both through formal and informal networks (CITES, 2010). Many recent studies have shown that the presence of the main wild traded species has declined in their natural habitats. This indicates the loss of commercially valuable biodiversity in the region due to trade and overexploitation (World Bank, 2008). The Wildlife Trade Monitoring Network (TRAFFIC) has conducted studies on the trade of endangered species. Its reports have suggested that wildlife trade in Southeast Asia indeed poses a threat to regional biodiversity (refer to Box 3).

[10] http://www.unep.ch/etb/areas/biodivAgriSector.php
[11] http://www.cites.org/

Box 3: Examples of illegal wildlife trade in S.E. Asia

There is very little evidence to suggest a significant decrease in the trade of gibbons and orangutans in Sumatra, Kalimantan, Java and Bali in the past 15 years. (Nijman, 2009; Nijman, 2005a, 2005b). Instead there is indication that *"…trade is still very much threatening the survival of these apes"* (Nijman, 2009: vii)

Both protected and non-protected species of cats are traded in Myanmar. However, those species, which are globally threatened, are offered in the country in significantly larger numbers than non-threatened species. *"…[T]his, and the frankness of the dealers, suggests a serious lack of enforcement effort to prevent this illegal trade, and highlights the threat that trade poses to already threatened species" (Shepherd and Nijman,* 2008a). The trade of tiger also continues openly in several areas of Sumatra. While tiger trade appears to be declining in some parts of the island, trade has increased in others (Ng and Nemora, 2008).

Thailand still has one of the largest and most active ivory industries seen anywhere in the world despite the fact that the quantity of worked ivory in Thailand seen openly for sale has decreased substantially in the past (Stiles, 2009a). Vietnam has experienced an increase in the number of artisans working with ivory, which suggest that demand for ivory is rising (Stiles, 2009b). Finally, ivory and other elephant parts are routinely smuggled out of Myanmar, which indicates a serious lack of law enforcement and a blatant disregard for international conventions and national laws (Shepherd and Nijman, 2008b).

Reptile trade out of Indonesia is allowed only if the animals have been bred in captivity. Surveys suggest that for the majority of reptile species and for the majority of exporting companies, it does not appear that captive breeding of these species in commercial quantities actually occurs at these facilities. On the contrary, it appears that "wild-caught" animals are labeled as "bred in captivity" in order to allow their export (Nijman and Shepherd, 2009).

Even though in Indonesia the local use of the box turtle is minimal, its international trade is extensive and represents the major threat to the species' survival. The extent of plastrons and carapaces illegally traded is also of major concern (*S*choppe, 2009a*).* Similar findings were reported for Malaysia (Schoppe, 2009b).

It should be noted that the Southeast Asia wildlife trade supplies local and global markets involving several actors such as rural harvesters, professional hunters, traders at several points along the supply chain as well as the final consumers (World Bank, 2008). Many of these species are exploited and traded in order to meet basic subsistence needs (i.e. food, medicine) and as a source of income. Furthermore the increased economic affluence across the region (e.g. in China) seems to be a much stronger driver of illegal wildlife trade in the region than poverty (*ibid*).

3.4 Urbanization

The Southeast Asian region has witnessed a tremendous increase in urbanization in the last few years. The proportion of urban population is expected to increase to about 50% in 2025 (Table1). The increase in urbanization reflects economic growth at the expense of biodiversity in the region. Urban expansion is concentrated primarily around urban cores, replacing peri-urban agriculture and natural vegetation at a slower rate than in developed countries of the world (McGranahan and Satterthwaite, 2003). This pattern of urban growth markedly homogenizes biota. Dense populations and industrial economic activities in the urban centers places tremendous pressure on natural habitats. A recent study indicates that 29 of the world's 825 ecoregions[12] have over one-third of their area urbanized, and these 29 ecoregions are the only home of 213 endemic terrestrial vertebrate species (McDonald *et al*., 2008). The same authors have shown that several important and highly biodiverse eco-regions in Southeast Asia were highly urbanized in 1995, e.g. Western Java rainforests (22.7% urbanized), eastern Java-Bali rainforests (18.2% urbanized), Indochina mangroves (15.3% urbanized), Western Java montane rain forests (10.2%) and peninsular Malaysia rainforests (10.1% urbanized) with urbanization trends expected to increase dramatically in the coming decades. Singapore with 100% urbanization is another example of the negative impact of urbanization on biodiversity. In the process of urbanization, the country lost between 34-87 % of butterflies, fish, bird and mammals forever (Sodhi *et a*l., 2004).

Urban production and consumption activities are key urban processes that have been identified as particularly damaging to biodiversity (Puppim de Oliveira *et al*., 2010). The latter can be linked to the increase of transport and the global circulation of commodities. A telling example in the region is the case of Vietnam where toxic effluents, transport-related air pollution, heavy metals and hazardous waste enter the sewage system or are dumped in landfills, degrading freshwater, marine and soil systems (Casselini, 2001).

One way of estimating the level of risk posed by urbanization to biodiversity is to determine the distance between urban areas and protected areas (MacDonald et al., 2008). The shorter the distance between urban areas and protected areas, the higher the potential human impact on biodiversity. As at 1995, 50% of protected areas in Southeast Asia were within 57 km of cities. By 2030, this distance will shrink by 30% to 40 km (Table 9). Eighty-eight percent of protected areas that are likely to be impacted by new urban growth by 2030 are in countries of low to moderate income with limited institutional capacity to adapt to anthropogenic stresses on biodiversity (McDonald et al., 2008). This phenomenon calls for strategies to protect biodiversity from future urban expansion.

Table 9: Distance from protected areas (km) to the nearest city with 50,000 inhabitants or more in Asia

	1995			**2030**		
	First Quartile	Median	Third Quartile	First Quartile	Median	Third Quartile
East Asia	18	43	84	10	23	45
Southcentral Asia	19	38	80	13	28	58
Southeast Asia	27	57	94	20	40	74
Western Asia	7	26	57	4	21	48

Source: (Adapted from McDonald *et al*., 2008)

[12] Ecoregions are delineated areas of relatively homogeneous environmental conditions and species composition used for conservation priority-setting.

4. Climatic Impacts and Biodiversity Loss

Climate change has direct and indirect impacts on biodiversity. The direct effects are through changes in temperature and precipitation that affect individual organisms, populations, species distribution, and ecosystem compositions and functions. Global warming is projected to increase the risk of extinction for already vulnerable species with limited climatic ranges and restricted habitats (IPCC, 2002)[13]. The indirect effects of climate change are through climate altering the intensity and frequency of perturbations such as forest fires. Changes in the frequency and intensity of perturbations affect whether, how and at what rates existing ecosystems will be replaced by new species (IPCC, 2002). Climatic factors typically amplify the effects of anthropogenically-driven processes mentioned in the previous section in accentuating biodiversity loss.

4.1 Climate Change and Fires

Forest fires are emerging as one of the key threats to tropical forests. Forest fires release 20-25% of annual global carbon dioxide emissions (Moutinho and Schwartzman, 2005). The El Nino effect has been identified as a key factor that combined with other land management practices to increase the devastation of the fires in Indonesia (Sodhi *et al.*, 2006). The experience of the 1997/98 ENSO particularly demonstrates how the effects of climate change and land use can synergize to threaten biodiversity and ecosystem services. Drought conditions triggered by ENSO across Southeast Asia markedly increased tree mortality and flammability (Gullison *et a*l., 2007). Secondary forests were the most affected in the 1997-1998 fires in Southeast Asia (Murdiyarso et al., 2002) with up to 5 million hectares and 4.6% of canopy trees in Indonesia affected (Sodhi *et a*l., 2006; Schweithelm, 1998). Other estimates indicate that in 1997-1998, 2002 and 2005, fires in Southeast Asia destroyed more than three out of the 24 million hectares of peatlands (representing 60% of the world's tropical peatlands). In addition to loss of habitats, it is estimated that 1000 orangutans in Indonesia (2.5% of the population) died from the 1997-1998 fires and it is predicted that future fires may kill up to 3.5% of the orangutan population per event (Singleton *et al*., 2004; and Suhud and Saleh, 2007).

Forests that have experienced widespread or edge fires become more susceptible to further fires and adaptive species as their edges are drier and become more fragmented by previous fire occurrence (Nepstad *et al*., 2001). Increasing frequency and intensity of dry periods synergize with forest degradation and land clearing and amplifies the devastating effects of forest fires (Corlett, 2003).

Forest incineration releases carbon dioxide into the atmosphere joining the feedback loop between forests and atmospheric carbon (Strand et al., 2007). The Southeast Asian forest fires of 1997-1988 released up to 1.2 billion tons of carbon.[14] The regional smoke haze caused by the forest fires in southeast Asia in 1980s and 1990s received much attention

[13] It should be noted that climate change might not be a significant driver of biodiversity loss in the tropics (Sodhi *et al*., 2004). However, the poor understanding of the links between climate change and biodiversity loss in Southeast Asia as well the high uncertainties associated with its assessment have been highlighted in the academic literature (Sodhi *et al*., 2004). Nevertheless there is evidence to suggest that very biodiverse ecosystems in the tropics, particularly montane areas can be severely affected by climate change (Sala *et al*., 2000).

[14] Information on ASEAN Secreatariat Webpage [http://www.aseansec.org]. Further information on ASEAN haze can be found at [http://haze.asean.org/].

due to their impact on regional climate change and regional air pollution and the effects on ecosystems, species, human health and the economy. Brunei Darussalam, Indonesia, Malaysia, and Singapore were seriously affected for several months by the forest fires of 1997-1998. The governments of the region began a joint effort to monitor, prevent and mitigate such hazards by establishing the ASEAN Agreement on Transboundary Haze Pollution (or ASEAN Haze Agreement) in November 2003. Potential hotspots are regularly identified for each country and compiled and published through the ASEAN Haze Watch. Not only are there concerns for air quality as it pertains to human health but studies have also looked at the impacts on rainwater acidity and effects on ecosystems. However, an analysis of rainwater in Brunei Darussalam during severe haze episodes in Borneo in 1994, 1997, and 1998 failed to reveal any significant impacts on rainwater acidity or wet deposition of hydrogen ions (Radojevic and Tan, 2000).

4.2 Climate Change and Species Distribution

Current global changes in climate have aroused interest in assessing the sensitivity of native species to climate change and the implication for biodiversity conservation. In addition to its interactions with existing fire regimes and air pollution, changes in climate affect ecosystems by shifting species ranges, composition and migration patterns; altering wildlife habitat, landscapes and succession patterns; and interacting with insect pests and pathogens (Blate *et al*., 2009; IPCC, 2000). The IPCC (2007) reports that up to 30% of species are at increasing risk of extinction and approximately 15%-40% of ecosystems are being affected by climate change. In Southeast Asia there has been a general increase of 0.1 degree C to 0.3 degree C increase in temperature between 1951 and 2000 with a general decline in the number of rainy days, whereas in the Philippine the annual mean rainfall has increased since the 1980s. There is some variability in rainfall patterns within countries, such as Indonesia with increased rainfall in the northern regions and a decreasing rainfall in the southern region (IPCC, 2007). Global warming potentially causes species to move to higher elevations in search of more suitable habitat. In an analysis of the elevational distribution of Southeast Asian birds from 1971- 1999, Peh (2007) observed an upward shift of lower and upper boundaries for 94 common resident species in response to global warming. The upward shift occurred irrespective of habitat specificity, implying that climate change is an additional factor to anthropogenically-induced habitat destruction and biodiversity decline in Southeast Asia.

The orangutan habitat in Indonesia has been influenced by the synergy of climate, rainfall and other factors. The El Nino event of 1997-1998 with increased hot, dry and drought weather affected the phenology including pollen patterns of trees in areas such as the Kayan Metarang National Park. This led to a decrease in the food supply as fruit productivity fell during 1998-1999-2000 resulting in the migration of orangutans to other areas. The fall in fruit productivity also affected other animals. It is predicted that climate change (in concert with other factors of human induced habitat loss, hunting and trades) will continue to challenge orangutan conservation in Indonesia (Suhud and Saleh, 2007).

Species extinction as a result of climate change is also a possibility as local factors such as land-use change, increased atmospheric carbon dioxide, and invasive species interact with global warming (Pounds and Puschendorf, 2004). Thomas et al., (2004) in a sample of 1,103 land plants and animals in terrestrial regions from Mexico to Australia suggest that 15-37% of species would become extinct by 2050 because of climate change, whereas other studies suggest a narrower range of species extinction of 20-30% if there is greater than 1.5-2.5 °C in the global average temperature (IPCC, 2007). Kitayama (1996) reported that water stress occasioned by the El Nino of 1991-1992 resulted in morphological adaptations in plants in montane environments.

Pine forests in Southeast Asia are affected by fuel wood collection; unsustainable resin tapping and deforestation has also decreased their area. In concert with these factors, the additional climate change threatens their growth and distribution. In a study of the impact of climate change on the distribution of two pine species (*Pinus kesiya* and *P. merkusui*), van Zonneveld *et al.,* (2009) found that only few areas in mainland Southeast Asia will be suitable for the species by 2050. In the Malay Archipelago, climate change may favour *P. mekusii* plantations. However, temperatures in the forests in eastern Thailand and northern Cambodia are expected to increase beyond the tolerance range of these species therefore threatening these species in combination with other factors such as diseases and insect pests whose virulence may also be triggered by climatic factors. A combination of the human induced stresses – forest burning, fragmentation and degradation – and other climate-driven factors such as outbreaks of insects and pests, drought and heat may lead to forest dieback. Allen (2009) in a global review lists several examples of drought related mortalities including Dipterocarpaceae in tropical moist forests in Borneo, Malaysia (Allen, 2009).

5. Policy Responses and Conclusion

Clearly, several of the stress factors affecting biodiversity loss are anthropogenic in nature. These pressures relate directly to policy directions undertaken at the national level. The policies, while serving to fulfill a few objectives, such as increase in GDP or conservation of forests, have had undesirable impacts on the biodiversity and welfare of the people immediately dependent on such resources for their livelihoods. Of greater importance is the fact that while the vulnerability of the several countries in the region due to climate change is high, their adaptive capacities, as can be evidenced from socio-economic factors, technological and infrastructural development are not at par (Yusuf and Francisco, 2009). Broadly, policy responses have been designed on the following categories:

- **Monitoring and regulation**

  Loss of biological resources through trade and other flows from the regions has been well acknowledged. The trade of wildlife has been targeted by important multi-lateral environmental agreements such as CITES. However the multi-faceted nature of the issue and the number of stakeholders involved both from the supply and the demand sides of the trade chain make the enforcement of such mechanisms difficult. For S.E. Asia there is a general lack of knowledge concerning the nature, causality and interlinkages of the trade of endangered species (World Bank, 2008). The World Bank and TRAFFIC have identified key areas and laid down a number of different interventions in order to minimize illegal trade of endangered species and as a result the risk it poses on biodiversity in the region. These range from improved monitoring mechanisms, inclusion of wildlife trade concerns in planning of infrastructure development, targeting interventions towards powerful groups in the trade chain, building multi-agency and cross jurisdictional law enforcement capacity and multi-lateral enforcement in the region, and have a balanced mix between positive incentives (for prevention) and penalties (World Bank, 2008: 68-74).

  Similarly, periodic assessments of the impacts of climate change mitigation on biodiversity are necessary. There is a need to develop strategies for optimizing biodiversity conservation and ecosystem services management. The IPCC has proven effective at providing the leading scientific review of climate change through corporative global efforts. Likewise the proposed Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services can provide the international science-policy interface that is needed for biodiversity[15]. That could enable a scientific framework for tackling changes to biodiversity and aligning conservation priorities with ecosystem services.

- **Land use strategies**

  The foregoing arguments in the report do imply the need for encouraging resilient and sustainable land use strategies in the region. Conversion of the tropical forests for oil palm plantations to meet growing biofuel demand has resulted in several natural and socio-political complications. Some suggestions to mitigate the impact while still making use of the opportunity arising from global demand include: shifting the production of biofuel crops to degraded/abandoned agricultural lands; adoption of improved and ecosystem friendly management practices; development of certification schemes with

[15] IPBES [http://www.ipbes.net/]

the involvement of multiple stakeholders (such as being developed by the Roundtable on Sustainable Palm Oil (RSPO);[16] and the creation of appropriate financial incentives to ensure sustainable production (Stromberg *et al*., 2010).

Another area of concern is the increasing urbanization in the region. While this is considered a normal pattern in the cycle of development, it is important that some factors be considered in urban planning that aim to enhance ecosystem resilience. Such policy responses should include in addition to appropriate housing and transportation measures, innovative landscapes that integrate green spaces, urban agriculture and other functional habitats (Puppim de Oliveira *et al*., 2010).

- **Mitigation and adaptation responses**

Several innovative mechanisms are being considered to enhance adaptive capacities of different countries in the region in addition to reducing their vulnerability. These include:

i. financial incentives: through mechanisms such as UN-REDD, carbon markets, debt instruments and biodiversity compensation or offset schemes, payments for ecosystem services and funding for adoption of various measures related to reducing deforestation and degradation of natural ecosystems and/or to undertake additional measures to mitigate climate change (such as through Clean Development mechanisms);

ii. livelihood enhancement: schemes that ensure income diversity and security to local communities and primary producers.

As noted by the World Bank (2010), the use of protected areas to conserve ecosystems and species is not sufficient, as species range have the potential to shift beyond the protected areas. Therefore there is need to complement protected areas with innovative land management strategies such as creation of ecoagricultural landscapes. An ecoagricultural landscape is one in which farmers or land managers create mosaics of farmland and natural habitats to sustain food production, secure rural livelihoods and conserve biodiversity and ecosystem services (McNeely and Scherr, 2003). The landscape perspective links farm or forest level actions to the broader ecosystem and also integrates ecosystem thinking with related stakeholder processes.

The recent co-operation between Norway and Indonesia on activities to address greenhouse gas emissions from deforestation, degradation and peatland conversion should help in building adaptation substantially in the Indonesia. The project places an emphasis on participatory planning and livelihood guarantees in the process of achieving the objectives (Purnomo and Saloh, 2010)[17].

Policy makers need to realize that biodiversity conservation is not an automatic co-benefit of REDD. If REDD mechanisms only emphasize reducing deforestation rates, then market forces will most likely focus on areas that are cheapest to protect with the implication that biodiversity hotspot areas will not be cost-competitive (Grainger et al., 2009). Secondly,

[16] For more information refer (www.rspo.org)

[17] Purnomo, Agus and Yani Saloh, 2010. New approach could be elixir for Indonesia's deforestation malaise, Jakarta Globe, June 3 2010, from (http://www.thejakartaglobe.com/opinion/new-approach-could-be-elixir-for-indonesias-deforestation-malaise/378593) Accessed 18 June, 2010.

REDD emphasizes forests with high carbon density. Though there is considerable overlap of global carbon storage and biodiversity in terrestrial ecosystems, the synergies between carbon stocks and species richness are unevenly distributed (Strassburg *et al.*, 2010). Besides, not all biodiversity hotspots are forests. This means that some high-biodiversity regions, would not benefit from carbon-focused conservation, and could become under increased pressure if REDD is implemented (Myers et al., 2000). Thirdly, deforestation processes that are not effectively halted by REDD may be displaced to other areas within or outside a country (Gan and McCarl, 2007). Nevertheless in all likelihood REDD plus will deliver some biodiversity benefits with measures to further incorporate rules to conserve biodiversity in all REDD projects, whilst private conservation funding that would not otherwise be eligible for REDD funding could be redirected and focused on forests of high biodiversity value. Appropriate monitoring and reporting of sub-national and transnational leakages should be a top priority. As highlighted elsewhere, livelihoods and practices of several indigenous and local communities are dependent on these biodiversity rich ecosystems, requiring careful analysis of the implications of such projects to their wellbeing.

- **Research and Information, Education**

Addressing the impacts of climate change in this region requires both mitigation and adaptation responses with strong links between scientists and natural resources managers (Blate *et al.*, 2009). Impact adaptation may include livelihoods diversification (decreased dependence on agriculture and forest resources) or change in management techniques (Rubio, 2007; Kaufmann, 1998). Blate *et al*. (2009), also list several adaptation options for US forests some of which may be applicable to Southeast Asia. There is still a paucity of scientific information in Southeast Asia on the adaptive capacity of specific ecosystems to adapt to climate change. However, given the value of these ecosystems and agricultural systems to human development in Southeast Asia and the global significance of Southeast Asian forests it is important that policy makers and scientist accelerate both country and regional efforts to understand and adapt to the potential effects of climate change and anthropogenic land changes. For conservation efforts to be successful there is the need to build public support through awareness campaigns on the magnitude of biodiversity decline and the implications for social and environmental sustainability.

Collaborative research and responses between regional scientists, planners, policy makers and the private sector looking at simulating climate change with different scenarios, information sharing and mitigation and adaptation measures are essential (Tuan, 2009). There is also need for additional research on the links between climate change, biodiversity and economic development in the SEA region (ASEAN Centre for Biodiversity, 2010)[18]. Universities in Asia are increasingly sharing their successes and challenges in community empowerment and climate change adaptation research in an effort to strengthen the role of higher education in transferring and applying new knowledge to the challenges of society and local communities. Universities in Korea and Indonesia for example are further exploring programmes on climate change adaptation to increase the adaptive capacity of communities and practical education addressing the vulnerability of natural ecosystem (Tumiran, 2009). The University Network for Climate and Ecosystems Change Adaptation Research (UN-CECAR) is a promising initiative that can narrow the disparities

[18] ASEAN Centre for Biodiversity [http://www.aseanbiodiversity.org]

between higher education institutions and academics across the region with respect to climate change adaptation research.

Several issues related to climate change are symptomatic of a greater malaise affecting ecosystems and resources that help regulate nutrient cycling processes. Recent literature, as seen in the foregoing, points to increasing concern and measures being taken to address the problem of biodiversity decline, especially in the hotspot regions of Southeast Asia. It is hoped that the momentum being generated would result in appropriate policy and economic measures based on appropriate scientific evidence and ground scenarios.

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UNU-IAS Policy Report

Climate and Human-Related Drivers of Biodiversity Decline in Southeast Asia

Ademola K. Braimoh, Suneetha M. Subramanian, Wendy S. Elliott and Alexandros Gasparatos

Southeast Asia hosts diverse biological resources and cultural milieus that are under different degrees of stress from various factors. This report highlights the key underlying economic, political, and natural factors that contribute to biodiversity decline in the region, and provides specific policy directions that could help address the decline.

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Institute of Advanced Studies

United Nations University
Institute of Advanced Studies
6F, International Organizations Center
Pacifico-Yokohama, 1-1-1 Minato Mirai
Nishi-ku, Yokohama 220-8502, Japan

Tel +81 45 221 2300
Fax +81 45 221 2302
Email unuias@ias.unu.edu
URL http://www.ias.unu.edu

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