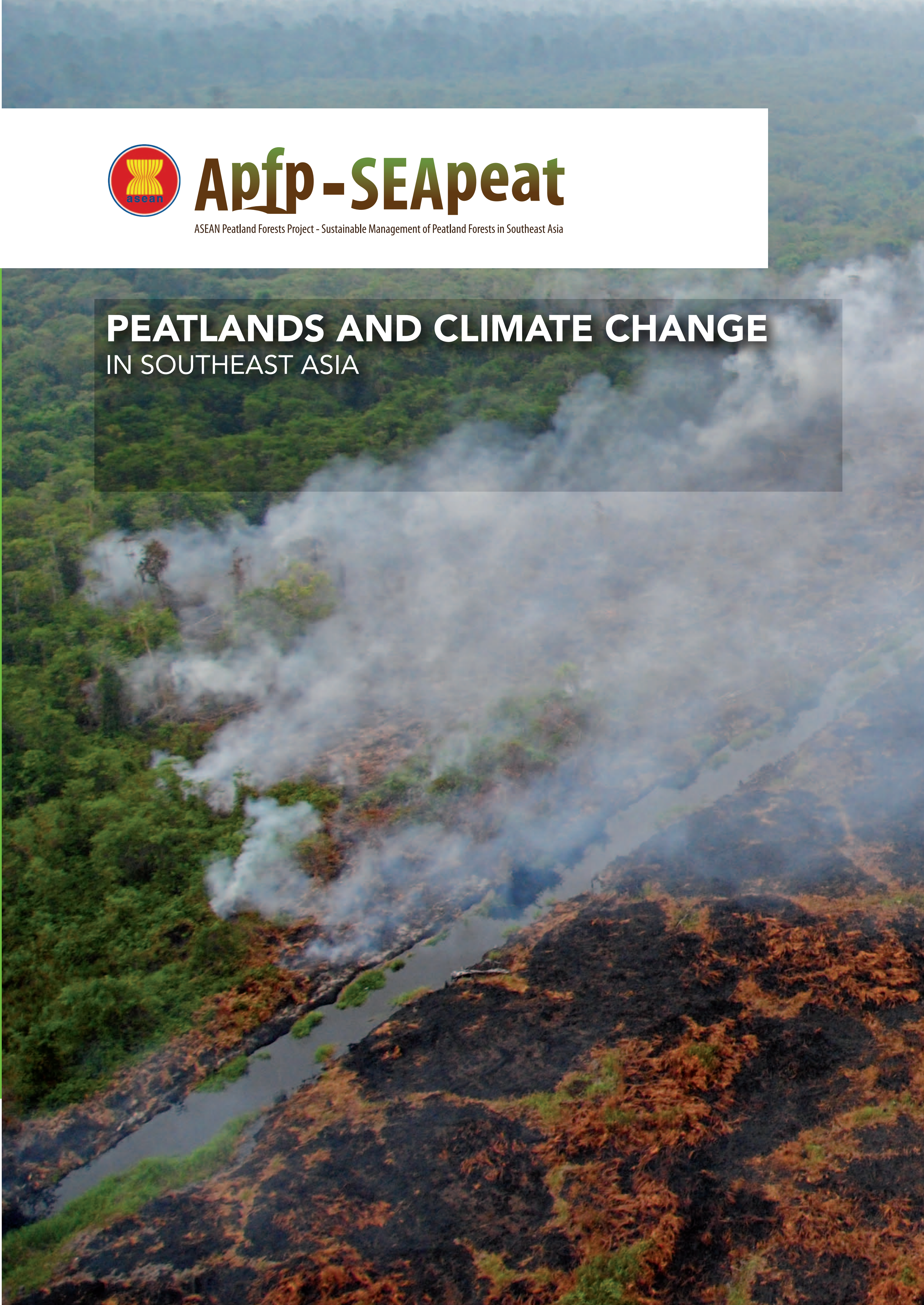
Apfp-SEApeat

ASEAN Peatland Forests Project - Sustainable Management of Peatland Forests in Southeast Asia

PEATLANDS AND CLIMATE CHANGE
IN SOUTHEAST ASIA



Published by the ASEAN Secretariat and Global Environment Centre.

First published September 2013.

ISBN 000

Printed in Malaysia.

This publication should be cited as:
Lo, J. and F. Parish 2013. Peatlands and Climate Change in Southeast Asia. ASEAN Peatland Forests Project and Sustainable Management of Peatland Forests Project. ASEAN Secretariat and Global Environment Centre.

Publication supported by:
ASEAN Peatland Forests Project (APFP) and Sustainable Management of Peatland Forests (SEApeat) Project with funding from Global Environment Facility (GEF), the International Fund for Agricultural Development (IFAD) and the European Union (EU).

For enquiries, please contact:
The Environment Division
The ASEAN Secretariat
70A Jalan Sisingamangaraja
Jakarta 12110, Indonesia
Phone: (62 21) 724 3372 / 726 2991
Fax: (62 21) 739 8234 / 724 3504
Email: riena@asean.org

or

Global Environment Centre
2nd Floor, Wisma Hing, No. 78
Jalan SS2/72, 47300,
Petaling Jaya, Selangor Darul Ehsan,
Malaysia
Phone: +(603) 7957 2007
Fax: +(603) 7957 7003
Email: outreach@gec.org.my
Websites: www.gec.org.my; www.aseanpeat.net

Book Design by Yap Ni Yan / GEC
Front cover photo © Nagarajan Rengasamy / GEC

Apfp-SEApeat

ASEAN Peatland Forests Project - Sustainable Management of Peatland Forests in Southeast Asia

PEATLANDS AND CLIMATE CHANGE
IN SOUTHEAST ASIA

BY JULIA LO AND FAIZAL PARISH

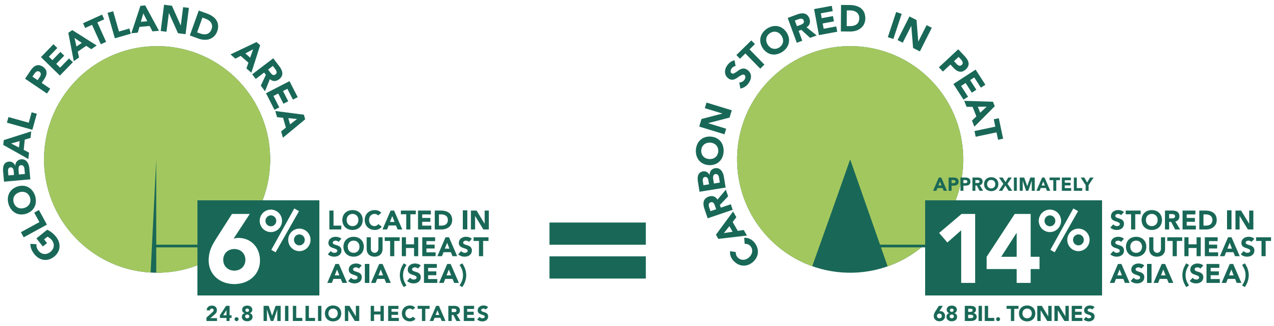
TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

CHAPTER 1: PEATLANDS IN SOUTHEAST ASIA

1.1 INTRODUCTION

The world is now facing the greatest challenge humanity has ever known. The climate is changing and planet earth is feeling the heat of global warming. Climate change is primarily caused by the increase in greenhouse gas (GHG) emissions into the earth's atmosphere which traps heat by reflecting infrared energy back to the earth's surface (the 'greenhouse effect'). The main source of GHGs is from fossil fuel burning, however, GHGs released from degraded and drained peatlands are also a major concern.



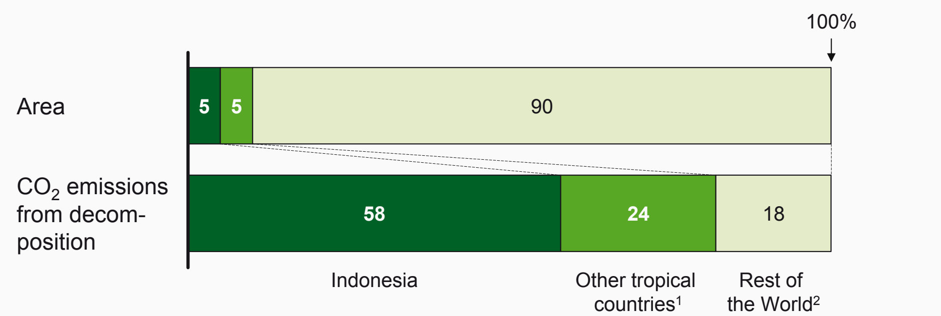
SOURCE: Page *et al.* (2011).

Over the last 10,000 years, since the last Ice Age, peatlands have been slowly accumulating and storing all this carbon. During this time, peatlands have played an important role in global GHG balance by sequestering an enormous amount of atmospheric carbon dioxide (CO_2). However, this delicate balance can be, and has been, easily upset through human intervention. Human disturbances such as deforestation, drainage and fire are now turning peatlands in Southeast Asia from carbon stores to carbon sources. Such disturbances, especially land use change, have now made peatlands in Southeast Asia the most significant GHG contributors at the global level.

In 2006, CO_2 emissions from tropical peatland drainage contributed to the equivalent of **1.3–3.1%** of global emissions from fossil fuel burning in the same year (Hooijer *et al.*, 2010).

Fire in peatlands is responsible for significant additional emissions. In his modeling, van der Werf (2008) estimated that carbon emissions due to fire in peatlands in Borneo and Sumatra was 457 million tonnes of CO_2 per year. Indonesia is ranked as the third largest global GHG emitter when emissions from land use change on peatlands is included in the country's emissions. *Figure 1* below shows the contribution of Indonesia's peatland emissions to the global total for emissions from peatlands.

Figure 1: Breakdown of global peatlands area by surface and corresponding CO_2 emissions (Anon, 2010).



- 5% of global and 50% of tropical peatlands are located in Indonesia
- Tropical peat has a share of more than 80% of emissions from peat decomposition
- Indonesia's share of total emissions from peat decomposition is 60% or 12 times more than share of area

1 Papua New Guinea, Brazil, Peru, Sudan, Malaysia.
2 Canada, Russia, Scandinavia, USA.

SOURCE: Hooijer *et al.* (2006); Wetlands International.

While GHG emissions from peatlands contribute to global warming, changes in climate also affect peatlands, which highlights the cyclical nature of climate change effects. Future changes such as higher temperatures and variation in precipitation could lead to drought, which in turn increases fire risk, especially in degraded peatlands that have been drained. In addition, coastal peatlands could be at risk from saline water intrusion as a result of sea level rise, and prolonged flooding could lead to the loss of biodiversity in peat swamp forests (PSFs).

1.2 LOCATION AND EXTENT OF PEATLANDS IN SOUTHEAST ASIA

Tropical peatlands are found in Southeast Asia, the Caribbean, Central America, South America and Central Africa. The most recent estimated tropical peatlands area by Page *et al.* (2011) is

44.1 million hectares

equivalent to 11% of the global peatland area. 56% of these peatlands are found in Southeast Asia.

In Southeast Asia, peatlands occupy mostly low altitude coastal and sub-coastal environments and are usually located at altitudes from sea level to 50m above sea level (Rieley *et al.*, 2008). The total peatland area in Southeast Asia is approximately 24.7 million hectares in which 20.7 million hectares are in Indonesia (Page *et al.*, 2011). The distribution of peatlands in Southeast Asia is shown in *Figure 2* and *Table 1*.

Figure 2: Distribution of lowland peatlands in Southeast Asia (Data modified from Page *et al.*, 2011).

Table 1: Area of peatlands in Southeast Asia by country (Modified from Joosten, 2009; National Environmental Agency Singapore, 2011; Page *et al.*, 2011; Quoi, 2012).

REGION	AREA/HECTARES
Indonesia	20,695,000
Malaysia	2,588,900
Papua New Guinea	1,098,600
Myanmar	122,800
Brunei	90,900
Philippines	64,500
Thailand	63,800
Vietnam	53,300
Lao PDR	19,100
Cambodia	4,580
Singapore	50
TOTAL	**24,801,530**

DID YOU KNOW?

PEAT is defined as a soil type containing at least 65% organic matter. It is comprised of partially decayed organic matter such as stems and roots. The decomposition of organic matter slows down in the presence of water and absence of oxygen, and peat is formed when the rate of accumulation exceeds the rate of decomposition. Over thousands of years, this layer of peat can reach a depth of 20m.

PEAT SWAMP FOREST (PSF) is a natural vegetation in lowland tropical peatlands in Southeast Asia. Most of the fauna and flora found in peat swamp forests are unique and highly adapted to the environment (i.e. acidic water and waterlogged condition).

Peat swamp forests have many ecological functions such as:

1. A source of freshwater supply.
2. Flood mitigation.
3. Carbon sink and store.
4. Safeguarding biodiversity.

1.3 DRIVERS OF LOSS OF PEAT SWAMP FORESTS IN SOUTHEAST ASIA

The main drivers of deforestation and forest degradation in tropical peatlands are the agricultural and forestry sectors.

Miettinen *et al*. (2012a) indicated that only 5,249,000 hectares, or 34% of the 15,528,000 hectares of former peat swamp forests in the western portion of Southeast Asia, are still covered with relatively intact forests. The remainder of the forest areas has been cleared for agriculture and plantations or degraded by logging and fire. The same study also reported that the deforestation rate for peatlands is at nearly 4% per annum which is considerably higher than the deforestation rate for all other forest types.

Many development activities have taken place in peatland areas without sufficient knowledge of the characteristics and eco-hydrology of tropical peat swamp forests and peat soils. As a result, many large-scale drainage schemes in tropical peatlands (such as the Mega-rice Scheme in Central Kalimantan, Indonesia) have been abandoned due to unsuitable soil, acidification, rapid subsidence, flooding, fire and other reasons.

1.3.1 PLANTATIONS: OIL PALM AND *ACACIA*

Peat swamp forests in Southeast Asia are being deforested, drained extensively and often burned for conversion to large scale plantations such as oil palm and *Acacia* plantations (Hooijer *et al*., 2010; Miettinen *et al*., 2012a). Global demand for oil palm and pulp and paper remain high and the high economic returns of such businesses are the main drivers for the expansion of these plantations. Miettinen *et al*. (2012a) showed that 3.1 million hectares of peatlands in Peninsular Malaysia, Borneo and Sumatra have already been converted to industrial plantations (two-thirds for oil palm and the balance for *Acacia*) in 2010. The same paper also further projected that half of the peatland area in Peninsular Malaysia, Borneo and Sumatra may be converted to plantations by 2020, if the current expansion trends persist.

Figure 3: Oil palm plantation on peat.

Figure 4: *Acacia* plantation on peat.

1.3.2 TIMBER EXTRACTION

Peat swamp forests in Southeast Asia used to be an important source of valuable timber species such as Ramin (*Gonystylus bancanus*) and Meranti (*Shorea platycarpa, Shorea uliginosa*). It is possible, with the correct approach, to harvest timber from peat swamp forests on a sustainable basis. However, a high proportion of timber extraction from peat swamp forests in the region has not followed sustainable practices. The extraction rates have often been too high and extraction methods using drainage have led to serious changes in the ecology of the system, reducing natural regeneration and also increasing the frequency of fire. Often, the remaining forest is left in poor condition. Studies have shown low density of forest cover, poor recovery and depleted conditions in post-logging peat swamp forests in Malaysia and Indonesia (Chai, 2004; Danced, 2000; Istomo, 2010; Rucker, 2008). Over the last 20 years, over-exploitation and illegal trade has led to trade restriction under CITES for one of the key peat swamp forest species — Ramin.

Figure 5: Logging operations on peatland

1.3.3 AGRICULTURE

Development of large scale agriculture projects has also led to significant loss of peat swamp forests. For example, in Central Kalimantan, Indonesia, about one million hectares of peat swamp forest was clear-felled and drained for rice production. Unfortunately, the project failed and was abandoned. It not only failed to produce rice, but left behind the degraded peatlands, which until today continue to emit CO_2 related to extensive drainage and annual fires.

In addition, expansion of smallholder agriculture is also very significant, especially in Sumatra and Kalimantan. According to Miettinen and Liew (2010), about half of the peatlands in Sumatra that have been developed for agriculture or plantations were developed by smallholders (1.48 million hectares), while 1.3 million hectares were developed as industrial plantations.

Figure 6: Abandoned and degraded peatland in ex-mega rice project area in Central Kalimantan

CHAPTER 2: PEATLANDS IN SOUTHEAST ASIA AND GHG EMISSIONS

Globally, peatlands are the most important terrestrial carbon pool of the world, storing more than 500 billion tonnes of carbon.

This represents 30% of the world's soil carbon and twice as much carbon as the biomass of all the world's forests combined. Tropical peatlands were estimated to store about 88.6 billion tonnes of carbon, while 77% of it is located in peatlands in Southeast Asia (Page *et al*., 2011). This carbon is stored mainly in the form of peat with a lesser amount in living tree biomass. Undisturbed tropical peatlands play a key role in climate regulation by absorbing large amounts of CO_2.

Peatlands also play a role in the regulation of two other GHGs – namely methane (CH_4) and nitrous oxide (N_2O). CH_4 and N_2O, both have a higher global warming potential (GWP) than CO_2, being about 25 and 298 times that of CO_2 respectively (IPCC, 2007). These two gases however have a comparatively smaller role in GHG emissions from drained and degraded tropical peatlands. Therefore, most of the information presented here will focus more on CO_2.

2.1 CARBON DIOXIDE (CO_2)

GHG fluxes from tropical peatland ecosystems are a balance between three different processes:

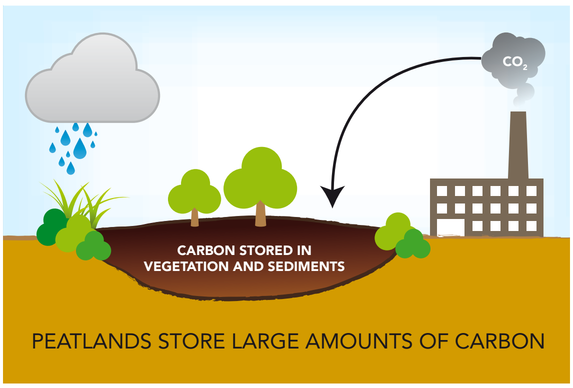
1. Carbon uptake by plants through photosynthesis.
2. Carbon loss primarily through the respiration of living roots (autotrophic respiration).
3. Bacterial breakdown of the peat or heterotrophic respiration.

Peat swamp forests in the tropics over the past 10,000 years have shown a positive balance by absorbing large amounts of CO_2 from the atmosphere and storing it as tree biomass and peat deposit (*Figure 7*) (Jauhianen *et al*., 2012; Parish *et al*., 2008; Verwer and van der Meer, 2010).

2.1.1 PEATLANDS AS A CARBON SINK

Peatlands in their natural state act as the most efficient carbon stores of all terrestrial ecosystems. In the tropical zone, peatlands store 10 times more carbon per hectare than adjacent ecosystems on mineral soil (Parish *et al*., 2008). Page *et al*. (2011) estimated that peatlands in Southeast Asia stored at least 68.5 gigatonnes (billion tonnes) of soil carbon. This figure represents 77% of tropical peat carbon and is equivalent to 14% of global peat carbon (Page *et al*., 2011).

Figure 7: Diagram showing carbon stored in peatlands



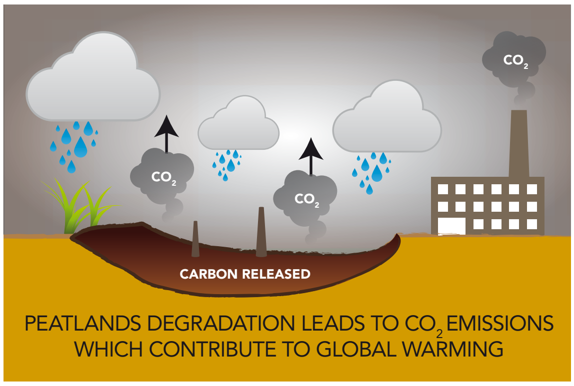
Carbon in peatlands is stored in two forms: tree biomass and peat deposit.

- **TREE BIOMASS OF A DENSE PEAT SWAMP FOREST:** Even though the above ground biomass is less compared to the below ground peat deposit, it is still significant as an ecosystem which continually absorbs CO_2 from the atmosphere.
- **PEAT DEPOSIT:** The mean thickness used by Page *et al*. (2011) is 7m for Malaysia and Brunei and 5.5m for Indonesia. Maximum peat thickness has been reported as up to 20m (Hooijer, 2006). The thickness of the peat deposits (developed mainly over the last 10,000 years) demonstrates the unique ability of the peat ecosystem to absorb and store carbon over thousands of years.

2.1.2 PEATLANDS AS CARBON SOURCES

Peatlands which are the most important carbon store in the region can also turn into the biggest GHG emitter through anthropogenic disturbance. CO_2 is the most important GHG resulting from human disturbances, and most CO_2 emissions from peatlands in Southeast Asia are a direct result of drainage and fire (*Figure 8*).

Figure 8: Diagram showing carbon emission in peatlands



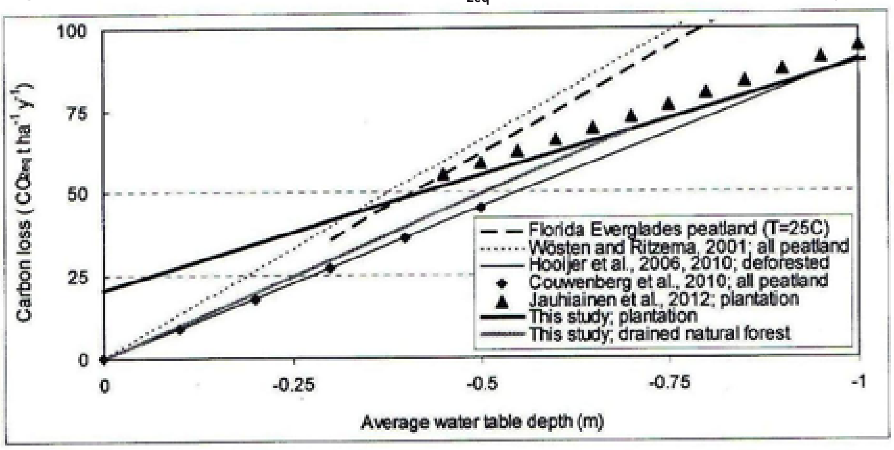
i. DRAINAGE

Drains or canals are an important feature of peatland development. Their main function is to lower the water table so that agricultural activities can be carried out. They may also be used as a transportation mode for logging or plantations. However, drainage of peatlands leads to aeration of the peat material and hence allows oxidation to take place — this process is also called aerobic decomposition (Hooijer *et al.*, 2006). This oxidation of dried peat material results in CO_2 emissions.

Figure 9: Canals in peatlands for drainage and transport

The amount of CO_2 emissions resulting from drainage is very much dependent on the ground water level, i.e. the lower the water table, more CO_2 will be emitted to the atmosphere. *Figure 9* below shows the relationship between CO_2 emissions and water table depth. This linear relationship implies that for every 10 cm of water drawn down from the water table there will be an increase in CO_2 emissions of 9.1 t CO_2/hectare/year (Hooijer *et al.*, 2010).

Figure 10: Relation between carbon loss (CO_{2eq}) and water table depth (m) (Hooijer *et al.*, 2012)



The total cumulative emissions from 1995 up to 2006 from peatlands in Southeast Asia was estimated at 9.7 gigatonnes of carbon (Hooijer *et al.*, 2010). This was equivalent to almost one-third of the world's total emissions in 2009, which highlights the global significance of drainage for CO_2 emissions.

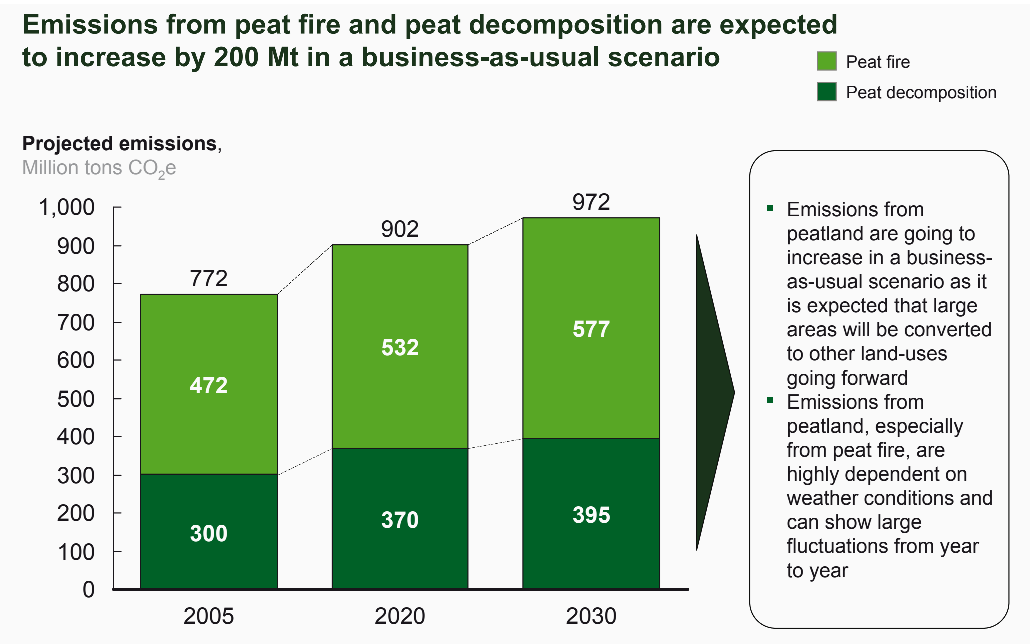
ii. FIRE

Fire is extremely rare in pristine peatlands or those that have not been drained. Miettinen *et al.* (2012b), through their studies of peatlands in Sumatra, reported that only 7 fires/100km^2 for 1996-2010 were in pristine peat swamp forests, whereares fires were highly concentrated in degraded areas with 140 fires/100km^2. Fires are responsible for approximately half of the emissions from tropical peatlands (Hooijer *et al.*, 2006). Based on a study of the impact of the 1997-98 El Niño related fires on peatlands in Central Kalimantan, it was estimated that between 2.9 - 9.2 billion tonnes of CO_2 was emitted (or 0.81 and 2.57 billion tonnes of carbon) Indonesia-wide as a result of burning peat and vegetation, which was equivalent to 13-40% of the mean annual global carbon emissions during that period of time (Page *et al.*, 2002).

Figure 11: Fire in peatlands

Ballhorn *et al.* (2009) determined that fires in 2007 led to an average burn scar depth of 0.33m for a severe peatland fire. They also further estimated that the peat fire in 2007 in Central Kalimantan released an estimated 175 million tonnes of CO_2. This underlines the importance of peat fire in the contribution to global climate change. *Figure 12* shows the emissions from peat fires and drainage (decomposition) from Indonesia in 2005 as well as projected emissions expected in 2020 and 2030 (Anon, 2010). Fire will continue to play an important role in the fate of global peatland carbon stocks (Strack, 2008).

Figure 12: Emission from peat decomposition and peat fires in Indonesia (Anon, 2010)

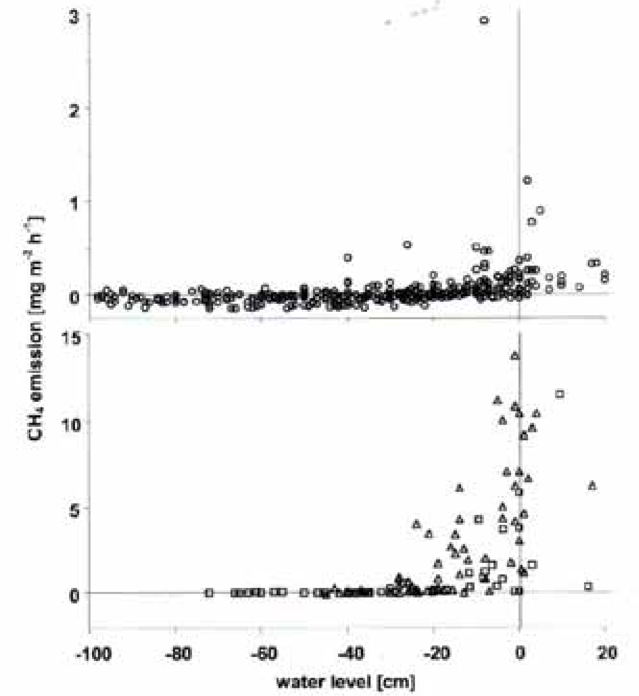


SOURCE: Hooijer *et al.* (2006) - PEAT CO_2e; Alterra; Wetlands International; Expert Interviews; Couwenberg et al. (2009); Van der Werft *et al.* (2008).

2.2 METHANE (CH_4) AND NITROUS OXIDE (N_2O)

Methane or CH_4 is a product of organic matter decomposition under water-logged conditions. CH_4 emissions from peatlands in Southeast Asia show a clear relationship to water level. Values are generally low (and often negative) for water levels 20cm below the surface and are higher and more variable when water levels are above this threshold (Couwenberg *et al.*, 2009). Tropical forested peatlands generally do not emit much CH_4 as there is normally an oxygenated layer just below the soil surface of about 20cm in which any CH_4 is oxidized before it is released to the atmosphere (*Figure 13*).

Figure 13: CH_4 emission in relation to water level in tropical versus temperate peatlands



In general, N_2O emissions from natural peatlands are low, but agriculture on peatlands may release significant amounts of N_2O (Strack, 2008). Areas which have been drained and on which inorganic fertilisers have been used usually produce high emissions of N_2O. The mean N_2O flux in drained peatland forests has been observed to be more than ten times higher in comparison to the fluxes from other sites (Couwenberg *et al.*, 2009).

Although detailed data on CH_4 and N_2O fluxes from tropical peatlands is still limited, it is clear that CO_2 has the main impact (>90%) in tropical peat when concurrent CO_2, CH_4 and N_2O fluxes are compared across various land use types (Couwenberg *et al.*, 2009).

CHAPTER 3: IMPACTS OF FUTURE CLIMATE CHANGE ON TROPICAL PEATLANDS

Natural peatlands have showed resilience to the changes in climate that have occurred in the past.

However, the rate and magnitude of predicted future climate change and extreme events may push many peatlands over their threshold for adaptation. Climate change scenarios suggest major changes in temperature, precipitation and other phenomena that will have significant impacts on the carbon store, GHG flux and biodiversity of peatlands (Parish *et al*., 2008).

3.1 EFFECTS IN PRECIPITATION CHANGES

It is predicted that the total rainfall in Southeast Asia will increase in the future as a result of global climate change, with a median change of about 7% in all seasons and strong seasonality within the region (Christensen *et al*., 2007). The predicted pattern is broadly one of an increase in wet season rainfall and a decrease in dry season rainfall.

How these future changes might impact tropical peatlands was addressed in a study by Li *et al*. (2007). Out of 11 climate models for Southeast Asia, seven models predicted a decrease of future rainfall and evaporative fraction (i.e. the residual water after balancing rainfall and evapotranspiration) during the dry season, especially south of equator, implying a decrease in water table and increase in surface dryness in peatlands. This will affect parts of Indonesia (Southern Sumatra, Southern Kalimantan and Papua) where most extensive peatlands occur. Such changes would increase the frequency of peatland fires and associated GHG emissions and the potential of turning these carbon sinks into carbon sources.

3.2 EFFECTS OF INCREASING TEMPERATURE

Increases in temperature will generally enhance the decay rate and accelerate the microbial processes responsible for CO_2, CH_4 and N_2O emission from peatlands (Charman *et al*., 2008). This process is complex and depends on the hydrological regime and other conditions. A combination of higher temperature and reduced rainfall would accelerate the oxidation of peat and result in the loss of carbon (Page *et al*., 2004). The predicted median warming for Southeast Asia is 2.5°C by the end of the 21st century with little seasonal variation (Christensen *et al*., 2007). This rise in temperature will increase the rate of evapotranspiration from peatlands, which in turn will increase the rate of peatland decomposition, peatland subsidence and frequency of fires.

3.3 SEA LEVEL RISE

Sea levels are predicted to rise by 18 to 59cm over the next 100 years (IPCC, 2007). In low-lying peatland areas, intrusion of saline water into aquifers may give rise to increased salinity and changes in the ecology and functioning of the system. Inundation of coastal peatlands may result in biodiversity and habitat loss with conversion of freshwater peatlands to mangroves and brackish marshes. On the other hand, a rise in base sea level may allow the spread of new peatlands inland if land is made available for this (Charman *et al*., 2008).

Natural undisturbed peatlands play an important role in maintaining freshwater tables in coastal soils. Coastal areas will be more vulnerable to salt water intrusion as a result of reduced freshwater supply from deforested and drained peatlands further inland.

For example, farmers in the fertile Mekong delta in Vietnam where many peatlands and freshwater marshes have been drained for agricultural development have already suffered the impacts of sea water intrusion into their rice fields (IRIN, 2013).

3.4 HYDROLOGICAL CHANGES

The hydrological regime is the principal factor controlling ecosystem processes in peatlands. Any changes in water balance will have far reaching effects on peatland ecosystem processes. A combination of increased temperatures and changes in precipitation will determine the hydrological status of peatlands (Charman *et al*., 2008).

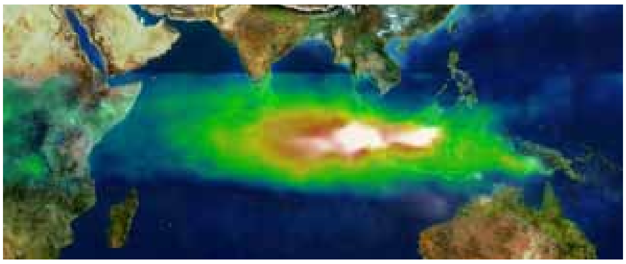
GHG exchange may be affected by hydrological changes combined with temperature rise. Drier surfaces emit more N_2O and CO_2 but less CH_4, with the converse true for wetter surfaces (Charman *et al*., 2008).

3.5 FIRES AND HAZE

In regions strongly affected by the drying effects of the El Niño - Southern Oscillation (ENSO) weather phenomenon, the frequency of drought is likely to increase due to the background increase in temperature and changes in precipitation. Fire frequency may increase in peatlands that are subject to greater extremes of drought (Charman et al., 2008). For example, the occurrence of fires in Indonesian peatlands is largely due to man-made drainage, logging and fire-setting, but the frequency and severity of fires is increased by changes in the length and severity of droughts. Severe peat fires have occurred in Indonesia during recent El Niño-induced droughts in 1997, 2002, 2004, 2006 and 2009 (Ballhorn et al., 2009).

Fires in peatlands burn for much longer that fires on mineral soils and these fires generate much more smoke — as a result of incomplete combustion. Peatland fires burn into the peat soil and have been recorded at up to four metres below the peat surface. These underground fires smolder at lower temperatures than normal fires and thus generate more smoke. It is estimated that up to 90% of the smoke which creates the regular transboundary smoke haze in the ASEAN region comes from peatland fires. Transboundary haze is one of the most serious regional environmental problems in the ASEAN region and has significant impacts on health, economy (especially transport and tourism) and the environment.

Figure 14a: Haze cloud in October 1997



SOURCE: NASA.

Figure 14b: Haze in 2005

SOURCE: MODIS.

Major increases in the area of peatlands burned have been documented in recent decades and this may continue in the future if peatlands dry out as a result of climate change and anthropogenic activities (Strack, 2008). Measures to reduce the risk of fires due to human activities – such as better water management, fire prevention and enhanced fire control capacity will also reduce the impact of climate change on peatlands.

3.6 FUTURE

Future climate change will not only affect peatland ecosystems. It will also have huge implications to local human populations, particularly for those living on or in the vicinity of peatlands. Some of the effects include:

a) Greatly reduced quantity and quality of freshwater supply.
b) Increased subsidence and flooding.
c) Increased fire and haze.
d) Increased saline intrusion.

CHAPTER 4: ACTION AND RECOMMENDATIONS FOR TROPICAL PEATLANDS IN RELATION TO CLIMATE CHANGE

By the end of this century, many ecosystems will have exceeded their ability to adapt due to an unprecedented combination of climate change associated disturbances and other global change drivers (IPCC, 2007). Natural peatlands have, in the past, shown resilience to changes in climate. However, human intervention has pushed its limits and it may not be able to maintain its resilience for long (Charman *et al.*, 2008).

The best way to increase the resilience of peatlands would be through conservation and protection of undisturbed peatlands.

For peatlands which are already disturbed or degraded, human activities can be minimized through better water management, fire prevention and control as well as restoration.

Climate change mitigation refers to efforts to reduce GHG emissions. This can be done through the use of advanced technology such as renewable energy or can be as simple as protecting forests. Four actions are recommended for mitigating climate change in tropical peatlands:

a) Avoiding new emissions from land use change

b) Restoration of peatlands to reduce emissions and enhance sequestration

c) Improved management practices to reduce emissions from existing production systems

d) Fire prevention and control

4.1 AVOIDING NEW EMISSIONS FROM LAND USE CHANGE

Natural peatlands are usually wet — a condition which allows peat to accumulate and allow carbon to be stored. Hence it is important to keep the remaining peatlands protected from future conversion, not only to maintain carbon storage and reduce emissions, but also to ensure that biodiversity and other ecosystem services are protected. Conservation of undrained peatlands can be a very cost effective management strategy for minimizing CO_2 emissions (Joosten *et al.*, 2012; Parish *et al.*, 2008).

4.2 RESTORATION OF PEATLANDS: REDUCING EMISSIONS

Peatland restoration is seen as the most cost effective way to reduce GHG emissions from degraded peatlands and combat global warming (Parish *et al.*, 2008). However, complete restoration is often difficult due to the complexity of peatlands and long time-scale for peat regrowth. Restoration is usually more successful if it takes place shortly after the original damage has been done. Plans for restoration should be based on the management of the whole peatland area as a hydrological and ecological unit.

4.2.1 REWETTING/ RESTORATION OF HYDROLOGY

Utilisation of peatlands often require lowering the water table through drainage canals. Therefore it is crucial to reduce water loss and elevate the water table in drained peatlands (Joosten *et al.*, 2012). This can be achieved through blocking the drainage canals, which is a cost effective way of maintaining the water level of the restoration site. In existing production peatlands, a raised water table will help to keep the soil moisture content which improves the production yield of the crops/plantation. In degraded peatlands, restoration of hydrology will stimulate natural regeneration of vegetation.

CASE STUDY: RAJA MUSA FOREST RESERVE REHABILITATION PROGRAMME

A rehabilitation programme was initiated by the Selangor Forestry Department in collaboration with Global Environment Centre for the Raja Musa Forest Reserve (RMFR), Selangor Malaysia. This site is one of the pilot sites in the ASEAN Peatland Forests Project (APFP) project. The activities were undertaken with the support from APFP, The SEApeat project, the private sector and local communities with a long term target to rehabilitate about 1,000 hectares of degraded peat swamp forest.

Before: Degraded area void of vegetation (Parit 6, RMFR in 2009)

Before: No trees and low-lying vegetation only (Parit 7, RMFR in 2010)

After: Area well-covered with vegetation including trees (Parit 6, RMFR in 2012)

After: Mahang trees clearly visible (Parit 7, RMFR in 2013)

The main activities carried out included establishing canal blocks at the existing canals, implementing fire prevention measures and tree planting in seriously degraded areas. In the initial stage, most of the existing drainage canals at the targeted sites were blocked to maintain the water table level. Since 2008, nearly 900 canal blocks have been placed by the state Forestry Department inside the forest reserve as the first step to restore the hydrology of the area. Subsequently, canal blocks were placed in the buffer zone outside the boundary to further support the maintenance of the water table.

The replanting activities were focused on areas which had been repeatedly burnt and cultivated, and where natural regeneration was thought to be unlikely. This involved replanting suitable pioneer tree species that originated from RMFR. Over the last four years (2009-2012), more than 60,000 seedlings of Mahang (*Macaranga pruinosa*) and Tenggek Burung (*Euodia rox burghiana*) have been planted within the project site covering 80 hectares. Other forest species included Mersawa Paya (*Anisoptera marginata*) and Ramin (*Gonystylus bancanus*) have also been planted at the project site.

Since the work started in 2008, good progress has been made. Vegetation cover, especially pioneer tree species, is slowly coming back to the once degraded areas.

4.2.2 RE-VEGETATION

In addition to canal blocking, it is important to re-introduce vegetation cover to degraded peatlands. A layer of vegetation can help keep the peat soil wet, and thus prevent further oxidation. Often, degraded areas may be populated by pioneer species such as *Imperata cylindrica* or "lalang" grass, ferns and scattered trees. It is recommended to initially plant pioneer, fast growing peatland species to rapidly establish tree cover (Parish *et al*., 2012) and later interplant climax forest species that have buttresses, which play a key role in providing the structural elements for hydrological self- regulation (Dommain *et al*., 2010).

Peatland restoration through rewetting and re-vegetation has been shown to significantly reduce fire risk and encourage regrowth of natural vegetation. It is recommended to invite the participation of local communities in the restoration process because community participation helps to ensure that the measures implemented will be sustained over time.

4.3 IMPROVED MANAGEMENT PRACTICES TO REDUCE EMISSIONS FROM EXISTING PRODUCTION SYSTEM

4.3.1 WATER MANAGEMENT IN PLANTATIONS

It has been shown that for tropical peatlands, every 10cm drop in the water level results in 9.1 t CO_2/hectare/year being emitted (Hooijer *et al*., 2010). Hence, water management in plantations such as oil palm and *Acacia* plantations on peatlands is key to reducing emissions. High water levels are also important for preventing subsidence and for optimizing yields. A sound water management plan can reduce substantial emissions from these plantations. The recently adopted RSPO manual for the Best Management Practices for Existing Cultivation of Oil Palm on Peat (Lim *et al*., 2012) recommends maintaining water levels in the field drains at 50cm for obtaining high yields and reducing GHG emissions.

Lim *et al*. (2012) also recommend other ways in which oil palm plantations can reduce their GHG emissions:

- **FERTILIZER PRACTICES**
  The use of 'coated' nitrogen will help to reduce N_2O emissions. Fertilizer practices that optimize N-fertilizer and maximize organic fertilizer use, including composting and careful fertilizer application during rainy seasons, will also help to reduce GHG emissions.
- **CARBON STOCK**
  Carbon stocks can be maintained and increased through maintenance and rehabilitation of buffer zones and high conservation values areas, planting other crops and ensuring optimal oil palm planting density. Conserving adjacent (or where appropriate, within plantations) forested areas will increase the carbon stock of the area. This can offset emissions from other practices.
- **MILL PRACTICES**
  Good mill practices such as methane capture, improving energy efficiency and production from palm oil mill effluent (POME) and empty fruit bunch (EFB) can also significantly reduce net GHG emissions.

4.4 FIRE PREVENTION AND CONTROL: REDUCING EMISSIONS

Drained and degraded peatlands are very prone to fire.

Previously burned areas also have great potential to burn again. Besides emitting more GHGs into the atmosphere, fire from peat also creates other impacts such as smoke haze which regularly affects five key countries in Southeast Asia — Brunei Darussalam, Indonesia, Malaysia, Singapore and Thailand. As a result, ASEAN established the ASEAN Agreement on Transboundary Haze Pollution in 2002 and adopted the ASEAN Peatland Management Strategy (APMS) (2006-2020) in 2006. The main goal of the APMS is to promote the sustainable management of peatlands in ASEAN through collective action and enhanced cooperation to support and sustain local livelihoods, reduce the risk of fire and associated haze, and contribute to global environment management. The APMS includes a number of specific actions to address fire prevention and control including:

i. Identify peatlands in the region with high fire risk and develop and promote preventive measures.

ii. Monitor weather conditions and hot spots in high-risk areas and issue alerts as appropriate.

iii. Manage water tables in peatlands appropriately according to land use to prevent fire.

iv. Develop and promote appropriate techniques for fire control in peatlands.

v. Strengthen coordination and capacity among agencies involved in peatland fire prevention and control, including establishment of peat fire prevention units in agencies responsible for forestry and agriculture.

vi. Active involvement of local community members and other local stakeholders in fire prevention and control.

vii. Implement zero-burning strategies for all commercial agriculture and zero or controlled burning for local communities.

Fire can often be prevented through better water management and enhanced vigilance and fire control measures (Parish *et al*., 2008).

4.4.1 ZERO BURNING

Fire is used as a traditional method of land clearing in many parts of the ASEAN region and is a key contributor of CO_2 emissions. Therefore, zero burning should be implemented to reduce the risk of fire. The ASEAN Secretariat (2003) produced a guideline for the implementation of the ASEAN policy on zero burning. The zero burning technique is a method of land clearing whereby the tree stand (either logged over secondary forests or an old area of plantation crops) such as oil palm are felled, shredded, stacked and left in-situ to decompose naturally. The basic steps of zero burning in existing plantations include:

- Planning for replanting.
- Removal of *Ganoderma*-diseased palms.
- Construction of roads and drains.
- Felling and shredding / chipping.
- Stacking and windrowing.
- Lining, holing and planting of oil palm seedlings.
- Post planting management.

CHAPTER 5: THE WAY FORWARD

5.1 SUSTAINABLE MANAGEMENT OF PEATLANDS

The sustainable management of peatlands requires an integrated approach in developing common strategies for management of different uses within each peatland area. The requirements for biodiversity conservation, land rehabilitation and climate change mitigation / adaptation also need to be incorporated into management strategies. The close coordination between different stakeholders and economic sectors is also critical. The current management of peatlands is often not sustainable and may have major negative impacts on biodiversity and the climate (Parish *et al*., 2008). A wise use approach is needed to integrate protection and sustainable use, and to maintain peatland ecosystem services despite increasing pressure from people and the changing climate.

The existing APMS has outlined key strategies to ensure the sustainability of peatlands in Southeast Asia. Effective implementation of the APMS is crucial to prepare ASEAN countries in reducing potential risk from disasters and economic loss in the region resulting from peatland degradation (*Table 2*). It should be noted that the integrated management of peatlands is one of the most critical focus areas for the APMS and progress in this is fundamental to achieving many of the objectives.

Table 2: Focal areas and respective operational objectives of the ASEAN Peatland Management Strategy (APMS)

	FOCUS AREAS		OPERATIONAL OBJECTIVES
1.	Inventory and Assessment	1.1	Determined the extent and status of peatlands in the ASEAN region (including issues of definition).
		1.2	Assess problems and constraints faced in peatland management.
		1.3	Monitor and evaluate peatland status and management.
2.	Research	2.1	Undertake priority research activities.
3.	Awareness and Capacity Building	3.1	Enhance public awareness of importance of peatlands, its vulnerability to fire and the threat of haze through implementation of comprehensive plan.
		3.2	Build institution capacity on management of peatlands.
4.	Information Sharing	4.1	Enhance information management and promote sharing.
5.	Policies and Legislation	5.1	Develop or strengthen policies and legislation to protect peatlands and reduce peat fires.
6.	Fire Prevention, Control and Monitoring	6.1	Reduce and minimize occurrence of fire and associated haze.
7.	Conservation of Peatland Biodiversity	7.1	Promote conservation of peatland biodiversity.

	FOCUS AREAS		OPERATIONAL OBJECTIVES
8.	Integrated Management of Peatlands	8.1	Promote multi- agency involvement in peatland management.
		8.2	Promote integrated water resources and peatland management using basin-wide approach and avoiding fragmentation.
		8.3	Promote integrated forest and peatland management.
		8.4	Manage agriculture in peatland areas in an integrated manner.
		8.5	Promote integrated community livelihood and peatland management.
9.	Promotion of Demonstration Site for Peatlands	9.1	Promote best management practices.
10.	Restoration and Rehabilitation	10.1	Develop appropriate techniques for the restoration or rehabilitation of degraded peatlands.
		10.2	Rehabilitate burnt, drained and degraded peatlands.
11.	Peatland and Climate Change	11.1	Protect and improve function of peatlands as carbon sequestration and storage.
		11.2	Support peatland adaptation to global climate change.
12.	Regional Cooperation	12.1	Promote exchange of expertise in addressing peatland management issues.
		12.2	Establishment of "centres of excellence" in the region for peatland assessment and management.
		12.3	Contribute to the implementation of other related agreements and regional cooperation mechanism.
		12.4	Enhance multi-stakeholder partnerships to support peatland management.
13.	Financing of the Implementation of Strategy	13.1	Generate financial resources required for the programmes and activities to achieve target of the strategy.

5.2 PUBLIC AND MULTI-STAKEHOLDER ENGAGEMENT

Various parties including public and other stakeholders must engage actively in the sustainable use of peatlands. The use and management of peatlands is fragmented between a broad range of stakeholders including government agencies related to forestry, agriculture, water resources and the environment; local communities involved in harvesting of timber and non-timber forest products including agriculture; and plantation companies related to oil palm and pulp and paper. The activities of one stakeholder group may frequently conflict with the needs and desires of other stakeholder groups. Hence it is important that multi-stakeholder collaborative frameworks are developed to facilitate collaborative activities.

Examples of successful multi-stakeholder mechanisms include the Roundtable on Sustainable Palm Oil (RSPO) which links together seven separate stakeholder groups including plantations, refiners, retailers, bankers and social and environmental NGOs related to the oil palm sector. The Peatland Working Group (PLWG) of the RSPO has recently worked to assess the impacts of oil palm plantations on peat and develop two best management practice manuals related to oil palm cultivation on peat (Lim *et al*., 2012) and the maintenance and rehabilitation of natural vegetation associated with oil palm plantations on peat (Parish *et al*., 2012).

5.3 INTEGRATION OF PEATLANDS INTO ENVIRONMENTAL AND CLIMATE CHANGE POLICIES

Scientists have long been aware of the role that degraded peatlands play in global GHG emissions. On the other hand, policy makers have been slower to react to this issue (Strack, 2008). The importance of peatlands has been emphasized in recent decisions of several global environment conventions including: UNFCCC, Ramsar Convention on Wetlands and the Convention on Biological Diversity (CBD).

Countries should pay increased attention to the importance of peatlands in national and international policies and allocate necessary resources for policy implementation, especially to incorporate peatlands into their climate change mitigation and adaptation strategies and also national wetland strategies.

Mechanisms and incentives for mitigation of emissions from peatland degradation and fire should be included in future climate frameworks (Strack, 2008).

5.4 POTENTIAL FINANCING OPPORTUNITIES FOR PEATLAND CONSERVATION

5.4.1 CARBON FUNDING: REDD/VCS

Tropical peatlands are increasingly being recognized as one of the biggest sources for global GHG emissions other than fossil fuels. Therefore, a relatively new mechanism called the Reduced Emission from Forest Deforestation and Degradation (REDD) under the UN Framework Convention on Climate Change (UNFCCC) could be the way for conserving the vulnerable carbon pools in tropical peatlands and at the same time reducing emissions from these ecosystems.

Voluntary market schemes such as the Verified Carbon Standard (VCS) have already provided a much needed platform for selling carbon credits in the global market. In 2011, emissions from peatlands and REDD were included in the Agriculture, Forestry and Other Land Use (AFOLU) requirement (VCS, 2011). The new project category, Peatland Rewetting and Conservation includes two types of projects: rewetting of drained peatlands (RDP) and conservation of un-drained and partially drained peatland (CUPP).

Local stakeholders need to be involved in all the financial mechanisms so that it can be a win-win situation for all i.e. poverty reduction, biodiversity conservation, improved water management and halting of land degradation and carbon store conservation and restoration (Silvius, 2008).

The revenue from the sale of carbon credits should be funneled back to project sites for the protection of peatlands and also to generate income for local communities. Carbon credits could also ease the pressure on peatland conversion and at the same time generate alternative financial returns.

5.4.2 INCENTIVES FOR SUSTAINABLE USE OF PEATLANDS

Communities have a very important role as stewards of peatland resources and should be effectively involved in activities to restore and sustain the use of peatlands. However, in developing countries, poverty may be one of the key driving factors for unsustainable use of peatland resources. Therefore, incentives are very important to support local efforts to practice wise use of peatlands. Without sufficient revenue, poor people may be forced to utilize cheaper agricultural methods or practices (i.e. the use of fire for land clearing on peat).

The private sector, such as large plantation owners, may also benefit from incentives to help them comply with best management practices on peatlands, which in turn would reduce the impact of peatland conversion. Best practices such as water management and rehabilitation of degraded forest areas will reduce GHG emissions but would require additional investments. Options for incentives for sustainable management of tropical peatlands are described by Macmillan (2013) and include:

- **MULTI DONOR TRUST FUND / ASEAN HAZE FUND / NATIONAL FUNDS**
  Establishment of funds at national or regional level to receive funds from government, private sector, international donors and donations from the general public.
- **INCENTIVES AT SITE LEVEL**
  Site level incentives may include access to land or use of resources or provision of incentives to local communities for forest protection or rehabilitation.
- **PEATLAND-USER PAY PRINCIPLE**
  Funding could be generated by charging users of the peatland area such as extractors of peatland products and those that undertake agriculture, plantation or eco-tourism activities.
- **PEATLAND POLLUTER PAY PRINCIPLE**
  Fines and emission permits would generate funds for peatland management and serve as an incentive to decrease forest degradation and fires.
- **PAYMENT FOR ECOSYSTEM SERVICES (PES)**
  Payment for ecosystem services may include options to support management of peatland areas which provide water supply to adjacent communities and developments by charging a levy on the water supply.
- **TAX INCENTIVES**
  Tax incentives may include rebates or discounts on tax (including levies, land premiums and other charges) for peatland developers for the introduction of best management practices or for forest rehabilitation on their land.
- **CERTIFICATION**
  Certification schemes are available to promote best management practices for forestry (e.g. Forest Stewardship Council) or oil palm cultivation (e.g. Roundtable on Sustainable Palm Oil). These certification schemes generate premiums or preferential market access for those companies that adopt good practices.
- **OTHER NON-MONETARY REWARDS**
  Non-monetary rewards can include awards or recognition for good management practices.

5.5 CONCLUSION

Peatlands in Southeast Asia play a globally significant role in carbon storage and climate regulation. In the past 30 years, peatland drainage and fires have turned peatlands in the region from a net sink of carbon to a net source. How peatlands respond to the changing climate still remains uncertain, but most of the feedback will be negative and peatland degradation and fire is expected to increase in future climate regimes.

Based on the current trends, peatlands in Southeast Asia, especially in Indonesia and Malaysia, will continue to be under great pressure from the expansion of industrial plantations and other development.

However, governments in the region, through development of national policies and the adoption of the APMS (2006-2020), have shown their concern about the need for enhanced sustainability of peatland management in the future. With the new opportunities for international support such as REDD+ and funds available locally and nationally, it is hoped that the necessary financial assistance can be provided to enhance the sustainable management of peatlands and reduce their contributions to regional and global GHG emissions, as well as minimize the impacts of future climate change on peatlands.

REFERENCES

Anonymous 2007, ASEAN Peatland Management Strategy, ASEAN Secretariat, Jakarta.

Anonymous 2010, Indonesia's Greenhouse Gas Abatement Cost Curve, Dewan Nasional Perubahan Iklim, Indonesia.

ASEAN Secretariat 2003, Guidelines for The Implementation of the ASEAN Policy On Zero Burning, ASEAN Secretariat, Jakarta.

Bach, J 2000, Malaysia DANCED project on Sustainable Management of Peat Swamp Forest, Peninsular Malaysia, 10 Year Integrated Management Plan for The North Selangor Peat Swamp Forest, Selangor State Forestry Department and Danish Cooperation for Environment and Development (DANCED), Malaysia.

Ballhorn, U, Siegert, F, Mason, M & Limin, S 2009, 'Derivation of Burn Scar Depths and Estimation of Carbon Emissions With LIDAR In Indonesian Peatlands', Proceedings of the National Academy of Sciences of the United States of America, vol. 106, no. 50, pp. 21213-21218.

Couwenberg, J, Dommain, R & Joosten, H 2009, 'Green House Fluxes from Tropical Peatland in Southeast Asia', Global Change Biology, vol. 16, pp. 1715–1732, DOI 10.1111/j.1365-2486.2009.02016.x.

Chai, EOK 2004, Restoration of Ramin in Peat Swamp Forests of Sarawak. Joint Working Group Malaysia - The Netherlands: Sustainable Management of Peat Swamp Forests of Sarawak with Special Reference to Ramin. Forestry Department of Sarawak and Alterra, Sarawak.

Charman, D, Laine, J, Minayeva, T & Sirin, A 2008, 'Impacts Of Future Climate Change On Peatlands', in Parish, F, Sirin, A, Charman, D, Joosten, H, Minayeva, T, Silvius, M & Stringer, L (eds), Assessment on Peatlands, Biodiversity and Climate Change: Main Report. Global Environment Centre, Kuala Lumpur and Wetlands International, Wageningen, pp. 143 - 151.

Christensen, JH, Hewitson, B, Busuioc, A, Chen, A, Gao, X & Held, I *et al.* 2007, 'Regional Climate Projections', in Solomon, S, Qin, D, Manning, M, Chen, Z, Marquis, M & Averyt, KB *et al.* (eds), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York, pp. 847 - 940.

Dommain, R, Couwenberg, J & Joosten, H 2010, 'Hydrological Self-Regulation Of Domed Peatlands In South East Asia And Consequences For Conservation And Restoration', Mires and Peat, vol. 6, no. 5, pp. 1-17.

Hooijer, A, Page, SE, Canadell, JG, Silvius, M, Kwadijk, J, Wösten, H & Jauhiainen, J 2010, 'Current and Future CO_2 Emissions from Drained Peatlands in Southeast Asia', Biogeosciences, vol. 7, no. 5, pp. 1505-1514.

Hooijer, A, Silvius, M, Wösten, H & Page, S 2006, PEAT-CO_2: Assessment of CO_2 Emissions from Drained Peatlands In SE Asia, Delft Hydraulics report Q3943, Netherlands.

IPCC 2007, Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, RK & Reisinger, A (eds). IPCC, Geneva.

IRIN 2011, 'VIETNAM: From rice to shrimps and ginger - adapting to saltwater intrusion', IRIN, 28 December, viewed [25 Sept 2012], <http://www.irinnews.org/Report/94552/VIETNAM-From-rice-to-shrimps-and-ginger-adapting-to-saltwater-intrusion>

Istomo, Komar, TE, Tata, MHL, Sumbayak, ESS & Rahma, A 2010, Evaluasi Sistem Silvicultur Hutan Rawa Gambut Di Indonesia, ITTO-CITES Project, Bogor.

Jauhianen, J, Hooijer, A & Page, SE 2012, 'Carbon Dioxide Emission From An Acacia Plantation On Peatland In Sumatra, Indonesia', Biogeosciences, vol. 9, no. 2, pp. 617-630.

Joosten, H, Tapio-Bistrom, M-L & Tol, S (eds) 2012, Mitigation Of Climate Change in Agriculture Series 5: Peatlands - Guidance For Climate Change Mitigation By Conservation, Rehabilitation And Sustainable Use. FAO and Wetlands International, Rome.

Li, W, Dickinson, RE, Fu, R, Niu, G-Y, Yang, Z-L & Canadell, JG 2007, 'Future Precipitation Changes And Their Implications For Tropical Peatlands', Geophysical Research Letters, vol. 34, no. 1, pp. L01403, DOI 10.1029/2006GL028364.

Lim, KH, Lim, SS, Parish, F & Suharto, R (eds) 2012, RSPO Manual On Best Management Practices (BMPs) For Existing Oil Palm Cultivation On Peat. RSPO, Kuala Lumpur.

MacMillan, DC 2013, Development of Financing and Incentives Options for Sustainable Management of Peatland Forests in Southeast Asia, ASEAN Peatland Forests Project and Sustainable Management of Peatland Forests Project, ASEAN Secretariat and Global Environment Centre, Kuala Lumpur.

Miettinen, J & Liew, SC 2010, 'Status of Peatland Degradation and Development in Sumatra and Kalimantan', Ambio, vol. 39, no. 5-6, pp. 394-401, DOI 10.1007/s3280-010-0051-2.

Miettinen, J, Hooijer, A, Shi, CH, Tollenaar, D, Vernimmen, R, Liew, SC, Malins, C & Page, SE 2012a, 'Extent Of Industrial Plantations On Southeast Asian Peatlands in 2010 with Analysis of Historical Expansion and Future Projections', Global Change Biology Bioenergy, vol. 4, no. 6, pp. 908 - 918, DOI 10.1111/j.1757-1707.2012.01172.x.

Miettinen, J, Hooijer, A, Wang, JJ, Shi CH & Liew, SC 2012b, 'Peatland Degradation and Conversion Sequences and Interrelations in Sumatra', Regional Environmental Change, vol. 12, no. 4, pp. 729 - 737, DOI 10.1007/s10113-012-0290-9.

National Environmental Agency Singapore, 2011. Peat profile of Singapore. Peat Site Profile Database. APFP-SEApeat Project. Viewed [11 April 2013] <http://www.aseanpeat.net/site_nomination_view.cfm?sid=16>

Page, SE, Rieley, JO & Banks, C 2011, 'Global And Regional Importance of the Tropical Peatland Carbon Pool', Global Change Biology, vol. 17, no. 2, pp. 798-818, DOI 10.1111/j.1356-2486.2010.02279.x.

Page, SE, Wuest, R, Weiss, D, Rieley, J, Shotyk, W & Limin, SH 2004, 'A Record of Pleistocene and Holocene Carbon Accumulation And Climate Change From Equatorial Peat Bog (Kalimantan, Indonesia): Implications For Past, Present And Future Carbon Dynamic', Journal of Quaternary Sciences, vol. 19, no. 7, pp. 626-635.

Page, SE, Siegert, F, Rieley JO, Böehm, HDV, Jaya, A & Limin, S 2002, 'The Amount Of Carbon Released From Peat And Forest Fires In Indonesia During 1997', Nature, vol. 420, pp. 61-65.

Parish, F, Lim, SS, Perumal, B & Giesen, W (eds) 2012, RSPO Manual on Best Management Practices (BMPs) for Management and Rehabilitation of Natural Vegetation Associated with Oil Palm Cultivation on Peat. RSPO, Malaysia.

Parish, F, Sirin, A, Charman, D, Joosten, H, Minayeva, T, Silvius, M and Stringer, L. (eds) 2008, Assessment on Peatlands, Biodiversity and Climate Change: Main Report, Global Environment Centre and Wetlands International (Netherlands), Kuala Lumpur.

Quoi, LP 2012, Preliminary identification of mangrove coastal peatlands in Koh Kong Province, Cambodia, APFP SEApeat Project Report.

Rieley, JO, Wust, REJ, Jauhiainen, J, Page, SE, Wosten, H, Hooijer, A et al. 2008, 'Tropical Peatlands: Carbon Stores, Carbon GasEmission and Contribution to Climate Change process', in M, Strack (ed) Peatland and Climate Change. International Peat Society, Finland.

Rucker, G 2008, Draft Report: Threat Analysis to Forest Coverage in Peat Swamp Forest in South Sumatra. A Contribution to an Assessment of Opportunities for Compensation Payments for Avoided Deforestation in South Sumatra, South Sumatra Forest Fire Management Project.

Silvius, M 2008, 'Innovations for Financing Wise Use Peatlands in Indonesia', in Riley, JO, Banks, CJ & Page SE (eds) Papers presented at the special session on tropical peatland at the 13th International Peat Congress Tullamore, Ireland, June 2008, CARBOPEAT Partnership, International Peat Society and University of Leicester, United Kingdom, pp. 39-49.

Strack, M (ed) 2008, Peatlands and Climate Change, International Peat Society and Saarijärven Offset Oy, Finland.

van der Werf, GR, Dempewolf, J, Trigg, SN, Randerson, JT, Kasibhatla, PS, Giglio, L, Murdiyarso, D, Peters, W, Morton, DC, Collatz, GJ, Dolman, AJ & Defries, RS 2008, 'Climate regulation of fire emission and deforestation in equatorial Asia', PNAS, vol. 105, no. 51, pp. 20350-20355.

Verwer, CC and van der Meer, PJ 2010, Carbon Pools In Tropical Peat Forest: Towards A Reference Value For Forest Biomass Carbon In Relatively Undisturbed Peat Swamp Forests In Southeast Asia, Alterra Report 2108, Wageningen.

VCS 2011, Agriculture Forestry and Other Land Use (AFOLU) Requirements: VCS Version 3, Verified Carbon Standard.

ABOUT ASSOCIATION OF SOUTHEAST ASIAN NATIONS

ASEAN was established on 8 August 1967. The members of the Association are Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The ASEAN Member States are working together to address common issues through collective spirit, collaboration, consultation and cooperation. The ASEAN Secretariat is based in Jakarta, Indonesia.

One Vision, One Identity, One Community

Global Environment Centre

ABOUT GLOBAL ENVIRONMENT CENTRE

GEC is a Malaysia-based non-profit organisation with activities at local, regional and global level to address environmental issues of global concern. It was established in 1998 and supports field programmes in more than 15 countries mainly in the Asia Pacific region as well as information exchange and policy formulation. It works primarily through multi-stakeholder partnerships and collaboration with networks of like-minded organisations.

Its primary programmes are:

- Forest and Biodiversity Programme
- Peatland Programme
- River Care Programme
- Outreach and Partnership Programme

It has been recognised by the Parties to the Convention on Biological Diversity for its work on peatlands and also river basin management. It is a founding partner of the ASEAN Peatland Management Initiative (APMI) and the development of ASEAN Peatland Management Strategy (APMS); both endorsed by all ten ASEAN Member States. It coordinates many networks and partnerships at local and international levels.

Building Partnerships for the Environment

ABOUT APFP-SEAPEAT PROJECTS

The ASEAN Peatland Forests Project (APFP), funded by the Global Environment Facility (GEF) and the International Fund for Agricultural Development (IFAD), is led by the Association of Southeast Asian Nations (ASEAN) Secretariat and selected ASEAN Member States. It aims to demonstrate, implement and scale up the integrated management of peatlands in Southeast Asia. The related SEApeat project, funded by the European Union (EU) through Global Environment Centre (GEC), seeks to reduce deforestation and GHG emissions caused by the degradation of peatland forests in Southeast Asia. The combined projects involve all ten ASEAN Member States in regional activities and/or pilot site activities. The projects aim to promote and support the implementation of the ASEAN Peatland Management Strategy (2006-2020) especially related to capacity building, fire prevention and sustainable management of peatlands in the region. The ASEAN Secretariat is the Executing Agency of the APFP while the GEC is the Regional Project Executing Agency of the APFP and the SEApeat project.

Scan this QR code with your smartphone to find out more!

www.aseanpeat.net

FUNDED BY:

IFAD
Enabling poor rural people to over come poverty

gef
GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

European Union

IMPLEMENTED BY:

Global Environment Centre

FSC

eco print

eco ink

ISBN