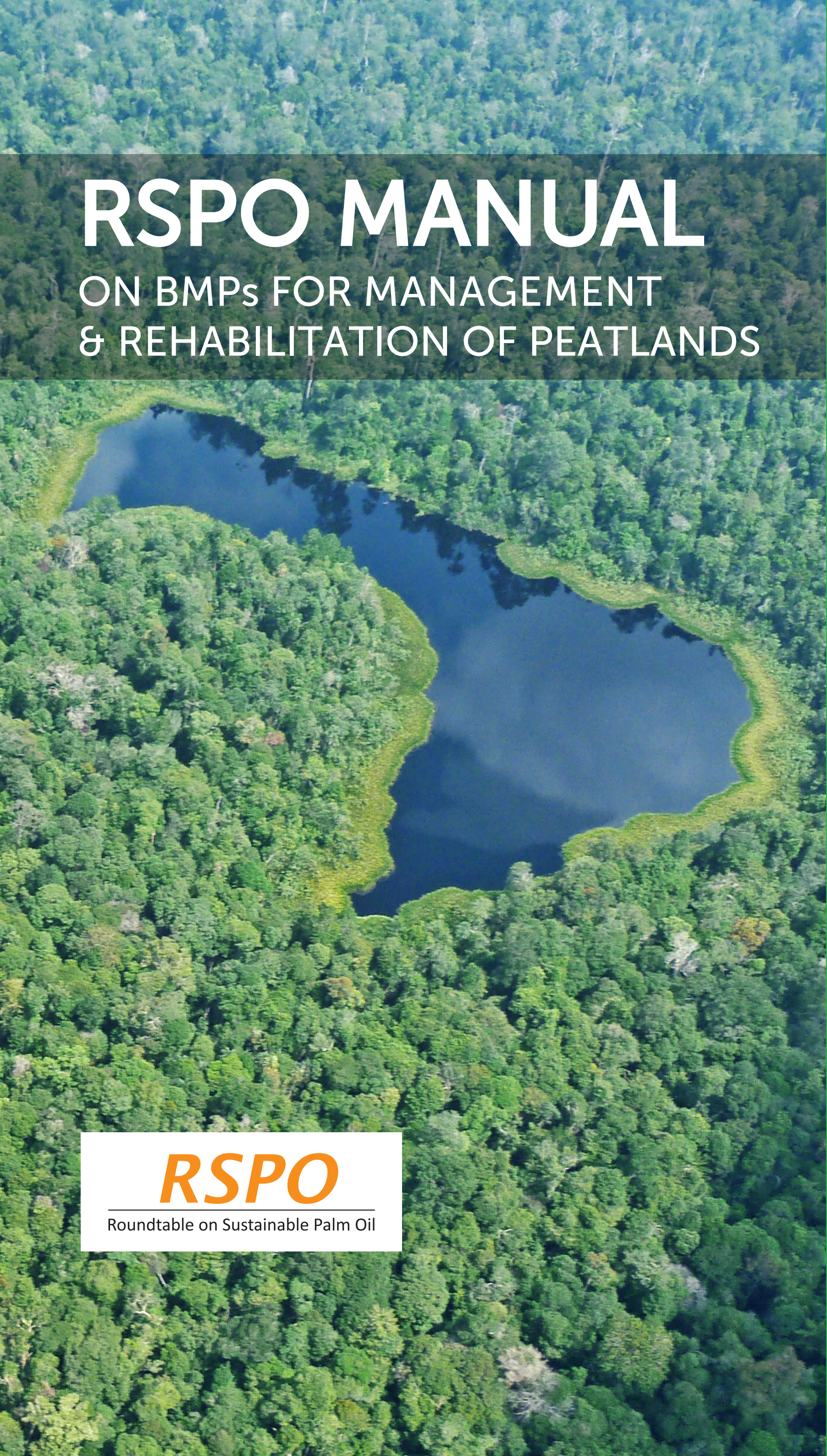
RSPO MANUAL

ON BMPs FOR MANAGEMENT & REHABILITATION OF PEATLANDS



RSPO
Roundtable on Sustainable Palm Oil

VOLUME 2

RSPO MANUAL
ON BEST MANAGEMENT PRACTICES (BMPs) FOR MANAGEMENT AND REHABILITATION OF PEATLANDS

JUNE 2019

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Also known as RSPO Peatland BMP Manual Volume 2

Parish, F., Lew, S.Y., Faizuddin, M. and Giesen, W. (Eds.). 2019. RSPO Manual on Best Management Practices (BMPs) for Management and Rehabilitation of Peatlands. 2nd Edition, RSPO, Kuala Lumpur.

RSPO
Roundtable on Sustainable Palm Oil

SUPPORTED BY: IFAD Investing in rural people

COMPILED BY: Global Environment Centre -building partnerships for the environment-

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e-ISBN: 978-967-11292-4-1

RSPO Publication Reference number:
RSPO-GUI-T04-010 V2 ENG

Book design:
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First Edition in English, published October 2012.

Second substantially revised Edition in English, e-book, published June 2019.

Disclaimer:

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ACKNOWLEDGEMENTS

The RSPO Manual on Best Management Practices (BMPs) For Management and Rehabilitation of Peatlands (RSPO Peatland BMP Manual Volume 2) was developed with the support of many people. RSPO would like to thank all the RSPO Peatland Working Group 2 (PLWG2) members, Co-Chairs (Faizal Parish of Global Environment Centre (GEC) and Joshua Mathews of Bumitama Gunajaya Agro (BGA) Group) and the contributions from the RSPO and industry members for the successful completion of the review and revision of the manual.

Special appreciation is given to Global Environment Centre which facilitated the overall review and updating process and revised the information with the inputs from the PLWG and other contributors. Extended appreciation is given to PT BNS (Minamas of Sime Darby Group), Adong Estate (Woodman Plantation), and Sungai Balim Estate (Sarawak Oil Palms Berhad) – for hosting the field visits during the preparation and review period. Significant contributions were made by all those that attended the consultations in Bali, Indonesia in November 2017 and Miri, Sarawak, Malaysia in January 2018. Important inputs and comments were made by many during the public consultation period in particular, the Malaysian Palm Oil Board (MPOB), USAID Lestari Project, and various experts including Dr Stephanie Evers, Dr Susan Page, Professor Hans Joosten and Drs Marcel Silvius. The photographs were mainly provided by GEC except where noted. New case studies and other inputs were provided by Bumitama Agri Ltd, IOI, Peatand Restoration Agency (BRG) Indonesia, SIPEF, Sime Darby and WWF.

Funding to support preparation and printing of this Peatland BMP Manual has been provided by the RSPO as well as through a project funded by the International Fund for Agricultural Development (IFAD) – Measurable Action for Haze Free Land Management in Southeast Asia (MAHFSA) through the ASEAN Secretariat and GEC.

1.0 INTRODUCTION

1.1 DEVELOPMENT OF THE RSPO MANUAL ON BEST MANAGEMENT PRACTICES FOR MANAGEMENT AND REHABILITATION OF PEATLANDS

This Manual was initially prepared under the guidance of the Roundtable on Sustainable Palm Oil (RSPO) Peatland Working Group (PLWG) which was established in 2010 in response to the RSPO General Assembly 2009 decision. This Manual has now been modified in 2017-2019 to incorporate new data, information, methods, and research and development by the second PLWG (PLWG-2) formed in March 2017. The scope and membership of PLWG 2 can be seen in **Annex 2**. This Manual is focused on the maintenance of existing natural vegetation in and adjacent to oil palm plantations on peat as well as rehabilitation of degraded peatland areas. This complements the 'RSPO Manual on Best Management Practices (BMPs) for Existing Oil Palm Cultivation on Peat' initially prepared in 2011-12 and also revised in 2017-19 (Parish *et al.*, 2019a)

1.2 PURPOSE OF BMP MANUAL AND BENEFITS OF ADOPTION

The objective of this Manual is to provide a set of practical guidance on BMPs that are important for the rehabilitation and management of forested or degraded sites within or adjacent to existing oil palm plantations on peat including riparian reserves, High Conservation Value (HCV), High Carbon Stock (HCS) areas and/or peatland set aside or conservation areas. It also provides guidance for the rehabilitation of sites where oil palm has been phased out as a result of drainability assessments or for other reasons.

This Manual draws on experiences of peatland management and rehabilitation by RSPO members and other organisations mainly in Southeast Asia, but to a limited extent in Africa and Latin America. It also refers to existing national regulations and guidelines especially from Indonesia and Malaysia where there is extensive experience in peatland management and rehabilitation.

This Manual is part of the effort by RSPO and its members, particularly producers, in responding to stakeholder concerns to promote the implementation of BMPs and contribute to sustainable peatland management as part of reducing the impacts of oil palm cultivation on peat.

While it may be possible to maintain peat swamp forests adjacent to oil palm plantation in good condition with good water management and fire prevention measures, restoration of degraded and drained peatland to its original pristine condition is almost impossible. In such cases, the objective should be to rehabilitate the degraded peat sites as much as practical towards their original condition.

These guidelines are also key to guide compliance with the RSPO P&C. The RSPO P&C 2013 and 2018 include significant requirements for the conservation and rehabilitation of peatlands in and around oil palm plantations. These guidelines provide practical guidance to RSPO member companies to maintain and enhance peatland conservation areas and meet key targets for sustainable oil palm production.

1.3 REASONS FOR MANAGEMENT AND REHABILITATION OF PEAT SWAMP FORESTS

Tropical lowland peatlands in Southeast Asia, Central and Western Africa and the Amazon Basin are naturally vegetated with peat swamp forests, which comprise species that are adapted to high water levels and high acidity conditions. When oil palm plantations are developed in peatland areas, the natural vegetation is normally cleared except in areas designated for conservation or deemed unsuitable for oil palm cultivation. The rehabilitation of certain sites within a larger area of plantation may provide benefits to the estate, environment and local communities.

The following are specific reasons for management and rehabilitation of peat swamp forests (PSFs) associated with oil palm cultivation on peat:

High Conservation Values (HCVs) within or adjacent to Plantation Areas

The concept of HCVs was developed to provide a framework for identifying areas with special attributes that make them particularly valuable for biodiversity and/or local people. PSFs are unique ecosystems and are valuable resources for local communities. By default, these areas would often be defined as HCV areas. Conservation and maintenance of HCVs are engrained and refined in the RSPO Principles and Criteria (P&C) 2018.

HCVs were previously defined as follows (HCV Toolkit, 2008):

High Conservation Value Area (HCVA): The area necessary to maintain or enhance one or more HCVs and there are 6 types of HCVs as seen below:

- **HCV 1.** Areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species);
- **HCV 2.** Areas containing globally, regionally or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance;
- **HCV 3.** Areas that are in or contain rare, threatened or endangered ecosystems;
- **HCV 4.** Areas that provide basic services of nature in critical situations (e.g. watershed protection, erosion control);
- **HCV 5.** Areas fundamental to meeting basic needs of local communities (e.g. subsistence, health);
- **HCV 6.** Areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

  See: 'The HCVF Toolkit' – available from www.hcvnetwork.org

Wildlife Corridors

A wildlife corridor is an area of habitat connecting wildlife populations separated by human activities (such as roads, development, or agriculture). Establishment and maintenance of wildlife corridors allows an exchange of genetic material between populations, which may help prevent the negative effects of in-breeding and reduced genetic diversity that often occur within isolated populations. This may potentially moderate some of the worst effects of habitat fragmentation.

More importantly for oil palm plantations, systematic and planned maintenance of wildlife corridors within and adjacent to their estates provide corridors for the movement of wildlife and help to reduce incidences of human-wildlife conflict. If not managed effectively, human-wildlife conflict

HCV 1: Species diversity
Concentrations of biological diversity including endemic species, and rare, threatened or endangered species, that are significant at global, regional or national levels.

HCV 2: Landscape-level ecosystems and mosaics and IFL
Large landscape-level ecosystems and ecosystem mosaics and Intact Forest Landscape that are significant at global, regional or national levels, and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance.

HCV 3: Ecosystems and habitats
Rare, threatened, or endangered ecosystems, habitats or refugia.

HCV 4: Ecosystem services
Basic ecosystem services in critical situations, including protection of water catchments and control of erosion of vulnerable soils and slopes.

HCV 6: Cultural values
Sites, resources, habitats and landscapes of global or national cultural, archaeological or historical significance, and/or of critical cultural, ecological, economic or religious/ sacred importance for the traditional cultures of local communities or indigenous peoples, identified through engagement with these local communities or indigenous peoples.

HCV 5: Community needs
Sites and resources fundamental for satisfying the basic necessities of local communities or indigenous peoples (for livelihoods, health, nutrition, water, etc.), identified through engagement with these communities or indigenous peoples.

Figure 1-1: Current definition of HCV (Source: Brown & Senior, 2014 amended 2018; RSPO P&C 2018)

can have enduring resource and cost implications for any oil palm plantation operating in areas with large animal populations, especially large mammals like elephants and tigers, and primates such as orangutan, gibbons or gorillas (see Dargie, 2017).

Riparian Reserves or Boundary Buffer Zones

River reserves are essentially the land adjacent to streams and rivers; a unique transitional area between aquatic and terrestrial habitats. Although constituting only a small part of the landscape, riparian reserves that are intact and functional are important habitats for biodiversity and provide ecosystem services. In Indonesia, riparian reserves are formally recognised as 50 - 200 meter-wide green-belts (*jalur hijau*) zones adjacent to streams (50 m), rivers (100 m) and peat/swamp (200 m). Malaysia requires 5 - 50 m wide river reserves depending on the width of the waterway.

The following are the main reasons why riparian reserves within and adjacent to oil palm plantations need to be conserved, maintained and rehabilitated:

- **Water quality improvement:** Non-point sources of pollution, including run-off from plantations, introduce a variety of pollutants into the river system. These pollutants include sediments, nutrients, organic wastes, chemicals and metals. River reserves serve as buffers, which intercept non-point sources of pollution. In particular, riparian vegetation absorbs the heavy metals and nutrients, trap sediments suspended in surface run-off and provide a habitat for micro-organisms that help break down the pollutants. In plantations where fertiliser, pesticides and herbicides are used, the maintenance of a vegetated river reserve of sufficient width is therefore extremely important to minimise the amount of these pollutants that enter the rivers.
- **Flood mitigation:** Riparian vegetation increases surface and channel roughness, which serves to slow down surface water that enters the river and reduce flow rates within the river. This helps to slightly alleviate the magnitude and intensity of flooding downstream.

- **Riverbank stabilisation:** Riparian vegetation protects riverbanks from erosion or scouring caused by rain, water flow, etc. Erosion caused by removal of riparian vegetation results in sedimentation of the river which increases flood levels, as well as bank failure, which may bring about the need for expensive remediation measures such as dikes, levees and flood walls.

Oil palm plantations growers have a role to play in identifying, managing and enhancing river reserves and PSFs that are on and adjacent to their land. Preferably, these areas should be identified during initial stages of plantation development. These areas need to be conserved/managed and where necessary, rehabilitated. This activity during the initial stages is crucial to avoid extensive costs to rehabilitate cleared or planted (oil palm) river reserves in the long run. For plantations that have already planted oil palms on river reserves, steps must be taken to restore these areas to its original state.

Undrainable Areas within Plantations

Continuous peat subsidence can cause some areas that were initially able to be gravity drained, to become undrainable after several years of oil palm cultivation. In addition, if the mineral subsoil is under the mean water level (MWL), the area may be undrainable for significant periods, rendering cultivation impossible. Such areas may be widespread, especially in the coastal lowlands of Southeast Asia where tectonic movements over the last 8,000 years have reduced the elevation of many coastal lowlands (e.g. east coast of Sumatra, southern coasts of Indonesian Borneo, coastal plains of Sarawak, west coast of Peninsular Malaysia), causing the base of many peatlands to be located now below MWL of rivers and sea. These areas should be clearly demarcated, not developed and if possible, rehabilitated.

Areas Predicted to Face Future Drainage Problems

In accordance with RSPO P&C (P&C 2013 - Indicator 4.3.4 and P&C 2018 - Indicator 7.7.5), prior to replanting on peat, it is necessary to undertake a drainability assessment – to determine the long term viability of drainage of the plantation. This assessment should be guided by the RSPO Drainability Assessment Procedure (2018). The result of the assessment may indicate if the oil palm can be replanted or if the area needs to be converted to other more water tolerant crops or rehabilitated as a natural ecosystem. In the latter case this Manual can provide further guidance.

Prevention of Hydrology Disruption at adjacent Peat Swamp Forest

Peatlands forms interconnected hydrological units, clearing and draining the land adjacent to a PSF (e.g. edges of peat domes) can lead to hydrological changes and subsequent degradation in the adjacent land. The effects from drainage often go beyond plantation boundary, impacting between 500m to two kilometres depending on the drainage intensity and hydrological conductivity of the peatlands, thus potentially impacting the nearby PSFs.

Fire Prevention

A major factor for peat fires is the drying out of peatlands. Fire risk is enhanced as a result of the drainage system in the plantations. Drainage leads to desiccation and this significantly increases the risk of fire, especially if fire is used as a tool for clearing adjacent land. Maintenance of natural vegetation and appropriate ground water levels (GWL) within the riparian reserves and peat conservation areas may help prevent fires from occurring and spreading to the cultivated areas. From recent studies GWL of 10-20cm below the surface is emerging as the level below which the fire risk increases significantly (Putra *et al.*, 2018).

Management of Disturbance/Encroachment

Facilitation of access is an issue: infrastructure created by plantations may create access to adjacent PSFs for poachers. Proper management of the riparian reserves and plantation boundaries are crucial for preventing disturbance/encroachment by illegal settlers or squatters. This is a widespread problem in Indonesia and Malaysia.

Maintaining and Increasing Carbon Stock

As part of the efforts to minimise greenhouse gas (GHG) emissions, it is recommended for oil palm plantations to maintain and increase their above ground carbon stock as well as minimising loss of below ground peat carbon in conservation or rehabilitation areas. Carbon stock can be conserved and increased through maintenance and rehabilitation of buffer zones and HCV areas. It is also recommended that oil palm plantations conserve adjacent (or where appropriate, within the plantation) forested areas. Adoption by a plantation of an adjacent PSF area can reduce the net GHG emission profile and so can be a useful part of any GHG emission reduction strategy, it can also reduce risks (e.g. from fires) due to inappropriate land use in adjacent peatlands. In line with an impact mitigation hierarchy, a company should first and foremost avoid impacts and emissions, then minimise impacts (including restoration on-site and other actions), and lastly provide offsets for remaining unavoidable impacts.

1.4 REGULATIONS AND GUIDELINES RELATED TO MANAGEMENT AND REHABILITATION OF PEAT SWAMP FORESTS

Peatland areas should be identified and subjected to particularly stringent Environmental and Social Impact Assessments (EIA, SIA and SEIA). In addition, regulations in major producers like Indonesia and Malaysia demand adherence to planning laws, pollution regulations, riverine buffers, zero-burning laws and a host of other laws governing various aspects of the industry.

The following are various regulations and guidelines related to management and rehabilitation of peat swamp forests. They consist of:

- RSPO Principles & Criteria (P&C) 2018 and guidance maintenance of conservation areas and riparian reserves
- Peatland specific regulations
- Malaysian, Indonesia and other countries' regulations

1.4.1 RSPO PRINCIPLES & CRITERIA (P & C) 2018

RSPO P&C 2018 consolidated specific guidance on peatland into Criteria 7.7 as follows:
Criterion 7.7 No new planting on peat, regardless of depth after 15 November 2018 and all peatlands are managed responsibly.

Indicators

7.7.1 (C) There is no new planting on peat regardless of depth after 15 November 2018 in existing and new development areas.

7.7.2 Areas of peat within the managed areas are inventoried, documented and reported (effective from 15 November 2018) to RSPO Secretariat.

7.7.3 (C) Subsidence of peat is monitored, documented and minimised.

7.7.4 (C) A documented water and ground cover management programme is in place.

7.7.5 (C) For plantations planted on peat, drainability assessments are conducted following the RSPO Drainability Assessment Guidelines, or other RSPO recognised methods, at least five years prior to replanting. The assessment result is used to set the timeframe for future replanting, as well as for phasing out of oil palm cultivation at least 40 years, or two cycles, whichever is greater, before reaching the natural gravity drainability limit for peat. When oil palm is phased out, it should be replaced with crops suitable for a higher water table (paludiculture) or rehabilitated with natural vegetation.

7.7.6 (C) All existing plantings on peat are managed according to the 'RSPO Manual on Best Management Practices (BMPs) for existing oil palm cultivation on peat', version 2 (2018) and associated audit guidance.

7.7.7 (C) All areas of unplanted and set-aside peatlands in the managed area (regardless of depth) are protected as "peatland conservation areas"; new drainage, road building and power lines by the unit of certification on peat soils is prohibited; peatlands are managed in accordance with the 'RSPO BMPs for Management and Rehabilitation of Natural Vegetation Associated with Oil Palm Cultivation on Peat', version 2 (2018)1 and associated audit guidance

For the purpose of audit compliance to Criteria 7.7 of the RSPO P&C 2018, a separate Audit Guidance - RSPO Peat Audit Guidance (P&C 2018) has been prepared by the RSPO PLWG2 and is included in **Annex 3**.

In addition, several, other criteria of the RSPO P&C 2018 are relevant to this issue including:

C7.8 Practices maintain the quality and availability of surface and groundwater.

- **I7.8.2 (C)** Water courses and wetlands are protected, including maintaining and restoring appropriate riparian and other buffer zones in line with 'RSPO Manual on BMPs for the management and rehabilitation of riparian reserves' (April 2017).

C7.10 Plans to reduce pollution and emissions, including greenhouse gases (GHG), are developed, implemented and monitored and new developments are designed to minimise GHG emissions.

C7.11 Fire is not used for preparing land and is prevented in the managed area.

C7.12 Land clearing does not cause deforestation or damage any area required to protect or enhance High Conservation Values (HCVs) or High Carbon Stock (HCS) forest. HCVs and HCS forests in the managed area are identified and protected or enhanced.

- **I7.12.1 (C)** Land clearing since November 2005 has not damaged primary forest or any area required to protect or enhance HCVs. Land clearing since 15 November 2018 has not damaged HCVs or HCS forests. A historic Land Use Change Analysis (LUCA) is conducted prior to any new land clearing, in accordance with the RSPO LUCA guidance document.
- **I7.12.2 (C)** HCVs, HCS forests and other conservation areas are identified as follows: 7.12.2a: For existing plantations with an HCV assessment conducted by an RSPO-approved assessor and no new land clearing after 15 November 2018, the current HCV assessment of those plantations remains valid.
- **I7.12.2 b:** Any new land clearing (in existing plantations or new plantings) after 15 November 2018 is preceded by an HCV-HCS assessment, using the HCSA Toolkit and the HCV-HCSA Assessment Manual. This will include stakeholder consultation and take into account wider landscape-level considerations.

RSPO has also developed a separate ***RSPO Manual on Best Management Practices (BMPs) for the Management and Rehabilitation of Riparian Reserves*** in 2017 (see **Box 1-1**).

BOX 1-1

RSPO Manual on Best Management Practices (BMPs) for the Management and Rehabilitation of Riparian Reserves (2017) cross referenced to P&C 2018

Conservation of natural vegetation within and alongside natural waterways is a compliance requirement for RSPO certified oil palm plantations (**Criteria 7.8**), which is also a legal requirement in many countries.

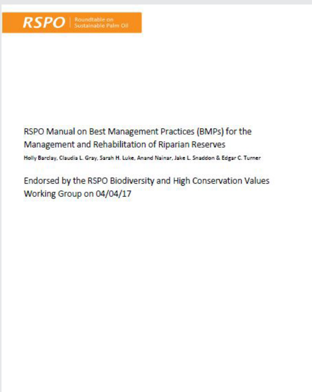
Natural vegetation should be protected inside riparian reserves (also called river reserves or riparian buffer zones), along all natural waterways – rivers, streams, lakes and springs – within and along the boundary of RSPO certified oil palm plantations.

Key environmental benefits of riparian reserves include water quality protection, bank stabilisation, flood protection, carbon storage and sequestration and biodiversity conservation. Hence, properly managed riparian reserves could generate significant benefits from the conservation of natural vegetation for oil palm companies, besides maintaining good relationships with local communities.

Specific guidance about which waterways would require riparian reserves and how wide such reserves need to be vary from country to country. National guidelines are outlined with appropriate national interpretations at the RSPO website (www.rspo.org).

In the absence of national guidelines, RSPO requires riparian reserves to be established along all natural waterways >1m wide. More detailed guidance on riparian reserve size, location and vegetation type is outlined in **Chapter 2** of this Manual.

Riparian habitats are also required to be protected as High Conservation Value Areas (HCVAs), typically under HCV4, as areas which provide "basic ecosystem services in critical situations, including protection of water catchments and control of erosion of vulnerable soils and slopes". Riparian reserve habitats should therefore be maintained and/or enhanced as part of the HCV management plans for oil palm plantations (**Criteria 7.12**).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RSPO Manual on Best Management Practices (BMPs) for the Management and Rehabilitation of Riparian Reserves

Holly Barclay, Claudia L. Gray, Sarah H. Luke, Anand Nainar, Jake L. Snaddon & Edgar C. Turner

Endorsed by the RSPO Biodiversity and High Conservation Values Working Group on 04/04/17

Figure 1-2: RSPO Manual on Best Management Practices (BMPs) for the Management and Rehabilitation of Riparian Reserves

1.4.2 INDONESIAN LAWS, REGULATIONS AND GUIDELINES RELATING TO CONSERVATION OF PEATLANDS

There are a significant number of recent laws and regulations related to conservation and rehabilitation of Peatlands in Indonesia.

Government Regulation on Protection and Management of Peatland Ecosystems

The Government Regulation on Protection and Management of Peatland Ecosystems (PP 71/ 2014 as revised by PP 57/2016) in December 2016 sets out the requirements for protection and management of peatland ecosystems in Indonesia.

This regulation:

i) Bans all new land clearing and canal building on peatland;

ii) sets a lower limit for the peatland water table at 0.4m below the ground surface;

iii) makes it illegal for both companies and local communities to burn peatland prior to development; and

iv) requires regular monitoring of water levels and status of peatlands as well as reporting to the local and central government.

With the issuance of PP71/2014 and PP 57/2016, Indonesian peatlands have been subdivided into more than 300 Peatland Hydrological Units (PHUs). At least 30% of each PHU must be conserved including areas of remaining quality peat swamp forests, and all areas over 3m depth. This means that a company operating in a peatland may be obliged to set aside an area for conservation (**Chapter 9, Clause3, 4(a)**).

Under the regulation, there are sub-regulations to detail out the requirements for inventory and mapping, ecosystem function assessment as well as water table monitoring and management as follows:

i. Peraturan Menteri Linkungan Hidup dan Kehutanan Nomor P.14/MENLHK/SETJEN/KUM.1/2/2017 tentang Tata Cara Inventarisasi dan Penetapan Fungsi Ekosistem Gambut (P.14/2017 on Procedures of inventory and determination of peatland ecosystem function).

ii. Peraturan Menteri Linkungan Hidup dan Kehutanan Nomor P.15/MENLHK/SETJEN/KUM.1/2/2017 tentang Tata Cara Pengukuran Muka Air Tanah di Titik Penaatan Ekosistem Gambut (P.15/2017 on Procedures for Measuring Groundwater Levels in Peat Ecosystem at Designated Monitoring Points)

iii. Peraturan Menteri Linkungan Hidup dan Kehutanan Nomor P.16/MENLHK/SETJEN/KUM.1/2/2017 tentang Pedoman Teknis Pemulihan Fungsi Ekosistem Gambut (P.16/2017 on Technical Guidelines for Restoration of Peat Ecosystem Functions)

Detailed maps showing PHUs and areas to be conserved are included in the following decisions:

i. Keputusan Menteri Lingkungan Hidup Dan Kehutanan Republik Indonesia Nomor SK.129/Menlhk/Setjen/Pkl.0/2/2017 Tentang Penetapan Peta Kesatuan Hodrologis Gambut Nasional (SK129/2017 on Determination of National Peatland Hydrological Units Map)

ii. Keputusan Menteri Lingkungan Hidup Dan Kehutanan Republik Indonesia Nomor SK.130/Menlhk/Setjen/Pkl.0/2/2017 Tentang Penetapan Peta Fungsi Ekosistem Gambut Nasional (SK130/2017 on Determination of Map of National Peatland Ecosystem Functions)

Indonesia Forest Moratorium: The Indonesian President made an official Indonesia Forest Moratorium starting on 20 May 2011. Under this moratorium, central and local governments are not allowed to issue new permits for conversion of designated primary forests or peatlands in Indonesia as specified in a map attached to the regulation (and subsequently revised on a regular basis). The moratorium was extended for the third time in May 2017 for another two years and in 2019 it was proposed to be made permanent.

Other Laws and Regulations

i. Law No.41/1999 on forestry recognises the following protective zones:
   - 500 (five hundred) meters from the edge of water reservoir (dam) or lake
   - 200 (two hundred) meters from the edge of water spring and alongside the river in swampy area
   - 100 (one hundred) meters from the river (left and right banks)
   - 50 (fifty) meters from streams facing downstream (left and right banks)

ii. Presidential Decree No. 32/1990 – This Decree prohibits the use of peatlands if the peat thickness is more than 3m or if the peatland is on conservation or protection forest land. Where existing plantation licenses or pending applications lie on peat soils with a depth greater than 3m, such licenses could be revoked under this provision. This Decree is reinforced by PP71/2014 and PP57/2016 mentioned above.

iii. Ministry of Agriculture Decree No. 14/2009 gives further guidance on development on peatlands. It states that peatland overlying acid sulfate soils and quartz sands may not be developed. Other provisions are largely subsumed under PP71/2014 as amended by PP57/2016.

Indonesian Sustainable Palm Oil (ISPO) Principles and Criteria

The Indonesian Sustainable Palm Oil (ISPO) requirements: Under the Ministry of Agriculture Decree No. 19/2011, ISPO criteria specifically relevant to cultivation of oil palm on peatland are to be implemented:

ISPO CRITERION 3.5 Identification and protection of protected areas – Oil palm planters and millers should identify protected areas, which have the prime function to protect biodiversity, including natural and manmade resources as well as historical and culturally valuable areas. These areas should not be planted with oil palm.

- **INDICATORS**
  i. Identified protected area is available
  ii. Plantation map showing identified protected area is available
  iii. Records of identification and distribution information of protected areas are kept

- **GUIDANCE**
  i. To do inventory on protected areas around the plantation
  ii. Distribution of protected forest information to workers and surrounding community/farmers around the plantation

ISPO CRITERION 3.7 Conservation area with high potential for erosion – Oil palm planters and millers should conserve the land and avoid erosion according to rules and regulations.

ISPO CRITERION 3.8 Plantation in accordance with Government Regulation No. 10 / 2011 – Postponement of oil palm plantation development to decrease greenhouse gas (GHG) emissions through moratorium on new permits and improvements to the management of primary natural forests and peatlands.

- **INDICATORS**
    i. Moratorium on new permit included in indicative maps;
    ii. Approved application by authorised institution on land permit is valid;
    iii. Existing permits issued before the moratorium remain in effect.

- **GUIDANCE**
    i. Postponement of new permits related to the plantation are site permits and IUP;
    ii. Postponement of new permits in accordance with indicative map for primary forests and peatlands, which exist in conservation forests, protected forests, production forests (limited production forests, regular production forests, converted production forests) and land for other uses);
    iii. This regulation is not applicable for permits on released forest areas except for permits with principle agreement from the Ministry of Forestry (now Ministry of Environment and Forestry);
    iv. Postponement on the issuance of permits on land use rights (HGU, HGB, HP, etc.) including processed applications in provincial B committee;
    v. Moratorium of location permits, IUP and other land use rights for 2 (two) years effective from 20 May 2011. Third extension was given in May 2017 to give authorities more time to pin down regulations on forest use (by November 2016, the government's forest moratorium covered an area of more than 66 million hectares).

ISPO CRITERION 2.1.5 PLANTINGS ON PEATLAND

Planting oil palm on peatlands can be done by observing characteristics of peat so as to not cause damage to environmental functions

ISPO CRITERION 3.6 PLANTINGS MITIGATION OF GREENHOUSE GAS (GHG) EMISSIONS

Management of the plantation business must identify the source of GHG emissions. Management measures include water management in peatlands.

ISPO may need to be updated to bring it in line with more recent regulations such as PP71/2014 and PP57/2016.

1.4.3 MALAYSIAN LAWS, REGULATIONS AND GUIDELINES RELATING TO CONSERVATION OF PEATLANDS

Regulations

Peat swamp forests are recognised by the Government of Malaysia as Environmentally Sensitive Areas (ESA) under Section 6B of the Town and Country Planning 1976 (ACT 172) and in the First to Third Five year National Physical Plans (NPP 1-3). Every State Government is also required to comply with the requirements of the NPP by incorporating ESAs into State Structure Plans and Local Plans. The NPP states that Malaysia's Protected Areas (PA) network shall be enlarged to include a full representation of the diversity of natural ecosystems, particularly the lowland dipterocarp forests and wetlands. It also recommends that there shall be adequate buffer zones between ESA and agriculture development. Most of the remaining peat swamp forests in the country are classified as ESA Class 1 which may not be developed.

Environmental Impact Assessment (EIA)

The requirements for Environmental Impact Assessment (EIA) under the Environment Quality Act (1972) have been updated in the EIA Order 2015. This has emphasised the importance of ESAs and has lowered the size of a peatland area where an EIA is mandatory.

EIAs are a mandatory requirement for proposed development projects categorised as 'prescribed activities'. The prescribed activities as stated in Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015 specified Schedule below (extracted list) Activities under the first schedule require preparation of an EIA. Activities under the second Schedule require public consultation to be undertaken as part of the EIA process:

a) AGRICULTURE

First Schedule

i. Land development schemes covering an area of 20 hectares or more but less than 500 hectares to bring forest land into agricultural production.

Second Schedule

i. Land development schemes covering an area of 500 hectares or more to bring forest into agriculture production

b) FORESTRY

First Schedule

i. Conversion of forest at least 300m above sea level to other land use covering an area of 20ha or more but less than 100ha.

ii. Conversion of an area of peat swamp forest for industrial, housing or agricultural use covering an area of 20 hectares or more but less than 50 hectares.

Second Schedule

i. Logging or conversion of forest to other land use within an area adjacent or near to any state park, national park or national marine park.

ii. Conversion of an area of peat swamp forest for industrial, housing or agricultural use covering an area of 50 hectares or more.

c) DRAINAGE AND IRRIGATION

Second Schedule

i. Any drainage of wetland, wild-life habitat or dry inland forest covering an area of 20 hectares or more.

National Action Plan for Peatlands (2011-2020)

Malaysia had adopted the National Action Plan for Peatlands (NAPP) in 2011. It provides a set of guidelines on peatland management in Malaysia. The goal of NAPP is to sustainably manage peatlands in Malaysia in an integrated manner to conserve resources, prevent degradation and fires, and generate benefits for current and future generation. It comprises four objectives:

1. Enhance knowledge, awareness and capacity for sustainable peatlands management and development
2. Conserve peatlands resources and reduce peatland degradation and fires
3. Promote the sustainable and integrated management peatlands
4. Ensure effective multi-stakeholder cooperation

The National Policy on Biological Diversity (2016-2025)

The Government of Malaysia also has adopted the National Policy on Biological Diversity 2016-2025 which provides the direction and framework to conserve biodiversity and use it in sustainable manner. The Federal government via Ministry of Water, Land and Natural Resource (formerly known as Ministry of Natural Resources and Environment) will play a leading role in implementing the Policy. The Policy has five overarching goals encompassing:

1. Stakeholder empowerment
2. Reduced the direct and indirect pressures on biodiversity
3. Safeguarded all key ecosystems, species and genetic diversity
4. Ensured that the benefits from the utilisation of biodiversity are shared equitably
5. Improved the capacity, knowledge and skills of all stakeholders to conserve biodiversity

One of the key indicators (7.3) sets the target to rehabilitate 10,000 ha of degraded peat swamp forests by 2025.

Malaysian Sustainable Palm Oil (MSPO) Principles and Criteria

The Malaysian government had introduced the Malaysian Sustainable Palm Oil (MSPO) Standard in 2013. Implementation of the MSPO certification scheme started on 1st January 2015, with a target of mandatory certification for both plantations and smallholders by 31st December 2019. The MSPO requirements for maintenance of conservation areas and river reserves include the following criteria:

CRITERION 4.5.5 NATURAL WATER RESOURCES

The management shall establish a water management plan to maintain the quality and availability of natural water resources (surface and ground water). The water management plan may include:

i. Assessment of water usage and sources of supply;

ii. Monitoring of outgoing water which may have negative impacts into the natural waterways at a frequency that reflects the estate's current activities;

iii. Ways to optimise water and nutrient usage to reduce wastage (e.g. having in place systems for re-use, night application, maintenance of equipment to reduce leakage, collection of rainwater, etc.);

iv. Protection of water courses and wetlands, including maintaining and restoring appropriate riparian buffer zones at or before planting or replanting, along all natural waterways within the estate;

v. Where natural vegetation in riparian areas has been removed, a plan with a timetable for restoration shall be established and implemented;

vi. Where bore well is being used for water supply, the level of the ground water table should be measured at least annually.

CRITERION 4.5.6: STATUS OF RARE, THREATENED, OR ENDANGERED SPECIES AND HIGH BIODIVERSITY VALUE AREA

Indicator 1: Information shall be collated that includes both the planted area itself and relevant wider landscape-level considerations (such as wildlife corridors). This information should cover:

a) Identification of high biodiversity value habitats, such as rare and threatened ecosystems, that could be significantly affected by the grower(s) activities.

b) Conservation status (e.g. The International Union on Conservation of Nature and Natural Resources (IUCN) status on legal protection, population status and habitat requirements of rare, threatened, or endangered species), that could be significantly affected by the grower(s) activities.

Indicator 2: If rare, threatened or endangered species, or high biodiversity value, are present, appropriate measures for management planning and operations should include:

a) Ensuring that any legal requirements relating to the protection of the species are met.

b) Discouraging any illegal or inappropriate hunting, fishing or collecting activities and developing responsible measures to resolve human-wildlife conflicts.

Indicator 3: A management plan to comply with Indicator 1 shall be established and effectively implemented, if required.

CRITERION 4.6.1: SITE MANAGEMENT

Where oil palm is grown within permitted levels on sloping land, appropriate soil conservation measures shall be implemented to prevent both soil erosion as well as siltation of drains and waterways. Measures shall be put in place to prevent contamination of surface and groundwater through runoff of either soil, nutrients or chemicals.

CRITERION 4.7.1: HIGH BIODIVERSITY VALUE

Indicator 1: Oil palm shall not be planted on land with high biodiversity value unless it is carried out in compliance with the National and/or State Biodiversity Legislation.

Indicator 2: No conversion of Environmentally Sensitive Areas (ESAs) to oil palm as required under Peninsular Malaysia's National Physical Plan (NPP) and the Sabah Forest Management Unit under the Sabah Forest Management License Agreement. For Sabah and Sarawak, new planting or replanting of an area 500ha or more requires an EIA. For areas below 500ha but above 100ha, a Proposal for Mitigation Measures (PMM) is required.

CRITERION 4.7.2: PEATLAND

New planting and replanting may be developed and implemented on peatland as per MPOB guidelines on peatland development or industry best practice.

CRITERION 4.7.3: SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT (SEIA)

Indicator 1: A comprehensive and participatory social and environmental impact assessment shall be conducted prior to establishing new plantings or operations.

Indicator 2: SEIAs shall include previous land use or history and involve independent consultation as per national and state regulations, via participatory methodology which includes external stakeholders.

Indicator 3: The results of the SEIA shall be incorporated into an appropriate management plan and operational procedures developed, implemented, monitored and reviewed.

Indicator 4: Where the development includes smallholder schemes of above 500ha in total or small estates, the impacts and implications of how each scheme or small estate is to be managed should be documented and a plan to manage the impacts developed, implemented, monitored and reviewed.

CRITERION 4.7.4: SOIL AND TOPOGRAPHIC INFORMATION

Indicator 1: Information on soil types shall be adequate to establish the long-term suitability of the land for oil palm cultivation.

Indicator 2: Topographic information shall be adequate to guide the planning

River Reserves

Malaysia through DID developed guidelines to identifying width of waterway to be conserved (**Table 1-1**).

Table 1-1: River reserve width requirements (DID Malaysia)

WIDTH OF WATERWAY BETWEEN BANKS	REQUIREMENTS FOR RIVER RESERVE WIDTH (BOTH BANKS)
> 40 m	50m
20 m – 40 m	40m
10 m – 20 m	20m
5 m – 10 m	10m
< 5 m	5m

1.4.4 OTHER COUNTRIES

Extensive peatlands are found in other regions of the world especially in the Congo and Amazon basins as well as Papua New Guinea. There are few if any specific regulations in these countries on the management of peatlands. However peatland management may be addressed in more general regulations on the environment or in policies or strategies related to wetlands. The Democratic Republic of Congo, for example, imposed a forest moratorium on new industrial logging titles since 2002 (which covers peatland forests). However, the government had started to lift the moratorium in 2018.

Democratic Republic of Congo

Based on the HCV National Interpretation of the Democratic Republic of Congo (DRC), the protection zone is determined from river and springs (see **Table 1-2**).

Table 1-2: Protection zone for water body in DRC

SIZE OF WATER BODY	SIZE OF PROTECTION ZONE
Width >10m	50m from each bank
Springs	150m in all directions

Papua New Guinea (PNG)

In PNG, riparian reserve buffer zones should be maintained and/or rehabilitated as per the PNG logging code of practice at the time of planting or replanting (**Table 1-3**).

Table 1-3: Riparian reserve as per PNG logging code of practices

Watercourse definitions in PNG include the following: Permanent water courses	Have water flowing for part or all of the year for most years. The stream beds have no vegetation growing on them, and may consist of water-washed sand, silt, stone, gravel or exposed bed rock materials. Class 1 Stream bed width = >5m Class 2 Stream bed width = <5m and >1m
Non-permanent water courses or drainage channels	Are usually stable, non-incised depressions which carry surface water during times of high rainfall. The beds are comprised of soil and are usually covered with leaf litter and vegetation.
Swamps	Have surface water present for 6 months of the year.
Stream buffer zone starting point adjacent to the stream	Delineation of the buffer zone should start where the vegetation is 10m high or higher*.

Uganda

Wetlands (including peatlands) in Uganda are protected through the National Environment (Wetlands, river banks and Lake Shore management) Regulations 3/2000. All rivers have a protected zone of 30m and specified rivers have a protection zone of 100m measured from the highest watermark. The protection zone for lakes is up to 200m from the low water mark. No drainage or large-scale cultivation is permitted in wetlands without a permit.

2.0 PEATLAND ECOSYSTEMS

2.1 DEFINITION, FORMATION, DISTRIBUTION AND CLASSIFICATION OF PEATLANDS

Definition

A peatland is an area with a layer of naturally accumulated organic material. Most tropical peat soils belong to the soil order Histosols and the sub-orders Fibrists and Hemists. Peat soils consist of partly decomposed biomass and develop when the rate of biomass accumulation from vegetation is greater than the rate of decomposition. The rate of decomposition is reduced due to the presence of a permanently high water table that prevents the aerobic decomposition of plant debris (Andriesse, 1988; Driessen, 1978). Soils are classified as peat soils when they reach an accepted threshold (e.g., host-country, FAO or IPCC) for the depth of the peat layer and the percentage of organic material composition. Some classifications adopt a minimum organic matter percentage of 35% in a minimum accumulated organic layer of 30cm, others specify an organic content of 65% while some require an accumulation of at least 40 or even 50cm to qualify.

RSPO P&C (2018) has adopted the following definition of peat effective 15 November 2018 as follows:

> ***Tropical peat soils are soils with cumulative organic layer(s) comprising more than half of the upper 80 cm or 100 cm of the soil surface containing 35% or more of organic matter (35% or more Loss on Ignition) or 18% or more organic carbon.***

This definition is derived from globally accepted definitions (USDA and FAO) for histosols.

Note that for management of existing plantations in Malaysia and Indonesia, a narrower definition has been used, based on national regulations: namely soil with an organic layer of more than 50cm in the top 100 cm containing more than 65% organic matter.

Distribution

Tropical peatlands are estimated to cover about 60 million hectares. Peatlands occur in the following regions: Southeast Asia (24 million ha, 40%), followed by Africa (20 million ha; 33%), South America (10.7 million ha; 18%), Central America and the Caribbean (2.3 million ha; 4%), the Pacific region (2 million ha; 3%) and Asia (other countries) (600,000ha; 1%) (updated from Page *et al.*, 2011). The area of peatlands in Africa increased recently with the documentation of the largest known tropical peatland complexes, covering 14.55 million ha in the Cuvette Centrale Region of the Congo Basin (Dargie *et al.*, 2017).

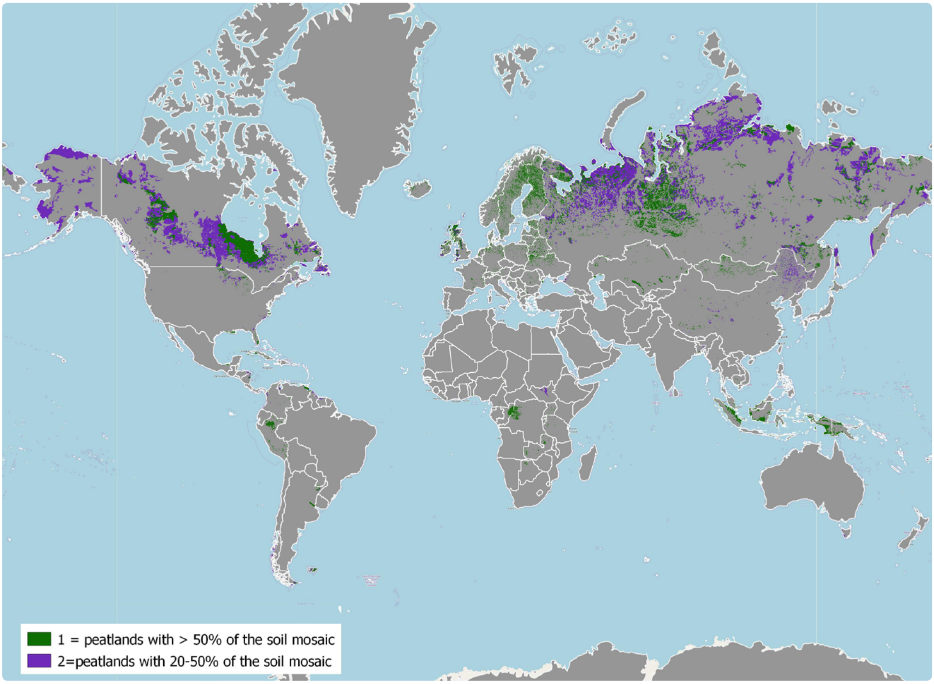


Figure 2-1: Map of peatland distribution in the world (Source: Global Peatland Database/Greifswald Mire Centre, 2019)

Formation

In contrast to temperate and sub-arctic peat soils, which are mainly formed from Sphagnum mosses consisting of very fine fibres, tropical peat develops under forest vegetation and is derived from coarse, more woody material. It is also formed at a much faster rate (most peat in Southeast Asia is only about 4000 years old) but decomposes more rapidly when exposed to aerobic conditions (Paramananthan, 2008). Tropical peat soils can vary greatly according to their genesis and hydrology and may be dominated by different vegetation types. Once established, most tropical peatlands are vegetated with peat swamp forest. Many coastal peatlands have formed in the last 5-10,000 years since the end of the last ice age while more inland peatlands may be 10-50,000 or more years old. Peatlands classified into two main types – Ombrogenous peatlands or bogs which are rain fed, nutrient poor and often domed; and topogenous peatlands occurring in lakes or depressions in the landscape with higher mineral input.

Many tropical peatlands, especially in Indonesia and Malaysia, are formed in the lowlands in-between rivers in areas which may have been inundated with water as a result of impeded drainage, flooding or sea level rise. In these conditions marshy vegetation formed which built up layers of peat over time (see **Figure 2-2**). The high water level and acidic conditions prevented the breakdown of plant material and the peatland grew to 10m or more thick in the centre (at a rate of 1-3mm/year). This type of peatland is raised above the surrounding area and is often disconnected with the ground water and is called an ombrotrophic bog, which is nutrient-poor or oligotrophic. Many of these tropical ombrotrophic bogs are dome shaped with a rise in elevation of the peat in the areas in between adjacent rivers (see **Figure 2-3**). These dome-shaped peatlands are the most common existing peatland in Southeast Asia,

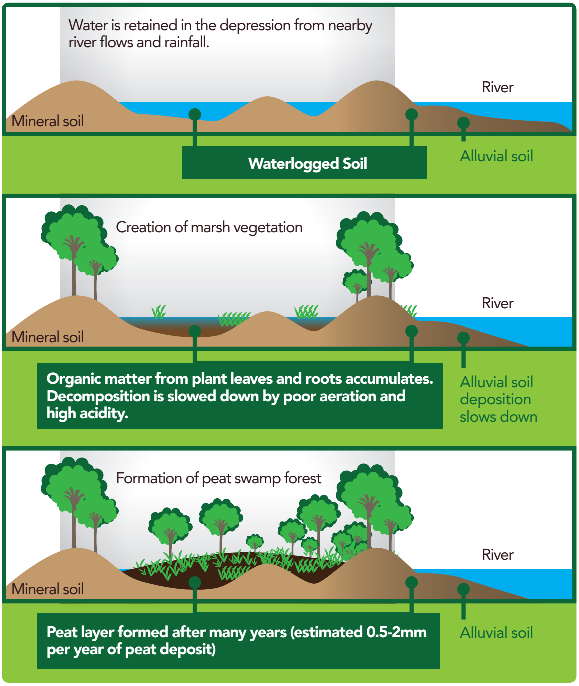


Figure 2-2: Formation of tropical domed peatlands (Source ASEAN, 2011)

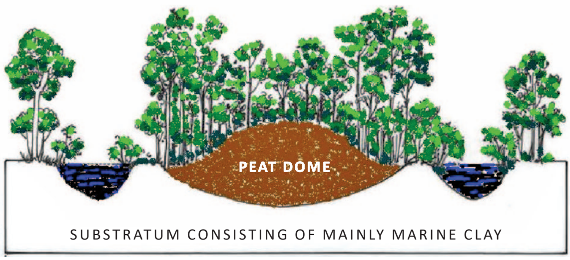


Figure 2-3: Schematic diagram of Ombrogenous domed peatland (Source: M. J. Silvius, Wetlands International)

as described by Anderson (1961). Peatlands in the Congo Basin in Africa occupy large-scale shallow inter-fluvial basins but the presence of domes has yet to be confirmed. Peat thickness gradually increases away from the river margins. These are also ombrotrophic-like peatlands, owing to their low-nutrient status and heavily rainwater-`dependent water tables. This peat is on average less deep and accumulated slowly in contrast to most peatlands in Southeast Asia (Dargie *et al.*, 2017).

Tropical lowland peat swamps are primarily rain-fed. They have their origins in the topographic conditions that lead to semi-permanent waterlogging. Under natural conditions, they are formed by the accumulation of vegetative matter, which is deposited in the waterlogged soils faster than it can decay. Hydrology is an important (if not the most important) factor in the formation and functioning of peat swamp ecosystems. The hydrology of a peat swamp depends on the climate, topographic conditions, natural subsoil, and drainage base. Any changes in the hydrology, especially those from the introduction of drainage, will often have irreversible effects on the functioning of these fragile ecosystems. A better understanding of the hydrology of peat swamps will make it possible to manage them in a more sustainable way.

Water is vital for the survival of the peatlands. Water, whether in terms of quantity (water level) or quality, affects the survival and growth of plants. A water level higher than the breathing roots (pneumatophores) of the peat swamp forest trees disrupts the respiratory and air exchange process of the trees. On the other hand, too low a water level causes organic soil to dry and oxidise and prone to damage by wild fires and subsidence. The result will be the loss of soil and peat swamp vegetation which have adapted to the natural water regime.

Good management of the peatlands requires identification of proper water level that naturally fluctuates around the surface. This is also important for maintaining the water balance of the overall peat swamp landscape as adjacent areas may be affected by water management activities. In Sarawak, the peat domes serve as reservoirs of water for coastal areas. Otherwise, these areas would suffer water shortages during droughts (Sawal, 2004).

The second main type of tropical peatland is basin or topogenous peatlands which have formed in depressions in the landscape or in lake basins, oxbow lakes or river flood plains (see example in **Figure 2-4**). They may also be formed when drainage is impeded in riverine systems due to reasons such as siltation, longshore sediment drift or rising sea levels. Basin peats often differ from the ombrotrophic bogs in that they receive more mineral input in terms of river or flood inputs as well as being fed by more mineral rich groundwater. These systems may be classified as freshwater swamps where they still receive mineral inputs – but over time some portions of the sites accumulate peat and may be raised up as bogs. As a result of the mineral inputs – they may have a lower % (dry weight) of organic matter – but as a result of being more compact (with higher bulk density) – may actually store larger absolute amounts of carbon per given volume. See also **Figure 2-5 to 2-7** for distribution of PSF in ASEAN and other regions.

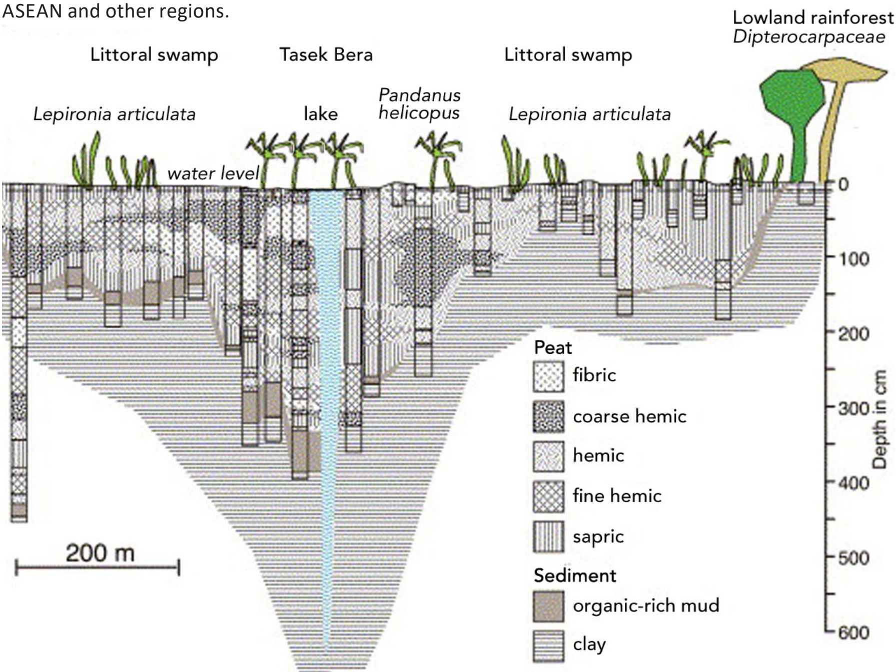


Figure 2-4: Cross section diagram of basin peat in Tasek Bera, Malaysia (Source: Wüst, R. A., & Bustin, R. M. 2004)

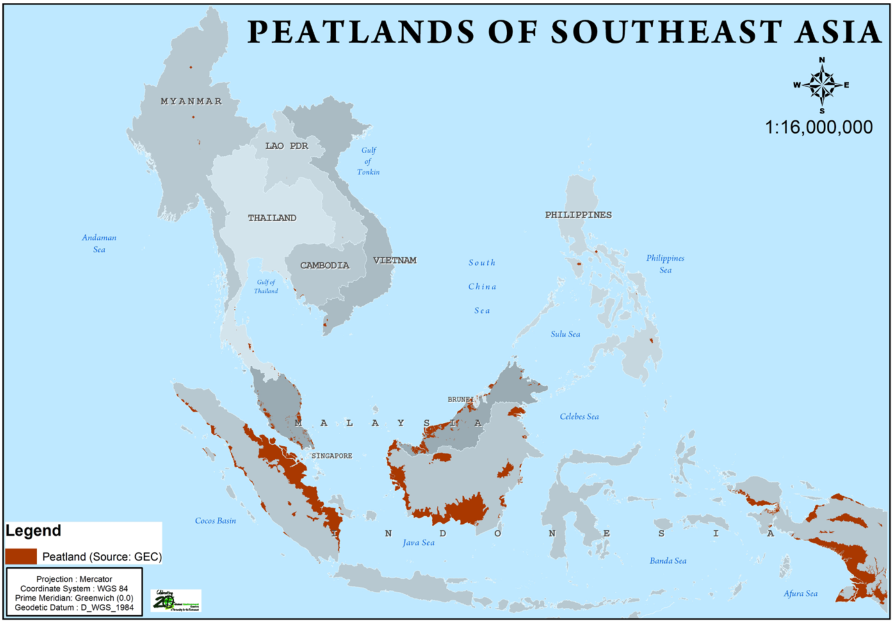


Figure: 2-5: Map showing distribution of tropical peatlands in Southeast Asia region (Source: APFP-SEApeat, 2015)

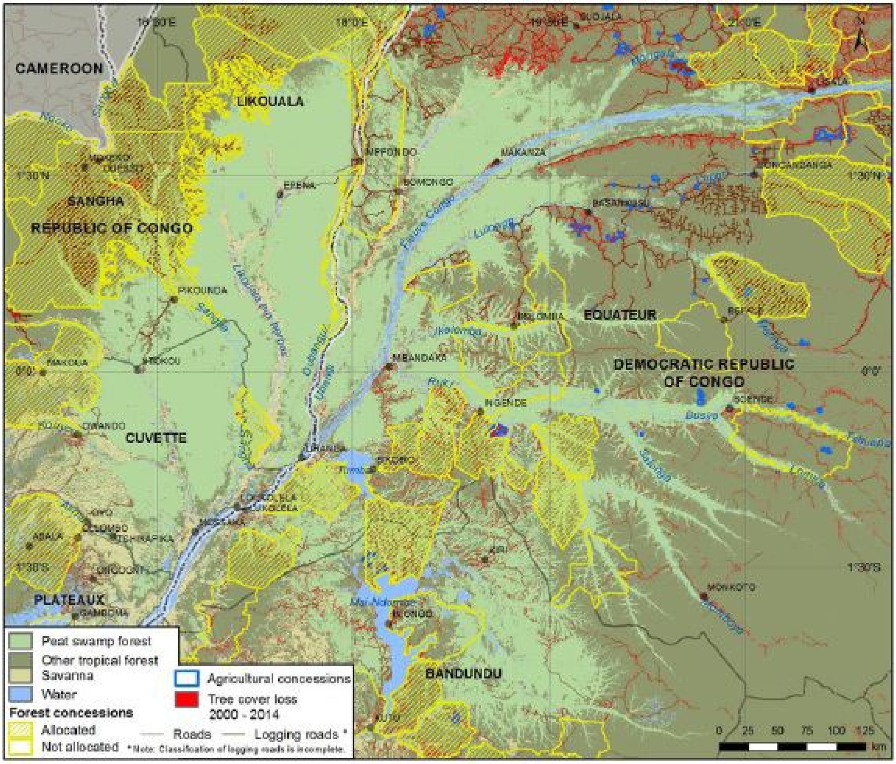


Figure 2-6: Peatland ecosystem of Cuvette Centrale, Congo Basin, the world's largest tropical peatland ecosystem with peat swamp forests (green), water bodies (blue) and forest concessions (yellow) (Source: Miles et al., 2018)

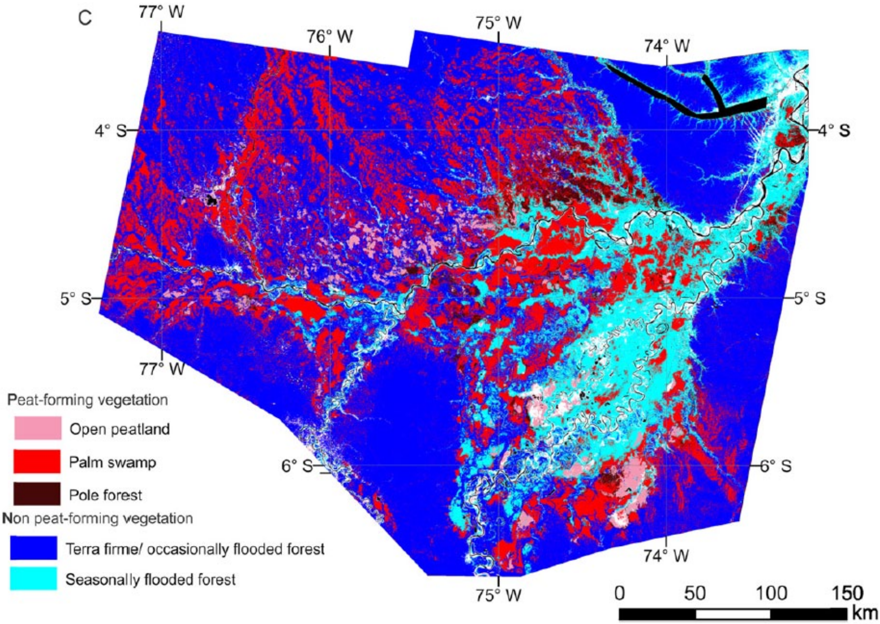


Figure 2-7: Satellite image of peatlands in Pastaza-Marañón Foreland Basin in Peru (Source: Draper et al., 2014)

2.2 FUNCTION AND VALUES OF PEATLANDS

Peatlands are an important component of the world's wetlands and form the main wetland type in Southeast Asia. They also occur in other oil palm growing regions in East, West and Central Africa and Latin America.

Peatlands are habitats for fauna and flora that are highly adapted to the acidic water and waterlogged condition. Commonly with a high proportion of endemic species that give these areas global significance and act as a gene bank with undiscovered resources for medicinal and other important human uses.

They play a major part in regulating water in the ecosystem. They serve as fresh water reservoirs, to stabilise water levels and reduce peak-flow. Coastal peat swamps act as a buffer between marine and freshwater systems, preventing saline water intrusion into the coastal land and groundwater. Peat swamps often serve as a natural gene bank, preserving potentially useful varieties of plant and animal species. At a global scale, the peatlands contribute to the storage of atmospheric carbon that is an agent of global warming, helping to slow down that process. Peatlands can also be very productive through the managed extraction of fish (see **Figure 2-8**), timber and other non-timber forest products (see **Figure 2-9**) (UNDP, 2006).

Figure 2-8: Fishery in peat swamp rivers is mainly for subsistence.

Figure 2-9: Non-Timber Forest Products (NTFP): Pandanus, rattan, etc. for walls, baskets, etc.

Further details of benefits provided by intact peatlands focusing on the provision of ecosystem services include:

Flood Mitigation

Intact peatlands can diminish peak flood flows mainly by reducing water velocity but also by providing large areas for storage of flood waters in terms of spatial area and, to a limited degree (dependent on how waterlogged the peat is already) through the water-holding capacity of the peat.

Maintenance of Base Flows in Rivers

The water from floods held in natural peatlands is released gradually over a long period. Intact peat swamps can contribute to maintaining the water level in rivers that run through them during dry periods.

Prevention of Saline Water Intrusion

Saline water intrusion is related to base flows in the rivers. By maintaining base flows in the rivers, peatlands can prevent the intrusion of saline water up to rivers and maintain fresh groundwater in coastal areas. In places where the coastal peatlands have been drained – saline water intrusion has often increased, having a negative impact on water supply and agriculture.

Sediment Removal

When a peat swamp area is flooded, the reduction in water velocity associated with it spreading over a wide area, together with the retarding effects of vegetation, allows suspended sediments to settle. Water flowing back into rivers will then be largely sediment free. However, it is noted that this occurs mainly in peatlands along the rivers or in depressions.

Toxicant Removal

Peat is very effective in binding metals. This largely accounts for the micronutrient deficiencies (such as copper) that are encountered when using peat soils for agriculture. Other metals (such as mercury and arsenic) are often bound in peat soils that are accumulated from waterborne and airborne sources over long periods. Some such metals are toxic in large quantities and peat acts as a store for them.

Carbon Storage and Carbon Sequestration

Peatlands are major carbon stores. Parish *et al.*, (2007) reported that peatlands globally cover 400 million hectares and store more than 550 giga (billion) tonnes of carbon (GtC) or 30% of all global soil carbon equivalents. This is approximately 60% more that the carbon stored in the living biomass of all the world's forests combined (Pan *et al.*, 2011). Tropical peatlands cover about 60 million hectares (ha) and store about 89 billion tonnes of carbon (GtC) with an estimated 68.5 GtC in Southeast Asia (Page *et al.*, 2011).

Large quantities of carbon are stored in tropical peatlands. Estimates suggest that up to 5,800 tonnes of carbon per hectare can be stored in a 10-meter deep peatland compared to 300-500 tonnes per hectare for tropical forest on mineral soil (UNDP, 2006).

Neuzil (1997) estimated that the annual carbon accumulation rate in Indonesian peatlands ranges between 0.59-1.18t C/ha/yr., which is much higher than the accumulation rates in temperate or boreal zones, which ranges between 0.2-1t/ha/yr. Suzuki *et al.*, (1999) measured net sequestration of 5.3t C/ha/yr. in primary peat swamp forest in To-Daeng, Thailand, in a typical wet year.

Since peatlands store large amounts of carbon – any degradation of peatlands will result in carbon emission. Current carbon emissions from drained and fire-affected peatlands in Southeast Asia have been estimated to be between 355-855 million tonnes (Mt) CO_2/year from drainage-related peat decomposition (Hooijer *et al.*, 2010) and 300-600Mt CO_2/yr. from peat fires (Couwenberg *et al.*, 2009, van der Werf *et al.*, 2008, Page *et al.*, 2002). Losses on this scale contribute significantly to atmospheric carbon loading and anthropogenic climate change processes (Page *et al.*, 2011).

2.3 CHARACTERISTICS OF TROPICAL PEATLANDS

Tropical peatlands are found in different forms; they may be naturally domed with water input mainly from rainfall or they may be in river and lake basins with water input from surface or groundwater flow. The different physical and ecological and geographic situations lead to significantly different vegetation types. Globally, the most common natural tropical peatland vegetation is peat swamp forest (PSF), but this includes a broad range of sub-types including ecological zones within one peatland and geographic variations between peatlands. Pristine tropical peat swamp forests (PSFs) represent a unique wetland ecosystem of distinctive hydrology which support unique biodiversity and globally significant stores of soil carbon (Evers *et al.*, 2017). Degraded peatlands may be vegetated with secondary forests dominated by a few pioneer tree species or with bushes and shrub or even grasses and sedges (depending on the degree of degradation or recovery). In time, with appropriate protection, degraded peatlands can recover to peat swamp forests. In some regions, peatlands may naturally be vegetated with sedges or reeds such as the Lake Victoria Basin in East Africa peatlands are dominated by papyrus (*Cyperus papyrus*) or in Inle Lake Basin in Myanmar where common reed (*Phragmites australis*) dominates.

2.3.1 OMBROTROPHIC DOMED PEATLANDS

Many tropical peatlands have a dome-shaped topography. Peat depth and elevation usually increase towards the centre of the peatland. This is due to differential decomposition rates – with slower composition in the poorly-drained centre and faster rates in the better drained periphery. Higher levels of nutrients in the periphery may also contribute to faster decomposition. Most domed peatlands are generally elevated 4–9 m above adjacent river courses but some old domes are up to 20m thick. Surface slopes vary between 1–2 m per km (Melling and Ryusuke, 2002). See **Figure 2-10a/b** for a digital terrain Model and profiles for the Berbak Peatlands in Sumatra as well as a cross section through the peat dome at in **Figure 2-11c**.

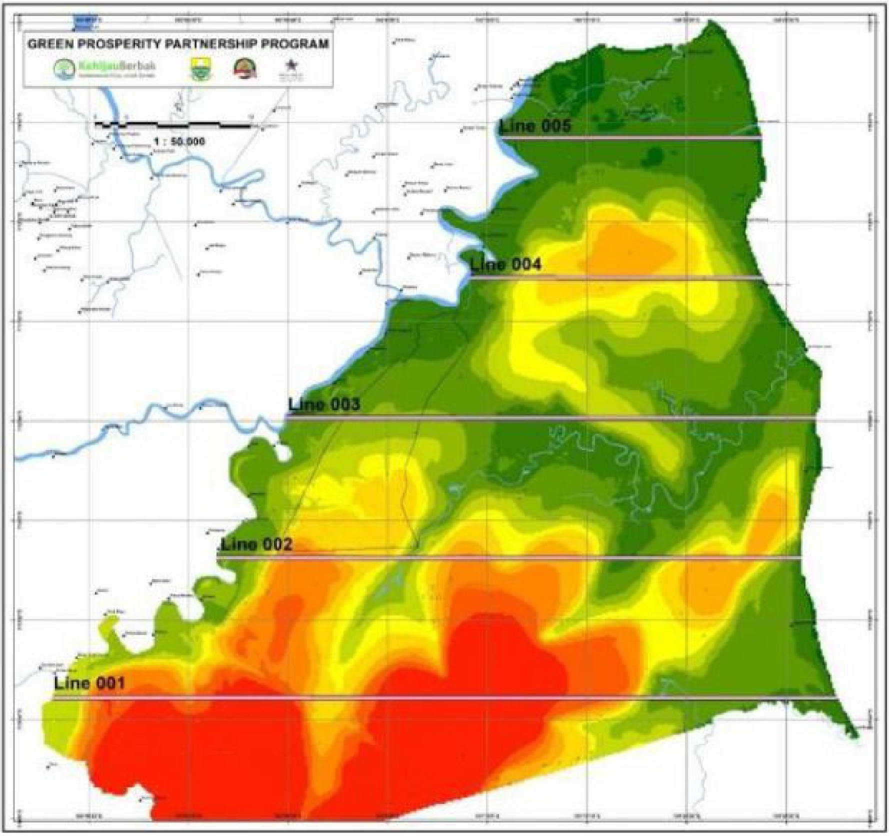


Figure 2-10a: LiDAR-DTM profile of the peat landscape in the Berbak region, Sumatra, Indonesia. The profile has a variable gradient with elevations up to 12 meter above mean sea level. The five lines depict the cross-sections shown in the Figure 2-10b below. (Source: Silvius et al., 2018/Nasrul Ichsan, Euroconsult Mott McDonald).

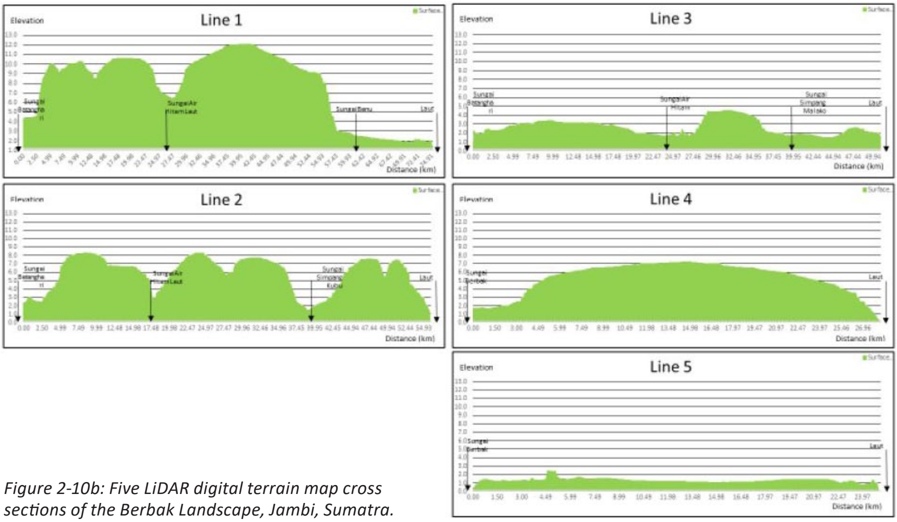


Figure 2-10b: Five LiDAR digital terrain map cross sections of the Berbak Landscape, Jambi, Sumatra.

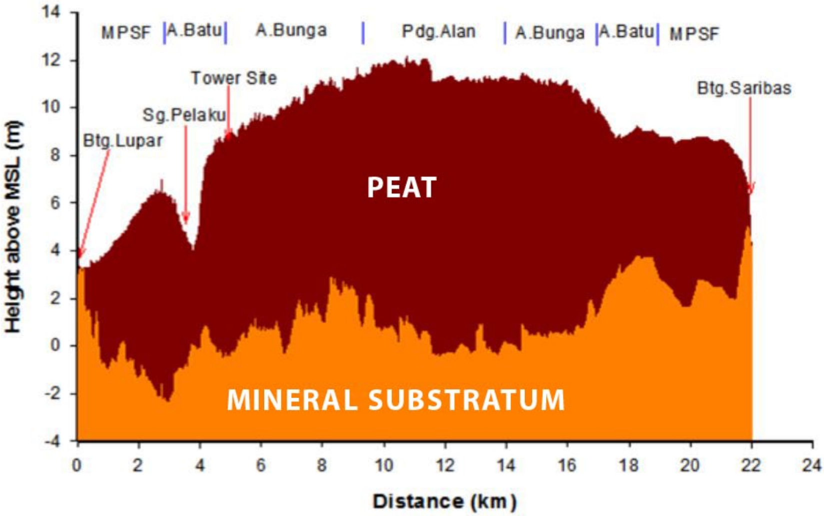


Figure 2-11: Cross-section of a peatland at Maludam Peninsular, Sarawak showing peat dome. (Source: Melling and Hatano, 2004)

Dome-shaped peatlands may have distinct vegetation types, which vary according to peat depth and nutrient status. The vegetation also influences the nature of the peat and the constraints for cultivation. It is noted that plant species may differ in similar zonations elsewhere across the tropics. For example, Dargie *et al.*, (2017) found Congo Basin peat consistently under two common vegetation types: hardwood swamp forest (in which *Uapaca paludosa*, *Carapa procera* and *Xylopia rubescens* are common) and a palm-dominated (*Raphia laurentii*) swamp forest. Peat was also usually found under another, much rarer palm-dominated (*Raphia hookeri*) swamp forest that occupies abandoned river channels (Dargie *et al.*, 2017).

The Peruvian Amazonia harbours a considerable diversity of peatlands which represent a gradient from very nutrient-poor to nutrient-rich (Lähteenoja and Page, 2011). They include both domed ombrotrophic as well as shallower minerotrophic peatlands. The peatland pole forests (dominated by a limited number of tree species) of the Pastaza-Marañón Foreland Basin (PMFB), Peru, are the most carbon-dense ecosystems known in Amazonia once below ground carbon stores are taken into account (Kelly *et al.* 2016).

2.3.2 VALLEY OR BASIN PEAT

Some tropical peatland occurs in lake basins and valley bottoms in which case there may be more input of mineral content at least in the edge of the system. Depending on the conditions, this peat type may also develop a dome-like formation in the centre (see **Box 2-1** below for example of basin peat area at Tasek Bera in Peninsular Malaysia).

BOX 2-1

Tasek Bera Basin, Wüst *et al.*, (2004)

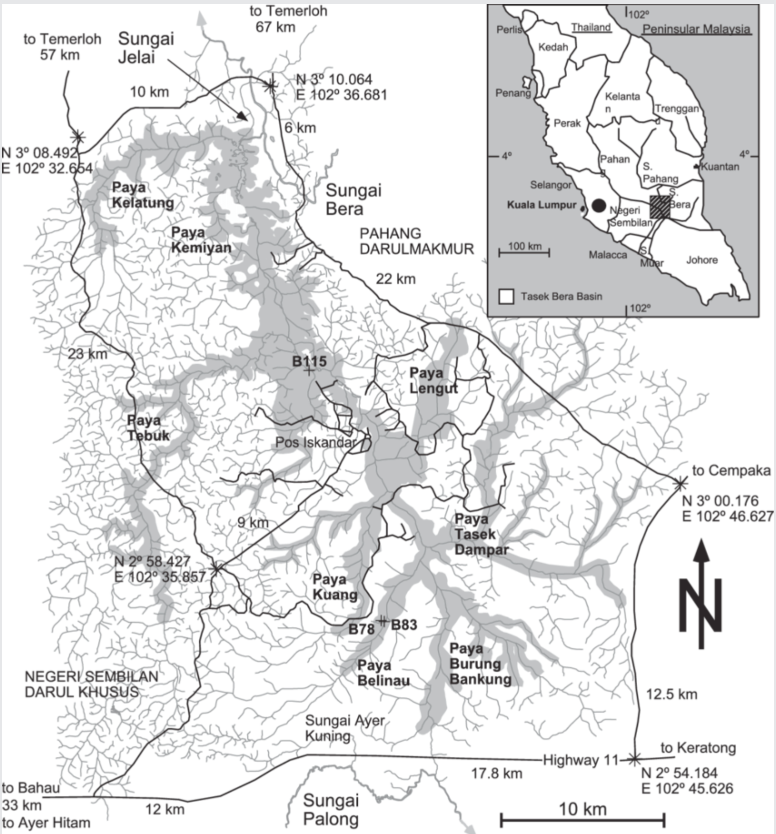


Figure 2-12: Location map of the Tasek Bera Basin.

Tasek Bera Basin (TBB) is a lowland dendritic basin in tropical Peninsular Malaysia located in the east-central State of Pahang and north-eastern Negeri Sembilan (**Figure 2-12**). The total drainage basin comprising an area of 625 km^2 of which 300 km^2 are rubber-and-palm plantations while wetland and pristine lowland forest cover an area of 325 km^2. The main drainage of the TBB is to the north, into Sungai Jelai and Sungai Bera, which join Sungai Pahang. Sungai Bera originates from the lowland hills of the eastern range to the North East of the TBB and flows first to the south, but changes course abruptly to the north, bypassing the swamp system to the east before capturing the drainage water from the Tasek Bera swamp system. Most of the southern swamp-forest tributaries drain towards the main basin, joining the Tasek Dampar drainage. The southern branch of Paya Burung Bangkung has two drainage directions. The northern part drains towards Tasek Bera, whereas the southern part drains towards the south into Sungai Air Kuning, which joins Sungai Palong. Both rivers belong to the eastern watershed. Sungai Palong drains into Sungai Muar and flows into the Strait of Malacca. Accumulation of organic matter occurred in local lakes during the last glacial maximum (LGM), but widespread peat deposition did not start until 5300 BP (**Figure 2-13**) when climatic changes led to the evolution of a wetland system. Peat accumulation progressively (rates ranging from 0.7 to 2.5 mm/year) expanded with terrestrialisation of channels and sub basins to paludification of the riparian part of the lowland forest zone.

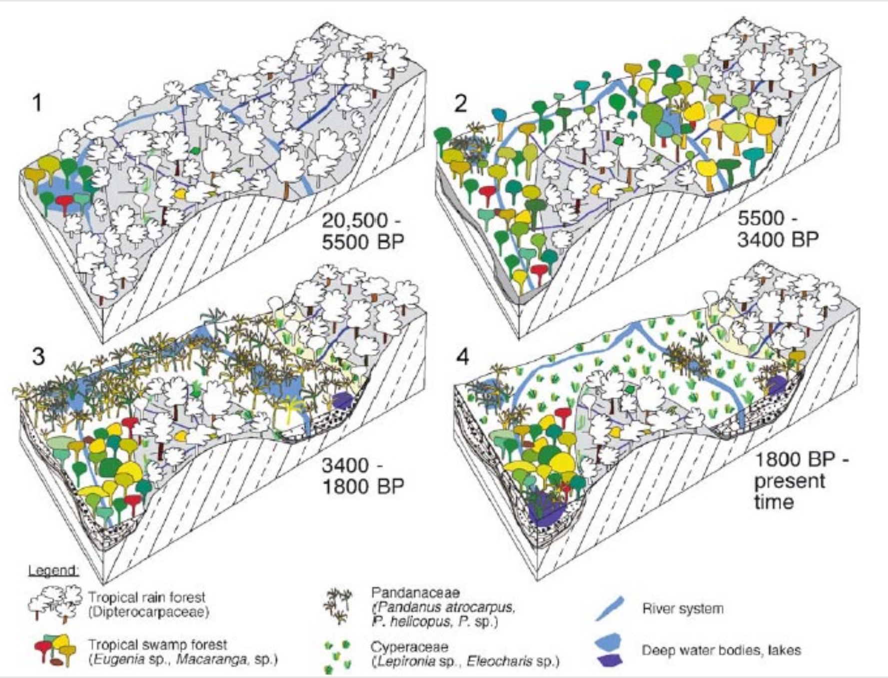


Figure 2-13: Schematic diagram of the possible paleo-ecological and sedimentological evolution of the Tasek Bera peat deposits over the past 20,500 years BP (before present).

In South-west Kalimantan, in the island of Borneo, peatlands are found in selected river valleys in-between low hills with podzolic soils which have a "hard-pan" or "iron pan" – an impervious layer of dense minerals between 50cm to 1.5 m below the surface. This hard-pan prevents water from penetrating the lower soil layers and as a result there is a high surface run-off to the adjacent shallow valleys which has helped enable formation of deep (up to 6m thick) peat deposits (see **Figure 2-14** and **2-15**. These peatlands are not domed and so when any drainage is made into the peatlands the water from the surrounding land will flow into the peatland in contrast to the normal Indonesian domed peatland systems). This is an important fact when conserving such peatlands in and around oil palm plantations in that drainage water from the adjacent plantations on the podzolic soils will flow into the peatlands together with any agrochemicals, minerals etc.

Figure 2-14a: Peat swamp forest in valley peats in-between grasslands on podzolic low hills in Southwest (SW) Kalimantan

Figure 2-14b: Satellite image of same landscape in Figure 2-14a showing unique shapes of valley peatlands in-between grasslands on podzolic low hills in SW Kalimantan (Source: planet.com).

Figure 2-15: Basin peat in edge of lake in Giam Siak Kecil-Bukit Batu Peatland landscape in northern Riau Province, Indonesia.

Uganda has significant areas of peatland ecosystems found throughout the country covering more than 1.4 million ha making it one of the top 20 countries in the world in terms of peatland area (Joosten, 2009). The peatlands are concentrated in the central and southern portions of the country along river valley bottoms and around lakes (See **Figure 2-16**). Ugandan peatland ecosystem types include papyrus valley bottom peatlands (with peat deposits up to 7.5m thick), river bank peatlands, floating papyrus peat mats along the shores of lakes; Raphia palm peatlands and upland peatlands. Most of these peatland types are basin peatlands.

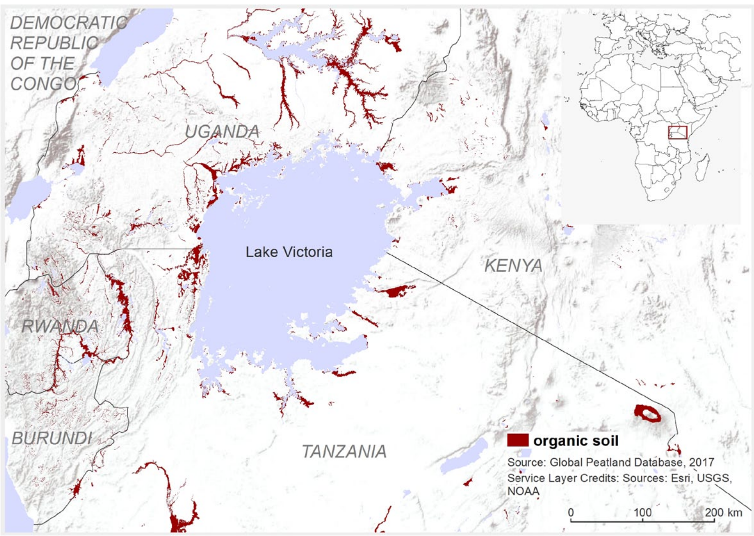


Figure 2-16: Probability map for organic soils/ peatlands in East Africa (Source: Global Peatland Database 2017 – Greifswald Mire Centre).

2.4 FLORA IN PEAT SWAMP FORESTS

Figure 2-17: Ramin (Gonystylus bancanus)

Peat Swamp Forests (PSFs) have reasonably diverse plant species with 1,337 species of higher plants recorded in Southeast Asian freshwater swamps (from Thailand to Papua) according to Giesen *et al.*, (2018). However, the majority of species are shared with other habitats including lowland forests and heath forests. Some are even shared with upland and montane habitats. The numbers, types and species can vary between sites – but well developed sites may have up to 250 tree species or 500 plant species. For example in Thailand, more than 470 species from 109 families have been recorded in the PSFs (Chamlong, Chawalit and Wiwat, 1991). In Kalimantan, Indonesia, 310 species and 78 families of plants were recorded in the PSFs (Simbolon and Mirmanto, 1999). Perhaps the most comprehensive and best known study of the ecology of the tropical lowland PSF was carried out by Anderson over a period of ten years in the 1950s (Anderson, 1961, 1963 and 1983). Anderson recorded 253 tree species including 40 small trees which rarely exceed 5-10m in height in the tropical lowland PSF. Recently, 312 plant species, comprised of 219 tree and 93 non-tree species, were recorded in the Katingan-Mentaya Peat Swamp in Central Kalimantan (Harrison *et al.*, 2011). In 2013, in Malaysia, a scientific expedition on the biodiversity was carried out at North Selangor Peat Swamp Forest. During the course of the expedition, 126 tree species from 38 families were recorded (Selangor State Forestry Department, 2014).

Giesen *et al.*, (2018) identify 45 higher plant species restricted to lowland peat swamp forests and another 75 found only in peat swamp forests and riparian/mineral soil swamps. Species restricted to PSF, include: Ramin (*Gonystylus bancanus*) (**Figure 2-17**), swamp Jelutung (*Dyera polyfilla*), *Shorea platycarpa*, *Shorea uliginosa*, *Calophylum lowei* and *Pandanus vinaceus*. Some of these species have been identified relatively recently such as *Hanguana thailandica*, described only in 2016 (Wijedasa *et al.*, 2016) and further studies are likely to reveal more species. Trees in PSF tend to develop buttresses and stilt roots to provide stability and anchorage in waterlogged condition. Because of the long periods of high water level, many of the tree species have pneumatophores, protruding roots above the water surface which function as breathing roots (**Figure 2-18**).

Figure 2-18: Examples of A) buttress, B) stilt root, and C) pneumatophores which enable breathing of the tree at different water levels.

The vegetation in Peruvian peatland ecosystems varies from open swamp to palm forests to peat swamp forests (see **Figure 2-19a** and **b**). One of the major types is dominated by a palm species—*Mauritia flexuosa*, which cover about 80% of total peatland area and store ~ 2.3 Pg C (Bhomia *et al.* 2018).

Figure 2-19a: Open/pole forest peatland (Source: Schultz et al., 2019).

Figure 2-19b: Mauritia flexuosa palm forest peatland in Chambira River Basin, Peru (Source: Schultz et al., 2019)

2.5 FAUNA IN PEAT SWAMP FORESTS

Peat swamp forests have long been regarded as a species-poor ecosystem with low productivity, low faunal diversity and few endemics (Johnson, 1967). In contrast, recent work had shown that peat swamp forests support a high diversity of animal species with 123 mammal, 268 bird, 75 reptile and 219 fish species recorded in Southeast Asia (Posa *et al.*, 2011). Studies have revealed that peat swamp forests are also critical for the conservation of threatened animal species (Husson *et al.*, (2018). Peat swamp forests are in particular habitat for many rare and endemic fish species with more than 20 new species to science described in recent years and more than 30 single site endemics recorded. Studies of insects – especially dragonflies in peat swamp forests have also recorded many new and rare species. Outside of Southeast Asia, very significant concentrations of animals have been recorded in peatlands in the Congo and Amazon basins.

Mammals

PSFs are found to have a high diversity of mammals with 123 species recorded of which six species are strongly associate with PSF; while 45% of the mammals in PSF are considered threatened with IUCN Red List status of near threatened, vulnerable or endangered (Posa *et al.*, 2011). Mammals in PSFs include some iconic species (**Figure 2-20**). In the Katingan-Mentaya peat swamp in Central Kalimantan, 77 species of mammal have been found. Husson *et al.*, (2018) have recorded 65 mammal species in the Sebangau Peatlands in Central Kalimantan.

Peat swamps are also important for the conservation of a number of endangered primate species. The richest habitats for orangutans are high-quality swamp forests and lowland alluvial forests (Russon *et al.*, 2001). In Gunung Palung National Park in western Kalimantan, primary peat forest had a higher density of Bornean orang-utan (*Pongo pygmaeus*) nests (49% more) and individuals (31% more) than lowland forest (Johnson *et al.*, 2005). The Sebangau catchment in central Kalimantan supports the largest single orangutan population in Borneo (Morrogh-Bernard *et al.*, 2003). Peat swamp forests are also important for conservation of other primates, such as proboscis monkeys (*Nasalis larvatus*), the Bornean banded langur (*Presbytis chrysomelas*) (Phillips, 1990) and the four primate species endemic to Siberut island, *Hylobates klossi*, *Presbytis potenziani, Macaca siberu*, and *Simias concolor* (Quinten *et al.*, 2010).

A number of endangered cats also make use of swamp forests, including the flat-headed cat (*Prionailurus planiceps*), Sunda clouded leopard (*Neofelis diardi*), and marbled cat (*Pardofelis marmorata*) (Cheyne *et al.*, 2009). Some of the key remaining sites of importance for the Sumatran Tiger (*Panthera tigris sumatrana*) are in Peat Swamp Forests such as on the Kampar peninsula and Kerumutan Wildlife Reserve in Riau Province Indonesia.

Figure 2-20: Mammals found living within the tropical PSFs (clockwise from top left - Sun bear, Tapir, Orangutan and Tiger)

Birds

Posa *et al.*, (2011) have documented 268 species of birds recorded from PSF in Southeast Asia of which 33% are considered threatened with IUCN Red List status of near threatened, vulnerable or endangered There are two bird species known to be near endemic to PSFs in SE Asia (Myers, 2016), the Javan White-eye (*Zosterops flavus*) and the Hook-billed Bulbul (*Setornis criniger*), while more than 200 species of birds have been recorded in Tanjung Puting National Park and a similar amount in the Katingan-Mentaya peat swamp, both in Kalimantan, Indonesia. Sebastian (2002) provides an assessment of the status of bird species of both West and East Malaysian PSF habitats; of the 237 bird species recorded in the PSFs, 27% are listed as globally threatened species.

Fish

It has recently been demonstrated that PSF support a wide variety of fish species with many endemic and highly stenotopic (restricted) species discovered in recent years (e.g. Kottelat & Lim, 1994; Kottelat & Ng, 1994). Up to 15% of the known freshwater fish species in Malaysia are associated with peat swamps, with more than 80 stenotopic blackwater fish species, representing more than 20% of this specialised fauna, discovered only in the last 20 years (Ng *et al.*, 1994). In the Katingan-Mentaya peat swamp in Indonesia, 110 species of fish are known. Posa *et al.*, (2011) documented 219 fish species from peat swamps in Southeast Asia, 80 of which are restricted to this ecosystem, 31 of which are point endemic species found only in single locations.

Among the faunal groups, fish exhibit the highest endemicity to peat swamps. Work in Peninsular Malaysia has shown that the blackwaters of peat swamps are not species poor or low in biomass, and up to 33% of the known freshwater fish species are associated with peat swamps (Ng *et al.*, 1994, Kottelat *et al.*, 2006). Peat swamps also harbour a number of miniature fishes, including *Paedocypris progenetica*, the smallest known vertebrate and member of a new genus of paedomorphic cyprinid fish from highly acidic blackwater peat swamps in Southeast Asia (Kottelat *et al.*, 2006). It is the smallest fish and vertebrate known, with the smallest mature female measuring a mere 7.9mm long. Of the 47 miniature fishes in Asian freshwaters listed by Kottelat & Vidthayanon (1993), 27 inhabit swamps, of which 11 live in peat swamps. Since then, new discoveries have brought the total up to 20 named miniature peat swamp species and more are not yet formally described.

In the PSFs, miniature fishes survive droughts in shallow pools, burrows of other animals, or in the soil, and small size is a considerable advantage when the water level falls. Even in very dry periods, the peat acts as a buffer and retains isolated pools of clean and cold water. In high domes, the waterlogged peat often releases permanent creeks. The permanent presence of water in this loose soil ensures stability of the peat swamp habitat. This stability must have allowed the survival and favoured the evolution of strictly stenotopic species, among them many miniatures.

The North Selangor PSF in Malaysia is one of the most well studied areas, in which 101 species of fish including 48 specialist peat swamp fishes have been recorded (Ng *et al.*, 1992, 1994). These include rare species from genera such as *Encheloclarias*, *Bihunichthys*, *Betta* and *Parosphromenus* as well as six newly described species of fish (Ng & Lim 1993; Ng & Kottelat, 1992, 1994). Far from being a depauperate ecosystem, peat swamps possess an interesting fish fauna, which is diverse and unique, and many of the species have narrow niches and restricted ranges (**Figure 2-21** to **Figure 2-23**). Even in relatively small peat swamp forest areas the fish fauna can be diverse - for example 72 species were recorded in the 4000ha Pondok Tanjung Peat Swamp in Perak, Malaysia (Ng *et al.*, 2018). Thornton *et al.*, (2018) documented 55 species of fish from 16 different families in the Sebangau peatland in Central Kalimantan. Results showed a positive correlation with seasonal water depth and increased river acidity and reduced fish catches after peatland degradation by fires.

Figure 2-21: Betta livida – an endemic PSF fighting fish from North Selangor PSF, Malaysia (Source: Stefan van der Voort).

**NOTE: Shortly after its first discovery in 1992, the site where it was first found was turned into a pineapple plantation, which then failed and was converted to an oil palm plantation.*

Figure 2-22: Paedocypris progenetica – the world's smallest vertebrate animal – a fish species found in PSF in Sumatra and first described in 2005 (Source: H. H. Tan).

Figure 2-23: Betta uberis – an endangered endemic fish that lives in small blackwater rivers of PSFs in Borneo.

According to (Ng C, 2018, pers. comm.) many species of PSF fish are already on the verge of extinction as their habitats were reduced by oil palm plantations expansion in 1980-90s. These include *Betta persephone*, *Betta chini* (hyper-endemic to Klias peat swamp, Sabah); and the world's smallest fish species *Paedocypris progenetica* and *Parosphromenus spp.* which are confined to the peat habitats. Through the expansion of oil palm to peatlands in different regions, the loss of niche peat fish has become an urgent matter as these species are hyper-endemic and they are not found anywhere else in the world.

Reptiles

Eight species of threatened freshwater turtle have been recorded in PSF, indicating that peat swamps are an important habitat for this highly endangered group (Posa *et al.*, 2011). In addition, PSF is the favoured habitat of the endangered false gharial (*Tomistoma schlegelii*) (Bezuijen *et al.*, 2001).

2.6 ZONATION OF PEAT SWAMP FOREST ECOSYSTEMS

Buwalda (1940) working in Sumatra was probably the first to report that different plant communities exist in the PSF depending on the thickness of the peat and the distance from the river. Where the peat was more than three meters thick, he reported that the vegetation was poorer than that at the shallow depths. On very thick peat deposits, *Myrtaceae* and *Calophyllum* species with tall slender trunks growing close to one another dominate. In the central or inner parts of the forest, the thickest layers showed more open vegetation with poorly developed, twisted and stunted trees and scattered pools containing deep brown water with a pH of 3.0 to 3.5. This *Myrtaceae-Calophyllum* forest is rich in Nepenthaceae whilst mosses, ferns and Cyperaceae cover the soils. On peat deposits shallower than three meters deep, the undergrowth consists of *Araceae*, *Commelinaceae*, *Palmae* (*Eleiodoxa conferata*, *Licuala*) and ferns. The soils had a pH of 3.5 to 4.5. Based on these studies in the Indragiri area, Buwalda reported six different vegetation types with the dominance of one or more species. Similarly, Anderson (1961, 1963 and 1964) working on Borneo Island (Sarawak and Brunei) described a similar situation.

Anderson (1961) also found that the tropical lowland PSFs show conspicuous changes in vegetation types from its periphery to the centre of each domed-shaped peat swamp. Anderson, who studied these swamps in Sarawak, Malaysia and adjacent Brunei on the island of Borneo, had used the term "Phasic Community" (PC) to designate a dominant vegetation zone. Anderson recognised six distinct PC or zones on the basis of their floristic composition and structure of the vegetation in each zone:

- **Type 1:** Mixed swamp forest; the *Gonystylus-Dactylocladus-Neoscortechinia* association;
- **Type 2:** Alan forest; the *Shorea albida-Gonystylus-Stemonurus* association;
- **Type 3:** Alan Bunga forest; the *Shorea albida* association;
- **Type 4:** Padang Alan forest; the *Shorea albida-Litsea-Parastemon* association;
- **Type 5:** The *Tristania-Parastemon-Palaquium* association; and
- **Type 6:** Padang keruntum; the *Combretocarpus-Dactylocladus* association.

They were numbered PC1 at the periphery to PC6 in the centre of the peat swamp. See **Figure 2-24** for an illustration of the lateral zonations of PSFs. **Figure 2-25a** and Figure **2-25b** show the Alan Bunga Zone dominated by *Shorea albida* in Brunei. It should be noted that this particular zonation is rarely seen outside of Sarawak. Zonation occurs at others sites but the exact nature and species composition differs from region to region.

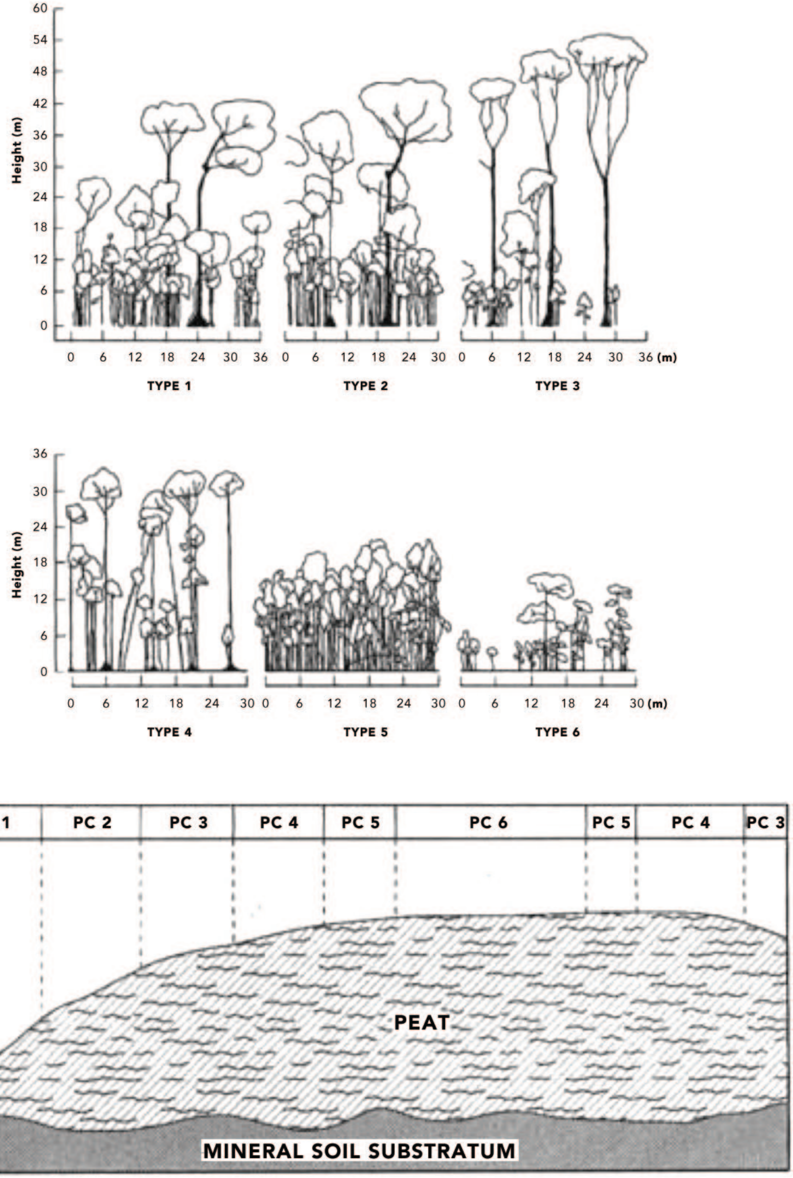


Figure 2-24: Lateral zonations of vegetation in the six phasic communities (Source: Anderson, 1961).

Figure 2-25a: Peat swamp forest dominated by Shorea albida in Brunei Darussalam

Figure 2-25b: Ground level view of Shorea albida dominated forest in Brunei Darussalam

2.7 DEGRADATION OF PEAT SWAMP FORESTS

In Southeast Asia however, 90% of the PSFs are degraded by logging, drainage and fire and millions of hectares are currently managed for industrial plantations including palm oil and pulp wood. In total, industrial plantations cover 4.3 million ha (27%) of the peatlands in Peninsular Malaysia, Sumatra and Borneo, the main peatland-areas in Indonesia and Malaysia. The great majority of industrial plantations are oil palm plantations (73%) while practically all the rest (26%) are pulp wood plantations (Miettinen *et al.*, 2016). In Malaysia in 2016, it is estimated that more than 1 million ha of the peatlands are under oil palm cultivation (Miettinen *et al.*, 2016). In Indonesia, more than 2 million hectares of peatlands are planted with oil palm. Both oil palm and pulp wood cultivation requires peatland drainage which has caused a major decline in biodiversity, huge GHG emissions, major fires and smog, and land subsidence that in the long term make these areas prone to flooding and no longer productive for agriculture.

Hydrology and Drainage

Drainage is an essential starting step for cultivation of oil palm and many other crops on peatland. However, drainage disrupts the hydrology functions of the peatland ecosystem, which often lead to negative impacts beyond the estate boundary, as the hydrology is contiguous. Over-drainage usually causes more serious impact but controlled drainage systems would still have impacts on the adjacent peatland. Drainage within the plantation area can affect significant portions of the peat dome, as drainage can impact water levels up to two km away from the drain – depending on the drainage depth, flow rates and hydrological conductivity of the peat.

Subsidence and Flood Risk

Subsidence is the lowering of the soil surface as the result of physical compression of the peat and loss of carbon due to oxidation and erosion. Peat soils comprise only 10% accumulated organic material and 90% water. When drained, most of the water is immediately lost and the remaining organic matter oxidises such that all peat above the drainage level will eventually be lost. Subsidence and the related flood risk is a well-known and inevitable phenomenon in all places in the world where lowland peatlands have been converted to drainage-dependent land-uses. Examples include the UK (Somerset), USA (Sacramento Delta, Everglades), northern Germany, Denmark and the Netherlands where a large part of the highly populated western part of the country is situated below sea level as a result of the soil subsidence.

In Indonesia (namely Sumatra and Kalimantan) and Malaysia, many of the PSFs have been drained for oil palm or pulp wood plantations. Research results show that in the first five years after drainage, peatland subsidence is typically 1 to 2 m. In subsequent years, this stabilises to a constant 3 to 5 cm/year, resulting in a subsidence of 2-3 m in 25 years and 4-5 m within 100 years (Hooijer *et al.*, 2012, Jauhiainen *et al.*, 2012).

Fire

One of the most serious risks to remaining PSFs in Southeast Asia and elsewhere in the world comes from fire. In the El Nino drought in 197-98 more than 2.5 million ha of peatland was burnt in Indonesia generating a smoke cloud covering 10 million km^2 for up to six months. Long term impacts are unpredictable, but a study of the effects of the 1997-98 haze crisis on foetal, infant and child mortality showed that the air pollution led to 15,600 fewer children being born in Indonesia (Jayachandran, 2009). During the El-nino drought of July-September 2015, more than 100,000 fires occurred in Indonesia, burning approximately 2.6 million ha of plantations, forests and peatlands throughout Sumatra, Kalimantan and Papua regions. An estimated 1.75 billion tonnes of carbon dioxide equivalent were released in just a few months, more than Germany's or Japan's total annual emissions. Daily emissions during the peak weeks of the fires exceeded the daily fossil fuel emissions of the entire USA economy (Harris *et al.*, 2015).

The fires created a smoke and haze crisis affecting all of Southeast Asia, triggering national emergencies across Indonesia and into Singapore, Malaysia and other countries, resulting in diplomatic tensions between Indonesia and its neighbouring countries. The human cost was high with 24 people directly dying during the fires and more than 500,000 cases of respiratory tract infections being reported. It was estimated by Koplitz *et al.*, (2016) that the fires and smoke may have led to more than 100,000 premature deaths in the region (up to 91,600 people in Indonesia, 6,500 in Malaysia and 2,200 in Singapore) because of exposure to fine particle pollution (PM2.5). The smoke haze crisis caused schools to close around the region and shut down air transport. The World Bank (World Bank, 2016) estimated that the damage to the Indonesian economy at around US$ 16 billion (IDR 221 trillion), equivalent to 1.9 percent of Indonesia's gross domestic product (GDP).

Drained peatlands are susceptible to fire as dry peat is highly inflammable (see Figure2-26). The magnitude of industrial-scale plantations led to large areas of drained peatland. In combination with natural and climate change induced droughts, these provide the fuel for catastrophic fires. As peatland burns with low oxygen levels and hence burns incompletely it leads to thick smoke haze formation. Development of large plantations has become one of the major drivers of fires and led to haze episodes of disastrous proportions. Emissions from peat-based fires also contain a myriad of Volatile Organic Compounds (VOC's) with additional health and environmental impacts, including nitrogenous compounds of ammonium and hydrogen cyanide, the concentration of which increase in areas where fertilisation has occurred (e.g. clearance of oil palm areas) (Smith *et al.*, 2018). Recent findings have also shown a link between higher bulk density peat (i.e. from degraded peat) and an increase in the more powerful GHG, Methane, during fire events (Smith *et al.*, 2019; Samuel, 2019 pers. comm.). As such, fires on previously cultivated areas, have a greater potential for environmental and health impacts.

Figure 2-26: Degraded peatlands next to plantations are susceptible to fire (Photo taken adjacent to Klias Forest Reserve, Sabah, Malaysia).

Encroachment/Unsustainable Extraction of Timber and NTFP

Typically, infrastructure and access to a peatland area may be improved as a result of the establishment of plantations. The need to ensure good transport (whether ground or water) for the palm oil crop means that access for migrants or local people to the edges of remaining PSF increases significantly. This presents an opportunity for either opportunistic or externally driven illegal actions including logging (which further increases the risk of fires), poaching, unlicensed fisheries, destructive fishing or other extraction of forest products without due permission. The presence of communities adjacent or within plantations often adds complexity to ensuring sustainable and fair use of the forest resources.

3.0 MANAGEMENT OF EXISTING PEAT SWAMP FOREST AREAS IN OR ADJACENT TO OIL PALM PLANTATIONS

3.1 INTRODUCTION

The conservation and management of existing peat swamp forest (PSF) areas in or adjacent to oil palm plantations is crucial to avoid the impacts of degradation as mentioned in **Chapter 2**, as well as saving the time and resources required to rehabilitate these areas if they are later degraded.

The following are examples of areas that are recommended to be identified, managed and enhanced as conservation areas within plantations on peatlands:

- Areas of intact peat swamp forest;
- HCV areas on peat;
- Riverine vegetation and areas in prescribed riparian buffer zones;
- Buffer zones adjacent to intact peat swamp forest;
- Central portion of peat dome area (kubah gambut, Padang Raya);
- Edges/shoulders of dome (in Sarawak with Alan Forest);
- Areas close to drainage base hence with flooding risks;
- Areas that cannot be drained using gravity or areas identified through drainability assessment as facing future gravity drainage constraints;
- Wildlife corridors (to avoid human-wildlife conflict and conserve biodiversity);
- Any remaining areas of peatland in the plantation/concession areas after November 2018 (designated as peatland conservation areas in line with P&C 2018);
- In Indonesia:
  a. Areas of peat identified as being in the conservation zone of the peatland hydrological unit (PHU) or Kawasan Hidrologis Gambut (KHG) – i.e. areas covering at least 30% of each KHG, areas of importance for biodiversity conservation and all areas deeper than 3m (in line with Indonesian regulations – PP71/2014 and PP57/2016);
  b. Areas of peat underlain with potential acid sulphate soils or infertile quartz sands (where development is not permitted according to Indonesian regulations);
  c. Areas identified as protection forest (hutan lindung);
- In Malaysia: areas specified as Environmentally Sensitive Areas (ESA) Class 1 or 2.

3.2 MAINTAINING THE INTEGRITY OF PEATLAND HYDROLOGICAL UNITS

Peatlands are wetland systems in which water is critical to the ecosystem integrity and health. Peat is 90% water and every portion of a peatland is connected to the rest of the peatland through the water. Changes in the water regime through drainage or flooding in one portion of the peatland will impact the peatland in other portions of the system. Each peatland occurs in a Peatland Hydrological Unit (PHU) or Peatland Basin which comprises any continuous area of peat together with the adjacent mineral soil leading to the nearest river or water body. Maps identifying Peatland Hydrological Units in the whole of Indonesia are available from the Ministry of Environment and Forestry (See **Figure 3-1a** and **b**). Maps of independent peat basins/domes (a similar concept) have been prepared for Sarawak (See **Figure 3-2**).

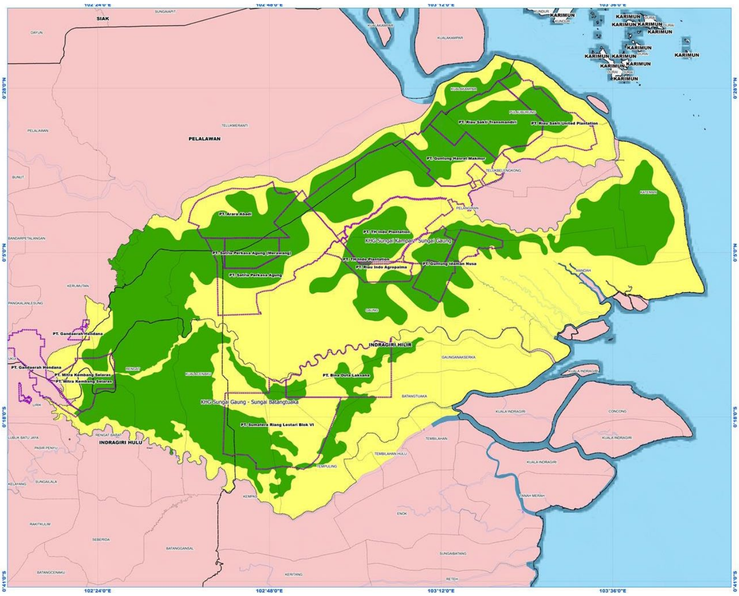


Figure 3-1a: Map of Peatland Hydrological Unit Sg Kampar to Sg Gaung, Riau province showing conservation area (green) and potential utilisation area (yellow) from Atlas for SK 130. (Source: Ministry of Environment and Forestry Indonesia, 2017)

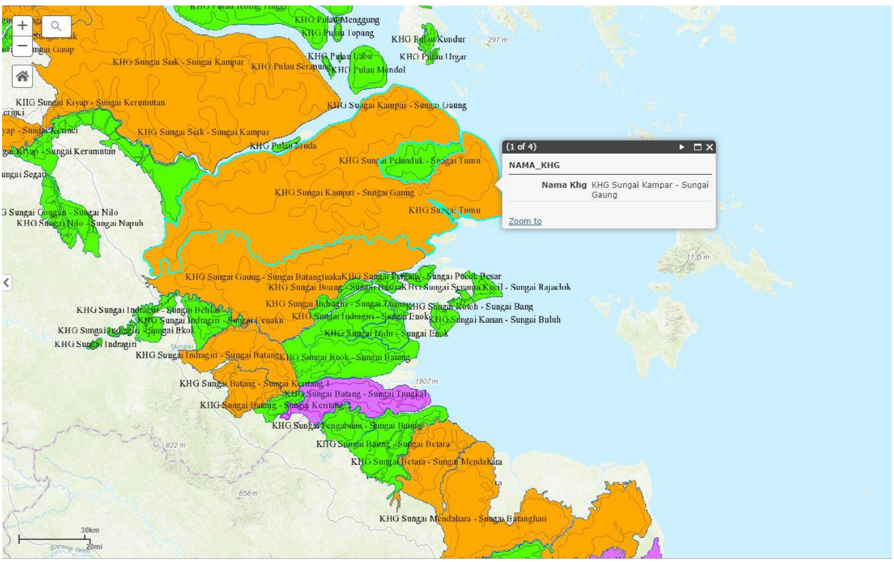


Figure 3-1b: Map of online data base on Peatland Hydrological Units (Source: Ministry of Environment and Forestry Indonesia, 2017)

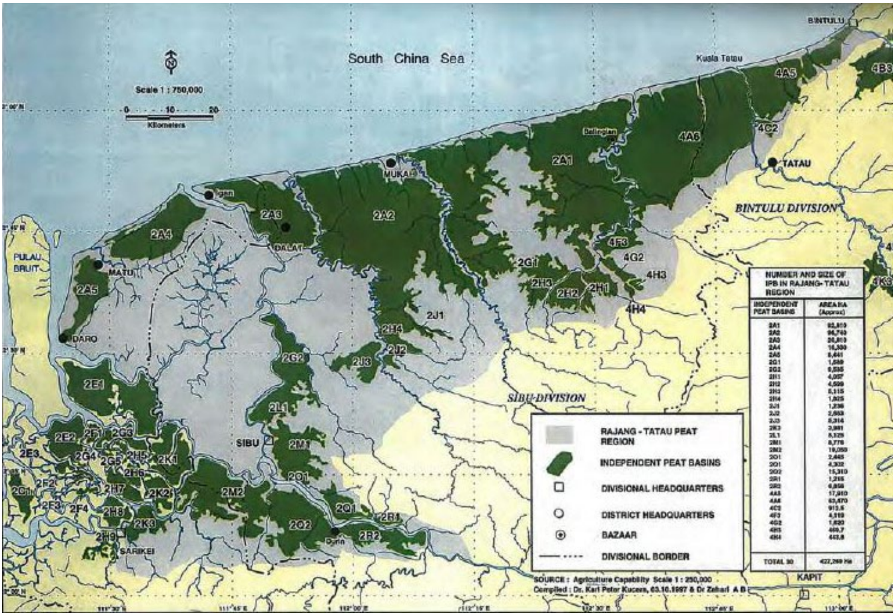


Figure 3-2: Map to show independent peat basins/domes in Central region of Sarawak (Source: Academy of Sciences Malaysia, 2018)

For the management and rehabilitation of peatland it is essential to understand the location and nature of the area in relation to its respective peatland hydrological unit. Understanding the connection between any proposed conservation or restoration site and the conservation status and hydrology in the remainder of the PHU is important to enable a sustainable management strategy to be developed. For example, if the area to be conserved is also being drained by nearby plantations or by canals dug for transportation or logging in the same PHU – then the restoration may not be viable in the long-term without consultation with other stakeholders and adjustment of the overall drainage patterns. **Figure 3-3** shows a 3D model for PHU for the Kampar Peninsular (showing clearly the central dome) which covers about 700,000 ha. The Central portion comprises forest and the periphery is plantations. A network of canals (blue) for logging and transport is cut into the forest area (green). Companies with plantations around the edge of the forest need to work together with an integrated approach to address the water management. If, however an area to be conserved comprises several peatland hydrological units – separated by rivers on mineral soil – then the management for each unit can be planned independently as activity in one will not directly impact the other. This logic does not apply however to basin peatlands as water from one portion of the peatland will flow into adjacent portions across the river as the peat is at a similar or lower level to the river.

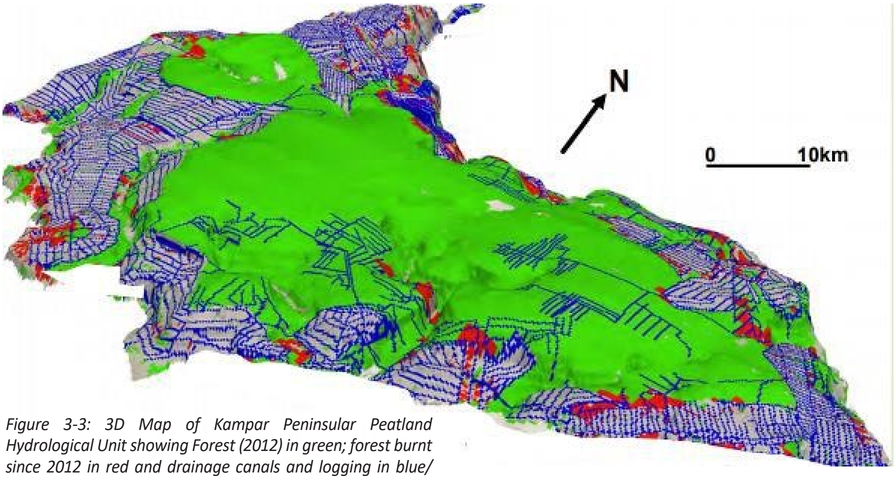


Figure 3-3: 3D Map of Kampar Peninsular Peatland Hydrological Unit showing Forest (2012) in green; forest burnt since 2012 in red and drainage canals and logging in blue/ black (Source: Wardhana, B., 2016)

3.3 INTEGRATED MANAGEMENT OF PEATLANDS

Based on an understanding of the peatland hydrological unit and landscape, it is important to develop an integrated management strategy or plan for the proposed restoration or conservation area or the entire PHU in which it sits. This can guide the overall approach for the long-term sustainable management of the peatland landscape into which individual stakeholders can link their individual efforts to support peatland conservation and rehabilitation.

Key principles for integrated management of peatlands are given in the guidelines for Integrated Management Planning for Peatland Forests in Southeast Asia (D'Cruz, 2014) as follows:

1. Recognition of the critical function of tropical peatland forests in retaining and distributing water across the river basin landscape;
2. Recognition of the complex interaction of climate, hydrology, geology, ecology and time on the creation and evolution of peatland forests in the tropical region;
3. Recognition of the need for inter-disciplinary collaboration and coordination when working towards integrated management planning;
4. Recognition that good will, compromise and communication among stakeholders will be invaluable in the pursuit of a complex and dynamic result – healthy, functioning peatland forests that approximate natural systems as best as current knowledge and capabilities allow;
5. Recognition that best practices will evolve with continued research, monitoring, and adaptive management.

As a matter of 'good practice', planners and managers need to build these cross-cutting principles into all components of their work, to ensure that the coordination and coherence required for effective results are actually achieved. In addition to these principles, there are 13 key elements that define a successful integrated management planning process for peatlands as in **Table 3-1**.

Table 3-1: The key elements of a successful integrated management planning process for peatlands.

ELEMENTS	CLARIFICATION
Jurisdiction	Management authorities and jurisdiction of government departments and agencies are acknowledged and affirmed.
Recognition	Existing agreements and commitments are recognised.
Cross-sectoral cooperation in policy development and implementation	All of the public sector agencies with responsibilities for activities or policies that influence land, water and peatland forests should commit themselves to cooperative processes of consultation and joint setting of policy objectives, at national level as well as at river basin level.
Equity in participation and decision-making factors	There should be equity for different stakeholders in their participation in management decisions related to peatlands.
Consensus	Decisions and recommendations are made by consensus and the process includes mechanisms for dispute resolution.
Accountability for decisions	Decision-makers should be accountable. If agreed procedures are not followed or subjective decisions can be shown to be contrary to the spirit of the above principles, then decision-makers should provide a full explanation. Stakeholders should have recourse to an independent body if they feel that procedures have not been followed.
Transparency in implementation	Once plans, procedures and management decisions have been defined and agreed, it is important that they are seen to be implemented correctly.
Clarity of process	The process by which decisions are made should be clear to all stakeholders.
Flexibility of management	It is essential that an adaptive management strategy be adopted, which requires plans that can be changed as new information or understanding comes to light.
Efficiency	The process respects and strengthens existing approaches, facilitates cooperation and collaboration and avoids overlap and duplication, with issues being addressed in a timely manner.
Credibility of science	Scientific methods used to support management decisions should be credible and supported by review from the scientific community.
Precautionary Principle	Decisions made are taken with due diligence to the risks identified.
Sustainability as a goal	Adequate protection from the impacts of land and water uses should be provided, respecting the natural dynamics of the ecosystem for the benefit of future generations.

Integrated management plans have been prepared for a number of sites in Malaysia including North Selangor Peat Swamp Forest (Selangor Forestry Department, 2014), Southeast Pahang Peat Swamp Forest (Pahang Forestry Department, 2008), Management Plan for Loagan Bunut National Park, Sarawak (Sarawak Forestry Department, 2008), and Klias Forest Reserve, Sabah (Sabah Forestry Department, 2007). **Box 3-1** provides information on the North Selangor Peat Swamp Forest.

BOX 3-1

Integrated Management Plan of North Selangor Peat Swamp Forest

The North Selangor Peat Swamp Forest (NSPSF) is situated on the west coast of Peninsular Malaysia about 50km Northwest of Kuala Lumpur. It is the largest remaining peat swamp forest in the west coast of Peninsular Malaysia. It is located on a flat coastal plain in the north western part of the State of Selangor and covers an area of 81,304 hectares (slightly bigger than Singapore). Before being constituted as forest reserve in 1990, the forests were state lands and have been selectively logged on a rotational basis. The first logging operation started about 65 years ago. **Table 3-2** gives details of the NSPSF which is made up of four Forest Reserves.

Table 3-2: Total area of North Selangor Peat Swamp Forest as included in formal gazettement documents.

FOREST RESERVE	SIZE (HA)
Raja Musa Forest Reserve	35,656
Sungai Karang Forest Reserve	37,417
Part of Bukit Belata (Extension) Forest Reserve	4,342
Sungai Dusun Wildlife Reserve / Sungai Dusun Forest Reserve	5,091
Total	**81,304**

The forest plays a critical role in the economy and ecology of the region – providing non-timber forest products (NTFP) and playing a key role in flood control and water supply to adjacent areas (e.g. Tanjung Karang Rice Schemes and towns such as Tanjung Karang, Sekinchan and Sabak Bernam), as well as playing a very significant role of global importance in storing huge amounts of carbon in the soil and acting as repositories for unique and important biodiversity.

The Integrated Management Plan (IMP) covers the period of 10 years from 2014 – 2023. The proposed overall management objective for the plan is "To maintain the geographical extent and integrity of the North Selangor Peat Swamp Forest to sustain and rehabilitate the functions of the ecosystem as provider of goods and services for the benefit of the local and global communities." The Specific Objectives of the Management Plan are as follows:

1) Re-establish the hydrological functions and the natural water balance of the NSPSF;
2) Prevent all fire occurrence and associated haze in and adjacent to NSPSF;
3) Restore the forest ecosystem of NSPSF by encouraging natural forest regeneration and where necessary supplement with planting in severely degraded sites;
4) Establish a buffer zone of at least 500m width along the entire outer boundaries of the NSPSF to minimise impacts of activities in adjacent areas;
5) Develop and promote sustainable use of NSPSF including eco-tourism, harvesting of NTFP, recreation and environmental awareness, education and research;
6) Promote conservation of peatland biodiversity and ecosystem functions;
7) Maintain and enhance carbon stock, minimise GHG emission and develop options for carbon financing; and
8) Promote multi-stakeholder participation in the implementation of the IMP.

Approach

The IMP was prepared using a participatory approach. The preparation was guided by the Selangor State Forestry Department and Forestry Department of Peninsular Malaysia with technical assistance from the Global Environment Centre. Five stakeholder consultations were organised at state and district levels between November 2013 and June 2014 to enable inputs to be provided by a broad range of state and local stakeholders. Stakeholder participating in the meetings included respective District Offices and District Township Councils (Kuala Selangor, Hulu Selangor and Sabak Bernam), Department of Wildlife and National Park, Economic Planning Unit , Federal Department of Town and Country Planning Peninsular Malaysia, Fire and Rescue Department, Minerals and Geoscience Department, Malaysian Palm Oil Board, Public Work Department, Department of Environment, Department of Veterinary and Services, Selangor Agriculture Development Corporation, FELDA, LUAS, IADA, Kumpulan Darul Ehsan Bhd, Kumpulan Semesta Sdn Bhd., Sime Darby Plantation and Peers Consult (M) Sdn Bhd.

Landuse

NSPSF is surrounded by state land and private land that is largely cultivated for agricultural purposes (see **Figure 3-4**). The main land-uses adjoining the forest reserve are Tanjung Karang Rice Irrigation Scheme to the southwest and west, sand and clay mining in the south and the oil palm plantations in the southeast and north. The forest is separated from the irrigation scheme to the southwest by the Main Irrigation Canal whereas the Bernam River forms the northern boundary. Sungai Tengi acts as the natural divider between Sg Karang Forest Reserve and Raja Musa Forest Reserve. NSPSF is under the jurisdiction of three administrative districts in Selangor State, namely Kuala Selangor District, Sabak Bernam District and Hulu Selangor District.

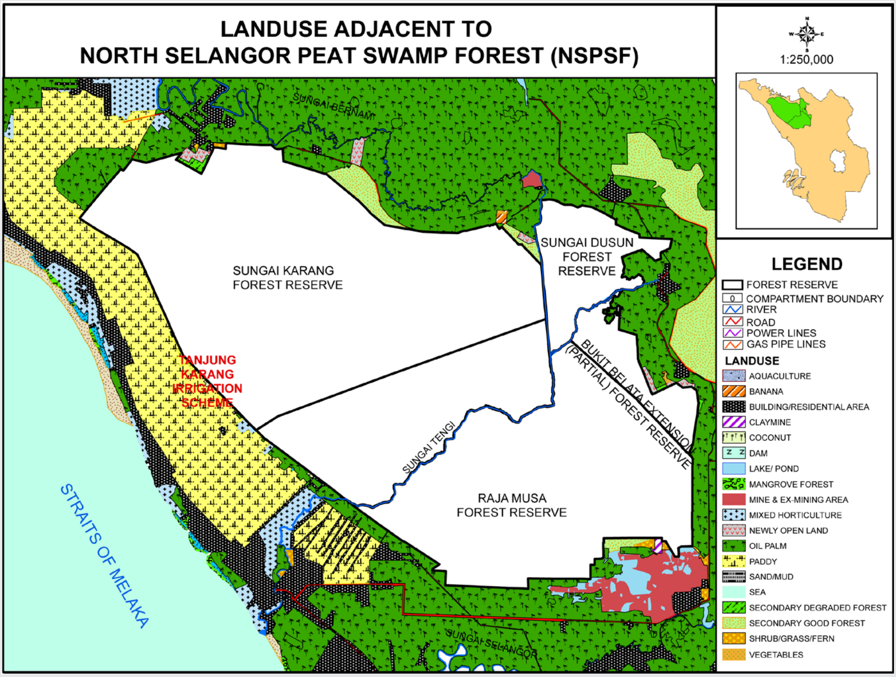


Figure 3-4: Landuse adjacent to North Selangor Peat Swamp Forest (NSPSF) (Source: IMP-NSPSF, 2014).

Forest Degradation

Over the last 30 years, large portions of NSPSF had been degraded due to a few factors including: widespread commercial logging, illegal land clearing, drainage and fires. The combination of these factors has resulted in large areas of NSPSF – close to 20,000 hectares being degraded, although degree of degradation varies greatly from site to site. At the southern portion of NSPSF, most areas had been burned repeatedly that the area had been severely degraded, it is largely void of trees and only covered in grass/ lalang (*Imperata cylindrica*). If no mitigating measures are taken to rehabilitate these areas, they may degrade further as the risk of future fires is very high. Therefore, priority should be given to rehabilitate these severely degraded areas.

Management Zones

The studies and inventories conducted showed the relative importance and degradation of different parts of the forest. Based on this and management requirements, the Forest Resources were divided into seven categories of zones each requiring different management (see **Figure 3-5**) as follows: i) Biodiversity Conservation (25,027ha); ii) Water Catchment Forest (22,594ha); iii) Rehabilitation Zone (18,547ha); iv) Recreation, Eco-tourism and Education (8,299ha); v) Sg. Dusun Wildlife Reserve (5,091ha); vi) Agro-Forestry Zone (1,521ha) and vii) Community Forestry (226ha).

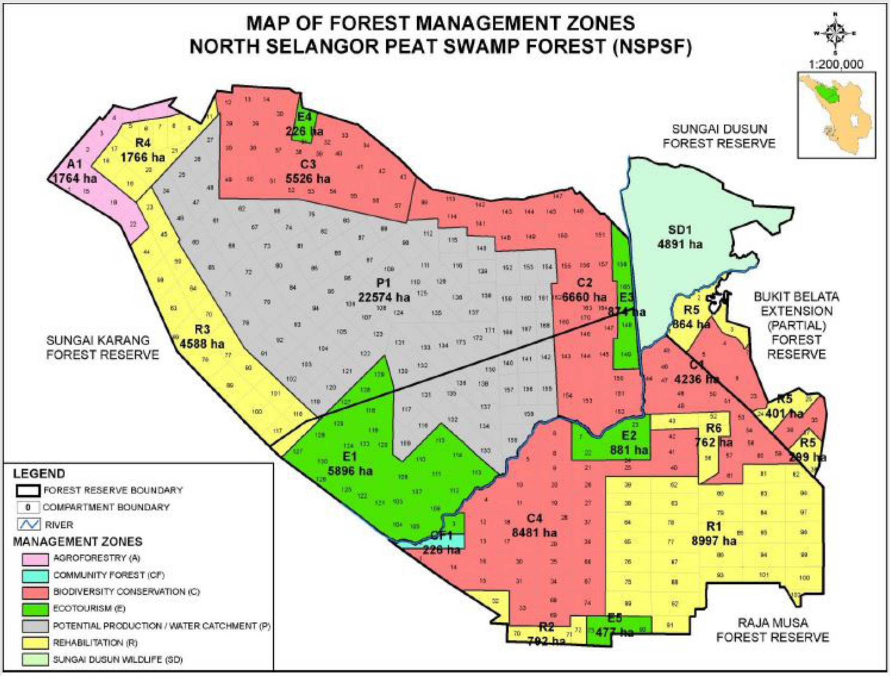


Figure 3-5: Map of Forest Management Zones of North Selangor Peat Swamp Forest

Forest Fire Prevention

Portions of the forest have been persistently impacted by fire over the past 20 years with about 6000 ha being affected. Based on an analysis of the frequency, extent and root causes of the fires a Fire risk map was developed as in **Figure 3-6**. The high risk zones were highlighted to the related stakeholders and action initiated to reduce the fire risk and enhance control measures. In addition, a Cooperative Fire Management Plan was developed as a subset of the IMP. This enables multiple agencies, private and community teams to join together during fire prevention and suppression efforts to support each other. Following the adoption of the IMP and cooperative fire management plan the extent of fire has been reduced from 1500ha in 2014 to less than 10ha in 2018.

Cooperative Fire Management Plan

A Cooperative Fire Management Plan (CFMP) is a subset of the IMP. It provides details and recommendations on fire prevention strategies, fire preparedness strategies, fire response strategies, recovery post fire strategies and proposed a budget for five years related to the CFMP for NSPSF. Essentially, the CFMP for NSPSF provides a list of strategies and action that must be carried out and implement at different times of the year, and a list of equipment and tools required for preparedness and suppression. Any fire management measures without addressing underlying causes would be irrelevant.

The plan is divided into three components, the first being the development of fire management strategies. Secondly, a resource planning budget is developed at a high level to provide guidance toward the costs of implementing the plan across the site. Thirdly an implementation plan has been prepared for both the prevention and suppression components. The implementation plans are in the

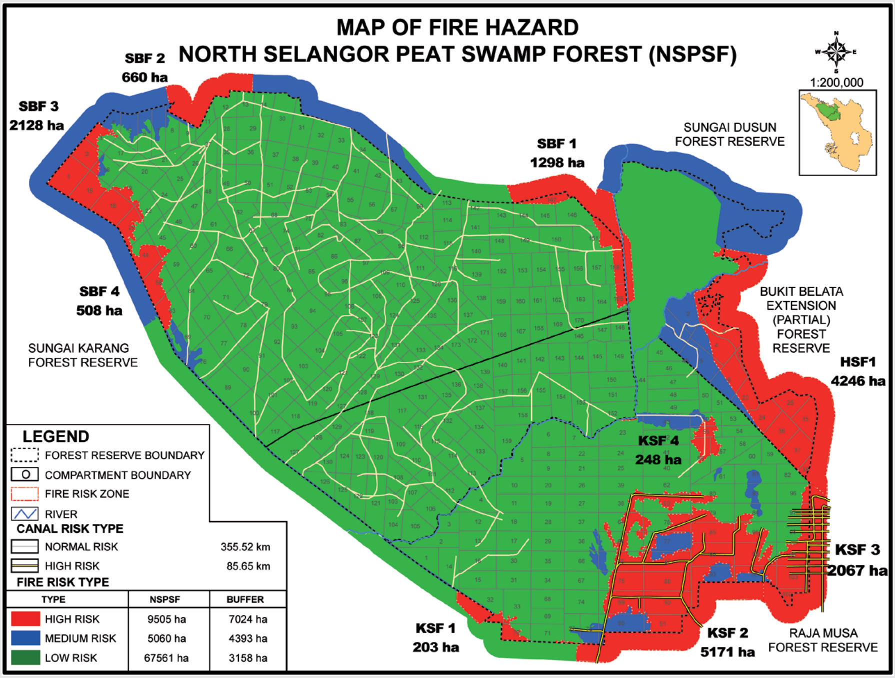


Figure 3-6: Fire Risk Map of NSPSF showing low (green) medium (blue) and high (red) risk areas.

form of a single A3 page with attached map and it is expected that they will be updated on an annual basis to reflect changes and features that are to be implemented across the coming 12 month period.

Preparation of the CMFP provides a consistent framework to define the principles and strategies to meet the primary objectives for the site while the implementation plans will define activities to better manage prevention, preparedness and response actions to be taken by agencies, communities and private sector participants. With this contextual appreciation in mind, the overriding objective within the actions and activities of this plan is to prevent any fire from igniting within the site, and if it should ignite, to respond rapidly to minimise the overall area burnt and costs of fire suppression.

Rehabilitation Plan

The degradation of the NSPSF is primarily caused by drainage and fires and so rehabilitation efforts should be focused on tackling these root causes. Hydrology restoration and fire prevention hold keys to the success of any rehabilitation efforts. Once these 2 factors had been addressed then only the third step, re-vegetation can take place. If not, the planted trees could be destroyed by fires and years of effort wasted. In short, rehabilitation can be summarised into 3 important steps: hydrological restoration; fire prevention and re-vegetation.

Drainage canals of NSPSF

Based on field observations and the Landsat 8 ETM satellite data as well as high-resolution satellite data (Worldview) from Google Earth, FRIM (2018) estimated 698km of ex-logging and agricultural drainage canals in the NPSPF (**Table 3-3**). **Figure 3-7** below shows the extensive networks of the canals across both the Sungai Karang FR and Raja Musa FR.

Table 3-3: The length of ex-logging and agricultural drainage canals network existing in the NSPSF (Source: Selangor Forestry Department, 2017)

FOREST RESERVE	CANAL LENGTH (KM)
Raja Musa Forest Reserve	289
Sungai Karang Forest Reserve	395
Sungai Dusun Forest Reserve	6
Bukit Belata (Extension) Forest Reserve	7
Total	**697**

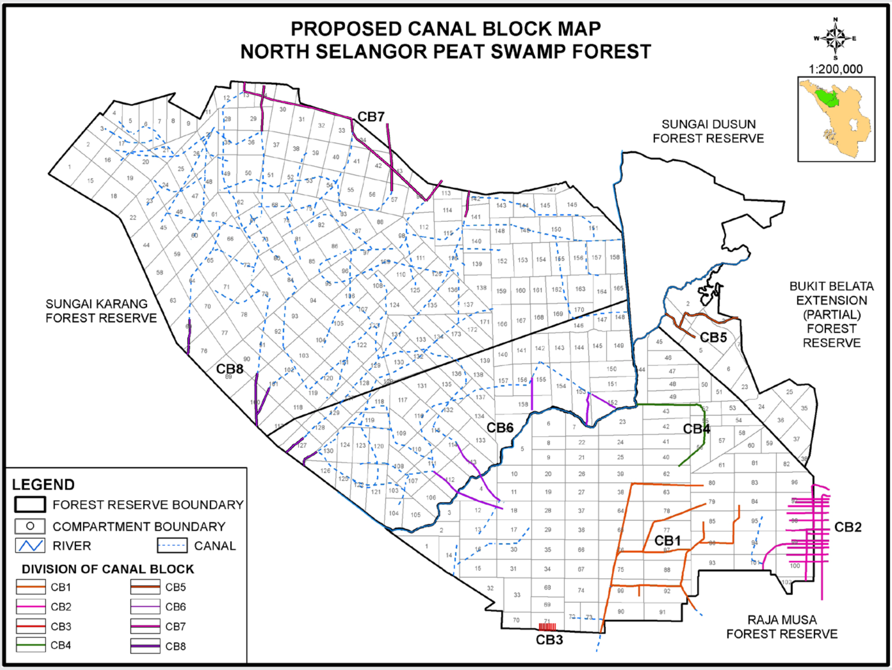


Figure 3-7: Network of drainage channels in NSPSF and priorities for blocking

Buffer Zone Management Plan

The NSPSF has been identified as an Environmentally Sensitive Area Class 1 (ESA 1) according to the National Physical Plan 2020 and Selangor State Structure Plan 2020, published by the Federal and State Department of Town & Country Planning. The government has defined the entire area of the NSPSF as an ESA Class 1 and 500m buffer area surrounded the NSPSF has been defined ESA Class 2 surrounding the ESA Class 2 is a further 500m buffer of ESA Class 3 given a total buffer zone of 1km width (see **Figure 3-8**). The management of the ESA is to be guided by the following criteria:

- **ESA Level (Rank 1):** No development, agriculture or logging shall be permitted, expect for low impact nature tourism (eco-tourism related activity).
- **ESA Level (Rank 2):** No development or agriculture. Sustainable logging and low impact nature tourism may be permitted subject to local constraints.
- **ESA Level (Rank 3):** Controlled development where the type and intensity of the development shall be strictly controlled depending on the nature of the constraints.

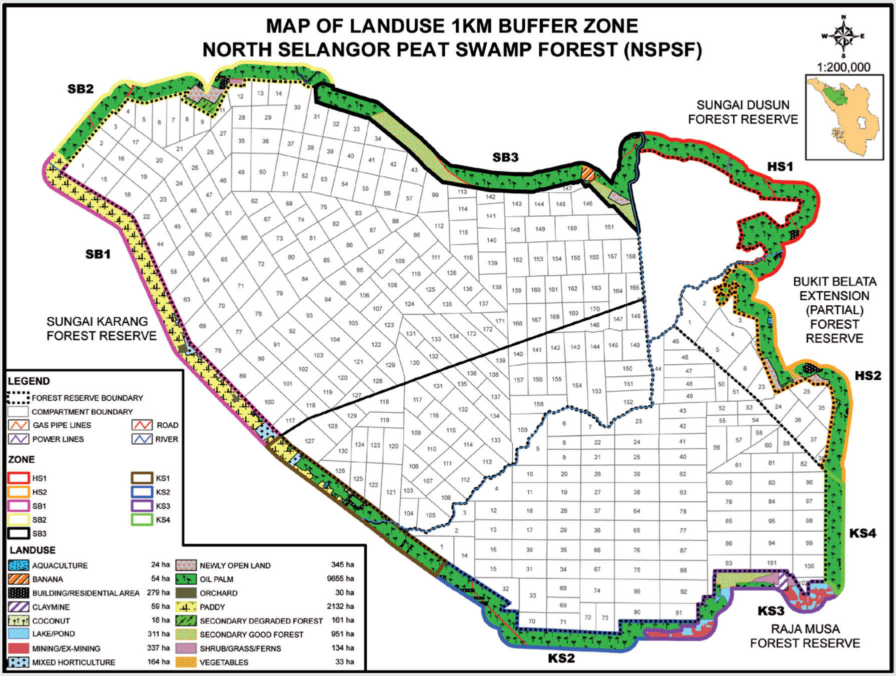


Figure 3-8: Landuse map of 1km buffer zone area of North Selangor Peat Swamp Forest

3.4 REWETTING AND REVEGETATION MANAGEMENT OF NATURAL HYDROLOGICAL REGIME

The proper management of the hydrological regime is critical to the success of any conservation or rehabilitation measures on peat. There should not be any artificial drainage in peatland areas identified for conservation as this will ultimately lead to degradation and/or loss of peat. In the areas of plantation bordering peatland conservation areas, the water table should be maintained as high as possible to minimise the effects of drainage from the plantation area into peatland (off-side impacts). If replanting is required as part of rehabilitation, only indigenous peatland plant species that are tolerant to high water tables and do not require any drainage should be used. The emphasis should be on hydrological restoration rather than or at least in parallel to any replanting programmes.

3.4.1 SYSTEMATIC BLOCKING OF CANALS AND DITCHES

One activity that greatly impacts adjacent areas during the development of oil palm plantations on peatlands is the digging of canals and ditches in these areas. This often occurs during the timber removal or land clearing phases, as timber may be extracted via canals and water tables may also be artificially lowered to allow access for heavy machinery. These peatland canals and ditches typically exit into main canals or rivers. When these canals and ditches are poorly constructed, large amounts of soil (fresh litter and peat) are intentionally or unintentionally discarded into rivers. This leads to changes in river morphology and water quality. Subsequently, this will have detrimental effects on aquatic life and biodiversity as well as the communities that depend on these resources. But the primary concern is that drainage via ditches and canals also results in the drying of the peatland, leaving the peat vulnerable to fire as well as subsidence of the peat. Drainage of oil palm plantations on peat also impact adjacent peatlands due to the high hydrological conductivity of the water in the peat soil (Wetlands International, 2016) (See Figure 3-9).

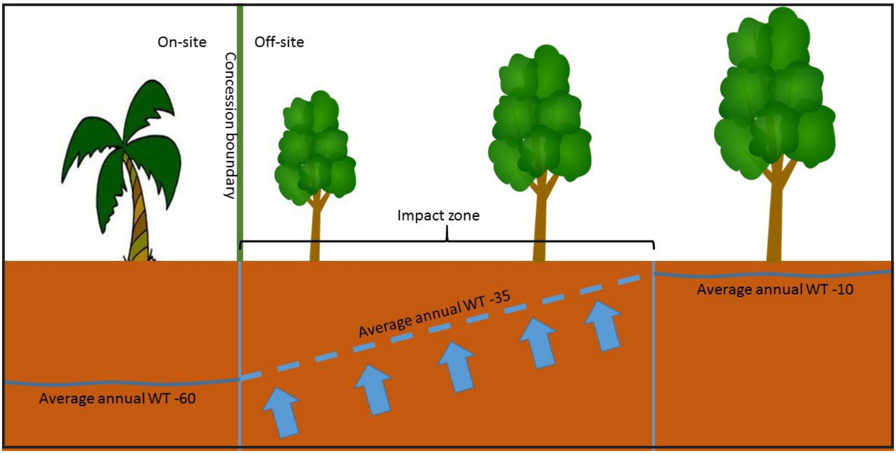


Figure 3-9: A simplified illustration of the impact of on-site drainage on hydrology of the surrounding area outside of the plantation (Wetlands international, 2016)

In some situations, oil palm plantations may wish to restore the hydrology of peatland ecosystems in and adjacent to their plantations through the systematic blocking of ditches and canals (see Figure 3-10 and Figure 3-11). By building blocks and dams, water and retention levels of peatlands can be increased and hopefully restored. 'A Guide to the Blocking of Canals and Ditches in Conjunction with the Community' published by Wetlands International – Indonesia in 2005 elaborates on methods of repairing the condition and hydrology of peatlands via blocking of canals and ditches. The following are important elements quoted from this Guide (Wetlands International – Indonesia Programme, 2005a):

Figure 3-10: Dam constructed to block a former logging canal to restore peat swamp water levels.

I. SITE IDENTIFICATION

- Study the existing drainage
- Review accessibility of site
- Risk assessment: submerging other lands, residential area
- Information source: maps, satellite images, drone survey, local community and authorities

II. GROUND ASSESSMENT

- Confirming suitable location for block
- Identify potential source of materials to be used (e.g. soil-bags, geotextile, soil, poles)
- Confirm design and construction process
- Secure stakeholder approval and identify stakeholder for involvement

III. START CANAL BLOCKING WORK

- Manual or machinery
- Consider access and safety

IV. MONITOR THE BLOCK

- Maintenance of the block
- Water table monitoring

Figure 3-11: Simplified process on blocking canal

3.4.2 GENERAL RECOMMENDATIONS FOR CANAL AND DITCH BLOCKING

Survey the location and status of canals/ditches: to map the bio-physical conditions of the canal/ditch and identify any potential socio-economic impacts on surrounding communities. Blocking activities should be socialised through consultation meetings with local community and government to secure their support or no objection. This involve clarifying the goals and usage of the blocked canals/ditches and address concerns about possible impacts.

Blocking technique: Blocking activities should start at the upstream side of the ditch/canal, working downstream. Distance between blocks should be minimised to allow more effective retention of water and decrease the velocity and head difference (the water level difference at each dam). Preparation and mobilisation of materials to the blocking site should be carried out at the end of the rainy season (or the beginning of the dry season). Construction of dams during the rainy season is difficult and requires additional labour. Large dams (more than 5m wide) have an increased risk of damage due to erosion of the peat layer on the sides and under the block.

Monitoring and maintenance of dams: Physical condition of blocks should be monitored at a minimum of once per month. Damaged or leaking block structures are issues need to be monitored and must be repaired immediately.

3.4.3 FURTHER RECOMMENDATIONS FOR CANAL AND DITCH BLOCKING

The following canal blocking strategies were developed based on the unique characteristics of peatlands:

- Peat has low bearing capacity, thus the dams should not create much head difference (difference between upstream and downstream water level in the canal);
- High permeability of the peat, thus dams cannot store much water, they mainly act as an extra barrier to flow (water retarders increasing flow resistance);
- Canals may also be used for navigation/transport by the local population. Therefore, consensus should be reached with the local people as to which canals can be considered inactive and thus can be blocked, and which canals remain active and therefore should not be blocked. Failure to reach consensus can result in ineffectiveness of the dam structures (Budiman and Wosten, 2009).

When constructing dams, the following aspects need to be considered:

- A cascade of dams is proposed to avoid too much head difference over the dam. Experience and the use of computer simulations with an unsteady-state simulation model show that head differences in relatively small drains, with an average width of 2m and an average depth of 1m, should be a maximum of 25cm height difference.
- Construction of a cascade of relatively simple dams with relatively short distances between the dams (for instance 300-500m) also reduces water velocity in the drains. In turn the limited water velocity stimulates sedimentation of mineral and organic particles to the upstream of the dam while also reducing erosion of the drains as well as of the dam.
- The blocking is best started at the upstream part of the canal to avoid too much discharge and thereby gradually decreasing the pressure on the dams constructed further downstream in the canals.
- Indigenous materials i.e. *Melaleuca* (gelam) poles, peat or soil bags etc. should be used to avoid excess load/weight. The principle behind this is that the ongoing consolidation of the peat layer under these structures should be approximately equal to the total unavoidable subsidence of the surrounding area. The practical consequence of this principle is that the overburden pressure should be very low (e.g. for a water table of 25cm, the overburden pressure should not exceed about 1,000 Pascals (kPa) or 100kg/m^2).
- Use of locally available material has the clear advantage of not only being practical and inexpensive but also means no new construction material needs to be transported to the dam building site.
- Considering the amount of dams needed to effectively conserve the remaining peatland, it is recommended to use wood sparingly to avoid deforestation and consider compacted peat dams or soil bag dams first as they use least wood. Compacted peat dams are significantly cheaper than wooden box dams. Experience in the Tahura Berbak National Park excavators was provided with logs (eg: coconut trunks) to move across peat to avoid sinking due to unavoidable construction during the wet season. Compaction proved possible, and dams were effective, judging from monitoring 6-12 months post construction.

- Dams should be designed in such a way that vegetation can easily re-grow thereby encouraging nature to take over with time. As indigenous materials i.e. peat above the groundwater level will oxidise and even gelam poles have a limited lifetime when they are not permanently water saturated, vegetation growth on the dam and in the blocked canal sections should be stimulated to ensure more permanent clogging up of the drainage system.
- The ultimate aim of a canal blocking system is to fill-in the drain with original peat forming vegetation thereby restoring the resistance to water flow in the peatland to its original value of hydraulic conductivity of peat of approximately for 30m/day. However, this process takes a long time (more than 20 years) (Budiman and Wosten, 2009).

It should be noted that canal blocking is fraught with difficulties and at best it is moderately successful. A much better and cheaper alternative is to avoid the need for dam construction in the first place, i.e. avoid canal and ditch construction in forested areas wherever possible.

Types of canal blocks

A broad range of types of canal blocks have been developed and used in peatlands as summarised in **Table 3-4**.

Table 3-4: Types of canal blocks for peatlands

CANAL BLOCK TYPE	DESCRIPTION	REMARKS
Compacted Peat Block	Blocks can be made from compacted peat excavated from adjacent areas. These can be constructed by excavators and need to be compacted by the excavator running over the top of the block or compressing it with its bucket (see **Figure 3-12** and **3-13**).	These blocks are relatively cheap and can be constructed fast provided that the site is accessible for excavators. Cost is relatively low (US$500-1000/block for a 8-10m wide canal and $100-200 for narrower drains), but need to be built close together as low head of 20-30cm should be maintained to minimise erosion of the block.
Sandbag Block	Constructed from sandbags or fertiliser sacks filled with mineral soil. Usually reinforced by a row of wooden posts (see **Figure 3-14** and **3-15**).	Suitable for narrower canals or drains or in remote sites without option of excavator access.
Earth-fill Block	An earth-fill block is constructed by excavator using mineral soil from adjacent areas. The edges may be protected from erosion by wooden poles and a layer of geotextile or sandbags (see **Figure 3-16**).	Used for medium or large canals close to source of mineral soil and access for excavator. May erode if no protection measures.
Geobag Block	Similar to sandbag block – these are made of bags made from geotextile – generally larger and stronger and more longer lasting compared to fertiliser sack or normal sandbag (see **Figure 3-17**).	Suitable for narrower canals or drains or in remote sites without option of excavator access but due to larger size and weight of bags – not so easy to move by hand.
Rock-fill Block	A rock filled block is constructed by excavator using a mixture of medium and small sized rocks and stones (see **Figure 3-18a**, **b** and **c**).	Used for large canals with high water head (difference in level across the block) – such as interface between forest and adjacent (subsided) peatland at lower level. Constrained by availability of rock and access for excavators in remote sites.
Timber-box Block	Similar to sandbag block but these are encased in timber planks to reduce impact of rain or water flow from eroding the block. Box may be filled with sandbags or earth fill (See **Figure 3-19**)	Suitable for narrower canals or drains or in remote sites without option of excavator access.
Plank Block	A simple and rapidly constructed block comprising a pole laid across the channel and a row of planks leaning against it. (See **Figure3-20**)	Suitable for small to medium canals. Can be quickly erected and removed. Can be enhanced with a tarpaulin sheet on the upstream face of the block to reduce leaks.
Water Gate	A permanent water gate may be appropriate in shallow peat where the gate can be anchored into mineral soils. (See **Figure 3-21**)	This type of structure is generally expensive and not appropriate for deeper peat sites where construction will be problematic and peat subsidence may make the gate not effective.
Multilayer Block	A block made from multiple block layers.	Example in **Figure 3-21** shows a double layer block with two large blocks combined to form 12m wide and 30m long block in 10m deep canal. The extra width and multiple cells give added strength.
Combination Block	A block made from a combination of the above features.	

Many of these types of blocks are illustrated in **Figures 3-12** to **Figure 3-22**.

Figure 3-12a (left): Compacted peat dam constructed in series of 5 along the 20+ metre-wide canal along the western side of the Tahura OKI (buffer zone of Berbak NP); these were constructed in the wet season Jan-Feb 2018 and were functioning well after 1 year (Photo courtesy of Mott MacDonald).

Figure 3-12b (below): A medium canal in conservation area in West Kalimantan blocked with compacted peat dam constructed by excavator.

Figure 3-13: Large canal blocked by compacted peat block (Source: Wardhana, B., 2016)

Figure 3-14: A medium-width ditch blocked with sandbags and wooden posts.

Figure 3-15: Sandbag block in large canal.

Figure 3-16: An Earth-fill Block made of wood, soil bags and earth fill in a medium-width canal

Figure 3-17: Geobag block

Figure 3-18a: Rock-fill dam in large canal in early late 2012, 2 months after construction

Figure 3-18b: Same rock-fill dam in 2014, one year after construction

Figure 3-18c (above): Same block seven years after construction. Note: Good recovery of trees on far side of block compared to Figure 3-18a.

Figure 3-19 (left): Timber Box Block for small canal (Source: Ministry of Environment and Forestry, Indonesia)

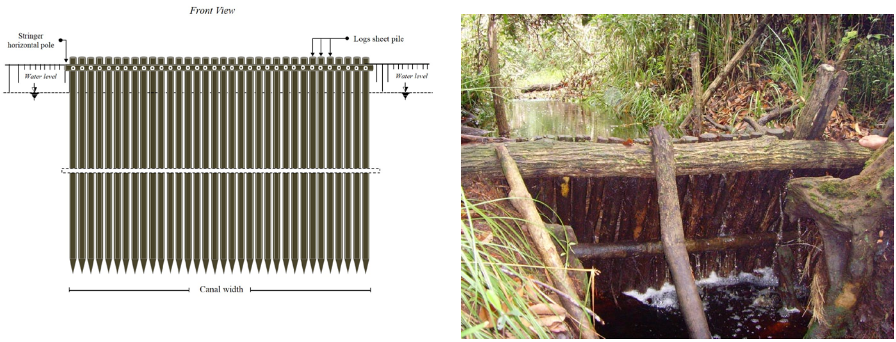


Figure 3-20: Plank Block in small drain. (Photo courtesy of Alue Dohong)

Figure 3-21: Multilayer block constructed in 2005 in abandoned primary inlet canal of the Mega Rice project Block AB in Central Kalimantan. Block is 30m wide and canal is 10 m deep. Main posts are 12-15 m long and inserted to mineral layer below the peat. 25,000 sand bags (wrapped in two large geotextile sheets) were used in the construction completed by hand by a team of nearly 100 workers over one month. (Photo courtesy of Alue Dohong)

Figure 3-22: Gabion and watergate with water being supplemented by adjacent tube well (Note: Gabion structure, with large rocks, is not appropriate as it lets water pass through the rocks and bypass the gate)

Spillways

It is important to design a proper spillway for the canal block to allow water to flow over or around the block in times of heavy rainfall. Water flowing over a block may lead to erosion of the block and its later failure. If water cannot flow over a block and there is a significant height difference above and below the block, it may erode a bypass channel around the edge of the block – negating the value of the block. In order to prevent these problems, it is important to consider the design of overflows or spillways. Spillways are of two main types – those that allow the water to directly flow over the block and those that divert water around the block. Spillway designs and materials vary as described in **Table 3-5**.

Table 3-5: Spillway types

SPILLWAY TYPE	DESCRIPTION	REMARKS
Sandbag or geobag spillway	Central portion of the block is lowered by removal of sand or geobags to permit water flow (see **Figure 3-14** and **3-17**)	Allowing overflow in centre may prevent side cutting of block – but also lowers the head of water maintained by the dam. Notch should be filled by sandbags in the dry season and removed only in wet season.
Wrapping with geotextile	Block can be wrapped with geotextile sheet to prevent erosion (see **Figure 3-23**)	Geotextile allows slow water seepage and helps maintain natural water levels
Wrapping with tarpaulin sheet	Sandbags can be wrapped with tarpaulin sheet to prevent degradation of the bags and erosion by water passing over the block (see **Figure 3-24**)	Plasticised tarpaulin does not allow water seepage. This may encourage too water to bypass block and erode edges.
Side-bypass channel	This type of spillway has been used by some plantations with boundary canals where some drainage may be needed to prevent flooding of adjacent plantation areas. (see **Figure 3-25**)	Use of bypass channel is not appropriate in conservation area as it will prevent full rewetting. In conservation area it is more appropriate to allow water upstream of block to over spill the canal banks and rewet the surrounding landscape.
Central wooden spillway	This design is often placed in timber box blocks to enable local people to use the canals for transportation and drag the boats through the spillway (see **Figure 3-26**).	Presence of large spillway partly defeats the purpose of the block to maintain high water levels. One option to address this is the place sandbags in the slot to be used to maintain water levels in the dry season.
Geotextile with vegetation planting	Planting of trees or other vegetation on top of the dam structure can help protect it from longer term erosion and contribute to overall restoration (see **Figure 3-28**).	Vegetation growth should be monitored. In short term vegetation growth may lead to breakage of geotextile – but in longer term will provide stability.

Figure 3-23: Geotextile wrapping of large block and central spillway to prevent erosion.

Figure 3-24: Sandbag block wrapped in tarpaulin sheet to prevent erosion when water flows over it

Figure 3-25a: Side-bypass spillways for compacted peat blocks – to allow excess water to bypass and not erode main block on canal. Note: bed of bypass is very shallow to enable easy blocking in dry periods. (Source: Wardhana, B., 2016)

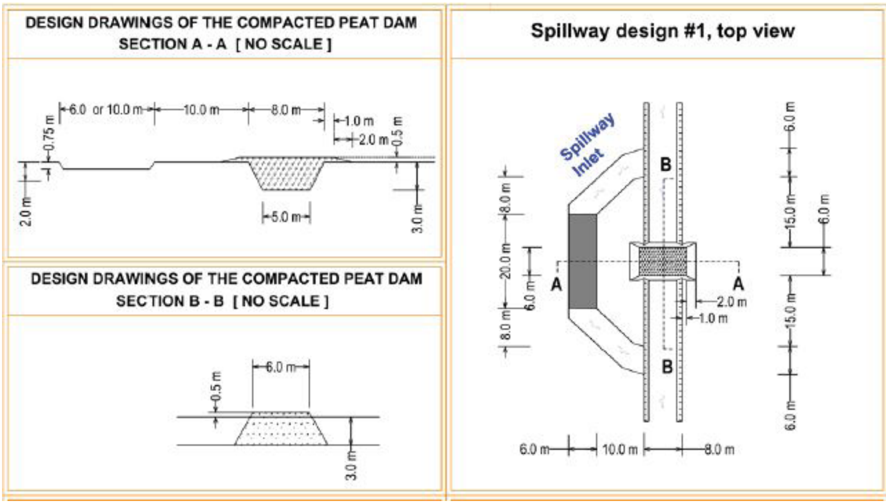


Figure 3-25b: Design for compacted peat block in large canal and associated spillway (Source: APP and Deltares, 2016)

Figure 3-26: Center overflow in timber box block to allow small boat to pass through (Source: Ministry of Environment and Forestry, Indonesia) (Note: Low level of this spillway means the upstream peat is not fully rewetted).

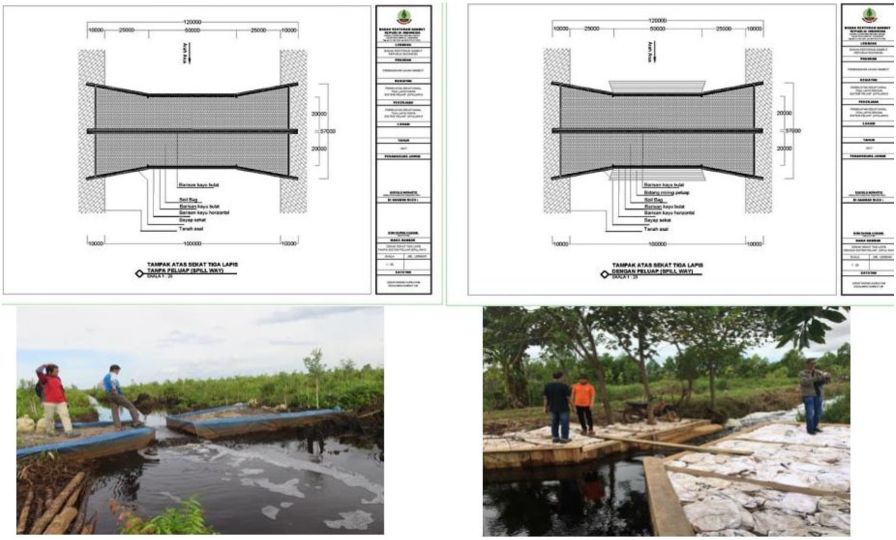


Figure 3-27: Block and Spillway design for medium block (Note: Relatively high level of spillway) (Source: BRG, 2018)

Figure 3-28: Sandbag block, topped by Geotextile and planted with trees (Source: Wardhana, B., 2016)

Box 3-2 includes a review of experience in canal blocking in the abandoned Mega Rice Project in Central Kalimantan, Indonesia. This project was developed in 1995-97 and involved the clearance and drainage of nearly a million ha and the construction of 4,600 km of canals for the development of a large rice scheme on deep (up to 15 m thick) peat (despite the fact that rice will not grow or produce grain on deep peat). The project was abandoned in 1998, before being operated, after 500,000ha of the land burnt in the 1997-98 El-Nino event.

Box 3-2

Practical canal blocking experiences in Central Kalimantan (Euroconsult Mott Macdonald *et al.*, 2008a)

Introduction

In Kalimantan as well as in other deep peat areas with similar conditions, several mainly non-governmental organisations (NGOs) have been active in blocking canals in order to raise the groundwater level and to rehabilitate the peat areas. This section gives an overview and evaluation of activities between 2000-2008 in Central Kalimantan mainly in the Ex-Mega Rice Project (Proyek Pengembangan Lahan Gambut, PLG) area. The information is based on interviews with members of the organisations involved, field observations, and a study of monitoring data and reports. Field visits were undertaken to collect specific information about the channel blocks and to evaluate their conditions and effectiveness in early 2008. The visits included the north-western part of Block A (Wetlands International dams), Block C (CIMTROP dams) and the Sebangau National Park (WWF structures). The main conclusions regarding each of the three areas are given below. It is noted that most of the larger canal blocks are all variants of the box dam, consisting of rows of wooden poles driven across the canal into the bed, with the space in between the rows filled up with soil bags.

CIMTROP (University of Palangkaraya)

The northern part of Block C and the north-eastern part of the Sebangau National Park, both deep peat areas, are research locations of CIMTROP. Since 2004 nine block structures have been built in the main canals with widths of up to 20m and another 50 smaller dams in secondary canals. The design and construction uses local expertise, labour, materials and equipment. The structures are rather light. Construction costs were in the order of Indonesian Rupiah (IDR) 25 million (US$2,500) per block. Several blocks were washed away in the rainy season. The actual lifetime of the blocks is short and they need to be replaced every 2-3 years. There are experiments to consolidate the blocking structures by means of vegetation.

CCFPI/CKPP/Wetlands International

Wetlands International carried out peat conservation activities under the CIDA-funded CCFPI Project (in partnership with Wildlife Habitat Canada and Global Environment Centre) and later under the CKPP Project in the north-west of Block A. The area is situated north of Mantangai, between the Kapuas and Mantangai Rivers. Between 2004-2010, twenty-six canal blocks were built with widths varying from 15 to 30m. The design of the structures was based on structural analyses, local experience and expertise. A local contractor built the structures in cooperation with the local community. Most of the materials were imported from outside the immediate area.

The structures were more robust than the CIMTROP structures. Poles were deeper and the dam body was wider. The canal flow was supposed to partly seep through the structures, and partly flow over the structure. Provisions to divert peak flows over the adjacent land have been added as well. In the later CKPP designs, the middle section of the dam is narrowed and equipped with wooden planks to facilitate pulling small boats over the dam, and so avoids people digging ditches for boat passage around the dam. The narrowing however generally tends to weaken the dam. Average costs were in the order of IDR 100 million (US$10,000) per structure. The expected lifetime was about 5-8 years, due to the use of timber, which degrades over time. Geotextile was used to limit seepage losses but after one year, many of the sheets were already torn. Vegetation was planted around the structure in an effort to let “nature take over” and gradually over-grow the canal.

Public Works Department (PU)

PU has not built any blocking structures in the peat conservation areas, but they are constructing many water control structures in the canals of the developed areas. The structures are mostly in the tertiary canals, 4 to 6m wide, and made of concrete, masonry or a combination of both. Some tests with fiberglass structures are ongoing. The structures serve to control rather than block canal flows, and are equipped with gates (i.e. stop logs, flap-gates or sliding gates). Without extensive bottom and side slope protection, seepage often develops below or besides the structure, and head differences of more than half to one meter can rarely be maintained for long periods, even though soils are predominantly (soft) clayey. Depending on their size, costs of the structures range from IDR 50 to 150 million (US$5,000-15,000). The structures are built by contractors. The large water control structures built in some of the primary canals by the PLG Project are mostly heavily damaged and beyond repair. Nevertheless, the remaining concrete foundations could possibly be incorporated in future blocking structures.

Evaluation and Lessons Learned

Valuable experience has been gained from past canal blocking efforts in Central Kalimantan, especially regarding the design of the blocks and how to construct these. Most of the structures are effective to create a water step, or head difference, in the canal, and they have been built with minimum material imported from outside the region. With the limited means available to the organisations who built them, much has been achieved. However, the large PLG canals were built by an enormous operation involving many large construction companies with dozens of heavy equipment and huge budgets.

The following conclusions and lessons learned are drawn from the Central Kalimantan experience:

- While it is effective to raise upstream canal water-levels, the effect of blocking on overall landscape groundwater levels may be relatively small in view of the fact that the canals have “eaten themselves into the land” and are now situated in small depressions. Nevertheless, raising the canal water is important to prevent further drops of the groundwater tables and reduce fires.
- The effect of each block extends only a few hundred metres or kilometres upstream, depending on the created head difference and the canal gradient. To raise the water-levels along an entire canal many more blocks with small head differences would be required.
- With the limited means available, it is tempting to try to create blocks with a big head difference to maximise the effect of the block. However, the bigger the head difference, the bigger the water pressure on the dam and the higher the seepage flows through or around the dam. With the materials and construction methods at hand, head differences of more than half a meter prove difficult to maintain.
- The Wetlands International built dams, especially the earlier CCFPI dams, appear to be the strongest, although also the most expensive. The later CKPP design is likely weakened by the narrower section in the middle of the dam. The structures should be deeply embedded in preferably the mineral subsoil to avoid instability.
- The expected lifetime of the dams is about 5-8 years. In many cases there is little sign of nature taking over by re-growth or sedimentation in the upstream canal, and new dams will soon need to be built. To promote re-growth in the canal, dam building may have to be combined with partial infilling of the upstream canal and planting of (water tolerant) tree species.
- Water flows over the dams damage the dam crests. The overflowing water takes away dam fill material and creates flow paths through the dam below the crest, hence reducing the head difference and effectiveness of the dam and threatening to further damage the dam.
- Seepage and piping through as well as below and around the dam is a serious threat and calls for small head differences over the dam, and long dam bodies. Dam fill material should preferably be clayey soil.
- The dams require regular inspection and a maintenance organisation capable of reacting quickly to repair small damage before such damage becomes bigger.

- Involvement of the local people in planning, design and construction of the blocks is important to gain their support, but is no guarantee that the dams will be safe from human intervention. Small bypass channels should be considered for dams in canals that are frequently used for transportation of goods or people. Planks provided for pulling boats over a lower section of the dam proved not very long-lasting. Providing alternative livelihoods for the local population could decrease their dependency on forest resources, but this is at best only a solution in the long term.

Experience from outside the region largely confirms the above conclusions. Small head differences over the dams and a large number of dams are essential to effectively raise water levels and to act as a safety precaution in case one or more of the dams fail.

For further technical details and guidelines on designing blocking strategies and structures as well as implementation, refer to Euroconsult *et al.*, 2008a.

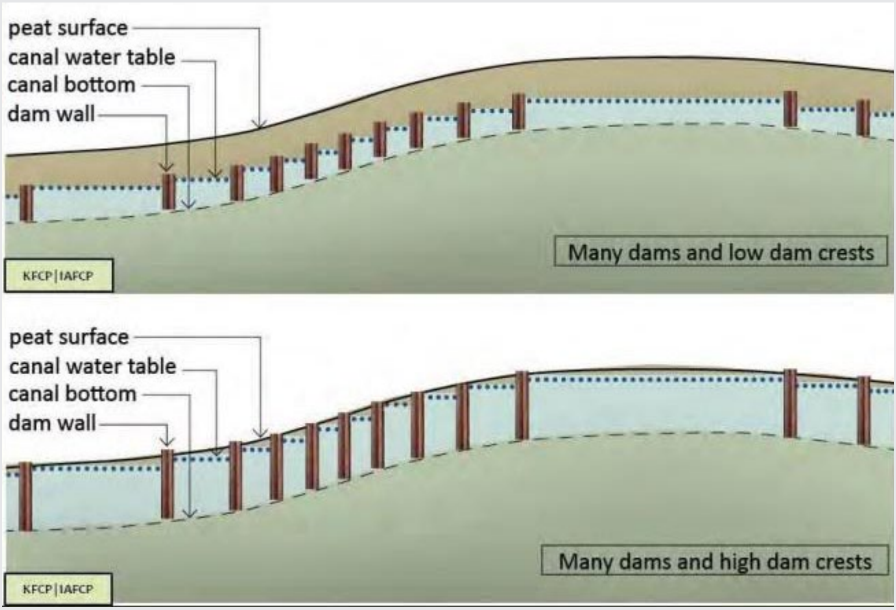


Figure 3-29: Importance of multiple dams with high crests in order to fully rewet the peat (Source: APP and Deltares, 2016).

Box 3-3 provides information on experience in blocking drainage canals in Sebangau National Park, Central Kalimantan.

Box 3-3

Rewetting of tropical peat swamp forest in Sebangau National Park, Central Kalimantan, Indonesia

Sebangau National Park is a 90,882 ha area peat swamp forest that was previously a Production Forest logged from 1970 to 1995. After 1995, illegal logging became rampant. Numerous canals were dug by illegal loggers to transport logs out of the peat swamp forest and these accelerated water-flow from the peatland, causing peat drainage and decomposition along with the release of associated greenhouse gases (GHG).

The WWF-Indonesia Sebangau Project was aimed at reducing the GHG emissions from peat decomposition, through rewetting the drained peatland, by constructing dams in the drainage canals. Construction of the dams began with pilot activities in 2004, and scaled-up these activities in 2008. By 2010, with funding support from two German sponsors, Deutsche Post and Krombacher, the project had built 434 dams in the Bakung, Bangah, and Rasau River sub-catchments in the eastern part of Sebangau National Park.

In addition to reducing GHG emissions, restoration of natural hydrological conditions is expected to result in the recovery of the peat swamp forest ecosystem in Sebangau. Rewetting the peat will support vegetation regrowth, enabling the recovery and expansion of wildlife populations including the endangered Bornean orangutan. The project area is an important orangutan habitat. A survey conducted between 2006 and 2007 showed a population of around 5,400 individual orangutans in Sebangau National Park.

Local communities have been involved in the project since its inception due to the importance of the project area for fishing and jelutung sap (wild rubber) collection. Three extended families in the nearby village of Kereng Bangkirai claim traditional management rights over the three Sub-catchments and for four generations families have depended on fishing in marshlands and tributaries of the Sebangau River for their livelihoods. Communities, especially the fishermen who fish intensively in the area, were consulted on the design of dams. In the canals which are frequently used for fishing and transporting jelutung sap the dam is made with a spillway, so that boats can still pass. Communities are also involved in the construction and maintenance of the dams.

(Source: WWF-Indonesia, 2012).

The experience of Sime Darby Plantations in raising water levels in boundary canals to enhance forest regeneration is given in **Box 3-4**.

BOX 3-4

Sime Darby Partnership Programme in conservation and rehabilitation of North Selangor Peat Swamp Forest

The North Selangor Peat Swamp Forest (NSPSF) is the largest peat swamp forest on west coast of Peninsular Malaysia (see **Box 3-1**). The forest plays a critical role in the economy and ecology of the region – providing non-timber forest products (NTFP) and playing a key role in flood control and water supply to adjacent areas (e.g. Tanjung Karang Rice Schemes and towns such as Tanjung Karang, Sekinchan and Sabak Bernam), as well as playing a very significant role of global importance in storing huge amounts of carbon in the soil and acting as repositories for unique and important biodiversity.

Administratively, the NSPSF is further divided into Raja Musa Forest Reserve (RMFR: 35,656 ha), Sg. Karang FR (SKFR: 37,417 ha), part of Bukit Belata (Extension) FR (3,140 ha) and Sungai Dusun Wildlife Reserve/ FR (5,091 ha). RMFR is located immediately north and west of Sime Darby's Bukit Talang and Tennamaram Estates. Here the FR has been continuously impacted by forest fires caused by illegal encroachment for agriculture activities and past unsustainable forestry practices. Such activities have caused excessive drainage making the peat susceptible to fire outbreaks especially during the dry season. Almost every year since 1992, there have severe fires which generate serious smoke haze affecting adjacent areas as well as much of the Klang Valley. Therefore, the prevention of peatland fires and haze, and reduction in GHG emissions from forest and peat degradation is a very important issue here.

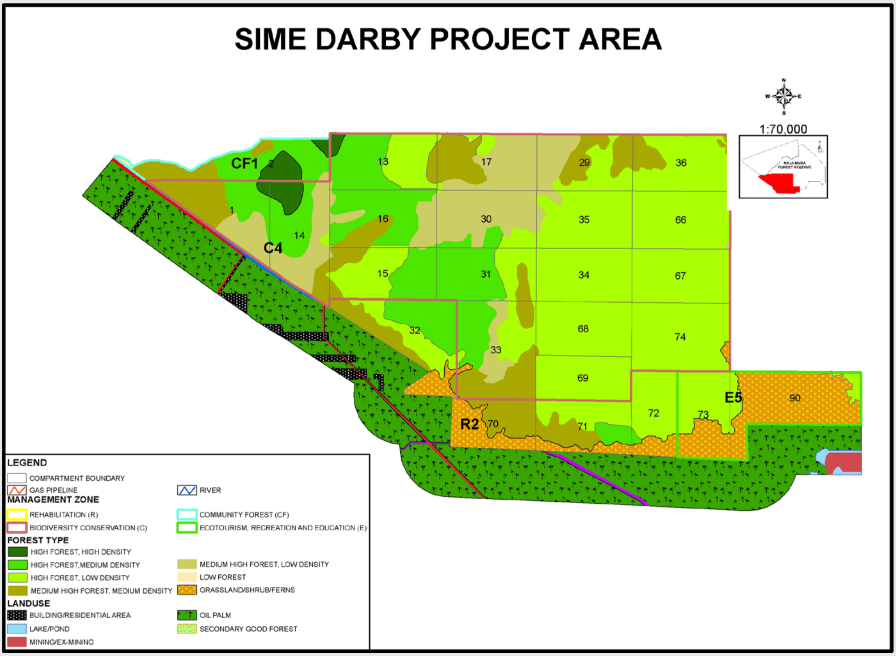


Figure 3-30: Map of site for Sime Darby Partnership Programme (in southwest corner of North Selangor Peat Swamp Forest)

A project was undertaken between May 2014 – May 2019 by Sime Darby Foundation and Global Environment Centre to strengthen the efforts for fire prevention and water management, rehabilitation and conservation of the RMFR (Forest Compartment 32 & 70) adjacent to Sime Darby Plantations - Raja Musa Division. The main activities undertaken between 2014-2019 included:

OBJECTIVE 1: PROJECT SITE DEMARCATION AND ASSESSMENT

a. Survey and marking of boundaries of the rehabilitation site/ degraded forest area

b. Placement of signboards highlighting initiative

c. Assessment and mapping of the existing vegetation, water levels and soil depths

d. Assessment of adjacent lands developed by communities to assess drainage, peatland and plantation (agronomic) management and fire risks

OBJECTIVE 2: WATER MANAGEMENT AND FIRE PREVENTION THROUGH BMPs APPLICATION IN THE BUFFER AREAS

a. Assessment of all drainage canals in the project site and install blocks to manage water levels to maintain optimal levels for PSF growth and prevent the area from drying up in the dry season and reduce fire risk and GHG emissions

b. Support for good peatland management through sustainable livelihood development and/or BMPs for adjacent communities

c. Strengthen capacity of State Forestry Department and local community and landowners to prevent peatland fires by promoting the fire danger and warning system and undertaking collaborative patrolling

OBJECTIVE 3: FOREST REHABILITATION

a. Seedling cultivation in community nursery

b. Land preparation, and planting of 20 ha with indigenous PSF pioneer species with the involvement of local communities, school children and plantation staff and workers

c. Maintenance of the planted seedlings/trees (20 ha)

d. Encouragement of natural regeneration of less degraded portions of the forest

OBJECTIVE 4: ENHANCING AWARENESS AND UNDERSTANDING OF THE ECOSYSTEM APPROACH FOR NORTH SELANGOR PEAT SWAMP FOREST MANAGEMENT AMONG THE KEY STAKEHOLDERS AT NATIONAL, STATE AND LOCAL LEVELS

a. Holding regular public awareness events and/or forums to support the SHGSU peatland water management and forest rehabilitation activities;

b. Enhance the engagement of school children in peat swamp forest conservation (Junior Peatland Forest Ranger (JPFR) Programme). It has approval from Kuala Selangor District Education Office and the Ministry of Education to organise the JPFR program;

The project has been very successful in enhancing understanding of key stakeholders including the plantation, local community and government agencies on the importance of peatland forests. It has also demonstrated appropriate approaches to preventing fires and rehabilitating the degraded forest area. A key element has been the raising of water levels in the boundary canal of the plantation and blocking the smaller drains earlier dug in the forest by local community. Almost 50 ha of degraded forest along the border have been rehabilitated through fire prevention, higher water tables and a further 20 ha of severely degraded forest has been replanted. As the result, forest fire incidents have been significantly reduced and the forest has recovered enhancing wildlife habitat and further reducing fire risk.

Figure 3-31a: Tree planting site before (2013) and after planting and regular maintenance (in 2019)

Figure 3-31b: Tree planting site before (2013) and after planting and regular maintenance (in 2019)

Figure 3-31c: Natural regeneration processes that has taken place from 2013 (left) to 2019 (right) following blocking of drains and fire prevention

3.4.4 MAINTAINING HIGH WATER LEVELS ALONG BOUNDARY CANALS BETWEEN PLANTATIONS AND CONSERVATION AREAS

It is critical to maintain high water levels between plantations on peat and adjacent conservation areas such as forest reserves, HCV zones etc. This is to prevent inadvertent drainage of the areas outside the boundary. (See **Figure 3-32**)

Figure 3-32a: 2012 picture high water level in canal between the peat swamp forest and oil palm plantation prevents drainage of the forest edge and minimises fire risk (but water should not be too high – i.e. not covering the peat surface)

Figure 3-32b: 2018 picture in same location with high water level maintained between oil palm plantation and peat swamp forest showing maintenance and expansion of the natural vegetation.

3.4.5 NATURAL RECOVERY FOLLOWING RESTORATION OF WATER REGIME

Provided that the natural water regime is restored rapidly after the loss of habitat or fire there can be rapid natural recovery as shown in **Figure 3-33a** and **b**.

Figure 3-33a: Area of peat swamp forest degraded by fire along an abandoned logging canal in Raja Musa Forest Reserve, Malaysia in 2012

Figure 3-33b: Same area after construction of rockfill dam and natural regeneration over five years.

3.4.6 AVOIDING ELEVATED WATER LEVELS

Avoiding water levels which are too high are as important as avoiding water levels which are too low. The peat swamp forest trees breathe through their roots. Although some species have extensive prop or stilt roots and others have pneumatophores to help them breathe in partly flooded environments – most tree species in the peat swamp forest cannot survive in permanent inundation (see **Figure 3-34a** and **3-34b**). Therefore, in developing infrastructure such as roads or bunds in and adjacent to the plantations, it is important that this does not lead to water levels higher than normal. As a guide, the water level in most PSFs is normally just below (5-15cm) the peat surface (allowing the presence of a shallow, oxygenated layer for the tree roots) and only above the surface following heavy rain or in areas which are affected by flooding from adjacent river systems.

Figure 3-34a (above) and 3-34b (right): Peat swamp forest trees killed by elevated water levels caused by back-flooding of the forest as a result of the construction of adjacent bund with no culverts between the forest and agricultural land.

3.5 FIRE PREVENTION AND CONTROL

As mentioned previously, fire constitutes a major threat to the peatlands. This fact has triggered added scrutiny from, for example, governments in Indonesia and Malaysia for any type of development in peatlands. This is especially true for plantation development, and the regulations surrounding fire prevention from the government is matched by the emphasis and implementation of zero-burn management guidelines by plantation companies. For more details, refer to the Guidelines for the Implementation of the ASEAN Policy on Zero Burning (ASEAN Secretariat, 2003) and ASEAN Guidelines on Peatland Fire Management (ASEAN, 2015), under the framework of ASEAN Agreement on Transboundary Haze Pollution (AATHP). A core element in the ASEAN Guidelines on Peatland Fire Management is that four elements of the fire management cycle need to be recognised, namely Prevention, Preparedness, Response and Recovery. Traditionally, most emphasis and resources have been placed on response. However, long experience has shown that it is much more cost effective to focus resources on prevention. The Guidelines recommend that 80% of resources are allocated for prevention of peat fires. Once peat fires start it is very difficult to control and very expensive to recover from them. **Figure 3-35** shows the Fire Management Cycle while **Figure 3-36** and **3-37** illustrate impacts of fire on peat.

Figure 3-35: Integrated Fire Management Cycle combines components of Prevention, Preparedness, Response and Recovery (PPRR) (Source: ASEAN, 2015).

Figure 3-36: Burnt forest adjacent to land developed for oil palm plantations.

Figure 3-37: Fires in peat swamp forest burn not only the vegetation but also the peat layer below the trees.

3.5.1 GUIDELINES FOR FIRE PREVENTION

Plantations can help prevent peat fires in the plantations and adjacent peatlands by ensuring the following recommendations are in place and implemented:

- Zero Burning methods for land clearing/replanting: Implementation of Zero Burning concept greatly reduces the risk of fires
- Maintaining high water levels in boundary canals or installation of sufficient buffer zones inside the plantation to prevent forest and peat to dry out
- Engaging surrounding communities in fire prevention programmes that enhances the awareness, capacity and means for fire-free peatland management
- Construction of fire watch-towers or use of drones for regular aerial surveillance
- Effective surveillance and monitoring: Maintenance of internal roads near fire prone areas – can ease patrolling and access of fire suppression equipment as needed. Care should be taken that such roads do not permit access or encroachment by external parties

Fires may often enter a peatland from areas outside (but adjacent to) plantations especially from areas with local communities or smallholders. Collaboration with communities and other landowners at landscape level is vital to avoid fires from starting and spreading.

In the case of forests and riverine buffer areas within peatland plantations as well as peatland areas adjacent to the plantation – the drainage of the adjacent plantation may also drain these sites making them more vulnerable to fire. In addition the surface vegetation and the large amounts of accumulated litter make such areas more susceptible to fire than plantation areas that have little and are normally more compacted or consolidated with less fire-prone vegetation cover.

In order to prevent fire problems in such areas – the following measures are needed:

- For peatlands, a buffer zone within the plantation boundary without drainage infrastructure or high water tables maintained by bunds or high level canals;
- For other undrained areas, the maintenance of high water levels (drainage of no more than 20cm below the soil surface) by use of high level perimeter drains in which water is maintained at or near the surface;
- Blocking of any ditches or canals cutting through forest or conservation areas;
- Regular patrolling of forest, river buffers and adjacent peatland areas to check for land clearing, drainage or other activities that could lead to fires;
- Rapid response units for fire control within and adjacent to the plantation; and
- Dialogue and cooperation with neighbouring stakeholders including plantation companies, local communities and local authorities to enhance protection of intact peatland areas.

Water Management and Monitoring

A major cause of peat fires can be attributed to the excessive drying of peatlands due to poor water management and over-drainage. But it should be noted that if peatlands are drained, the chance of fire is greatly increased. Putra *et al.* (2016) studied the occurrence of peat fires in 2010-2012 in the Ex-Mega Rice Project area in Central Kalimantan and their results showed that "most of fires occur in areas with a ground water level (GWL) less than -20 cm", indicating that fire is coincident with lower GWL. According to Putra *et al.*, (2018), this critical level may even be as high as -10cm below the surface. Hence it is extremely important to ensure water in the plantation and any adjacent forest areas is managed effectively. Maintaining a moist peat surface will help to minimise the risk of accidental peat fire. Water management plans should ensure that there is no drainage of any peatland conservation area within or adjacent to the plantation. The water management systems should ensure that water control structures are well maintained and monitored and measures taken to rapidly address any problems of lower water table in conservation areas. Care should be exercised to monitor and ensure water management activities within the plantation do not have adverse effects on adjacent peat swamp areas (**Figure 3-38a** and **Figure 3-38b**).

Water levels in peat can fluctuate rapidly especially during rainy or dry seasons. It is therefore important to carry out regular water level monitoring. This can be done by installing water level gauges at strategic locations and at the entrances of collection drains behind each stop-off and numbered. It is useful to have a full-time water management officer in each peat estate for effective and timely control of water at optimum level. This person would also be responsible for operating the water-gates, regular checking of bund condition and inspection of water control structures for damage, blockages, etc. There should also be coordination between the water management team and fire suppression units to jointly identify dry and fire-prone areas within the plantation. Specific attention should be taken to monitor the water levels in and adjacent to conservation areas and take actions to increase water levels when low. Options to supplement water tables in conservation areas by pumping of surface or groundwater during dry periods may need to be considered.

Figure 3-38a: Plantation perimeter drain in 2012 maintained with low water level led to drainage of adjacent peat swamp forest and was root cause of regular fires and poor forest growth.

Figure 3-38b: 2018 picture in same location - Plantation perimeter drain maintained with high water level improving natural regeneration hence minimise fire risk.

Groundwater Pumping

One of the constraints for fire suppression in peatlands is the availability of water in the dry season when the peatlands are most vulnerable to fire. Without water it is very difficult to control the fires. One strategy to address this is to install tube wells in fire prone areas to tap the underground water that is present in aquifers underneath peatlands (see Paramanathan, 2016). The groundwater can be utilised to maintain higher water tables in peatland plantations or conservation areas to prevent fires. Many peatlands have aquifers in the mineral substratum below organic layer (**Figure 3-39**). In most peat areas there are one or two aquifers, namely the one near to the surface within a depth of 10m (unconfined aquifer) and the other one between 30m to 40m deep (confined aquifer). The installation of the tube well is also relatively simple. For the 10m aquifer, the tube just has to be pushed down into the earth and an electrical pump is needed to pump out the water. Whereas for the deeper aquifer drilling is often required to install the tube but pump might not be necessary because the undergound water pressure will push the water to the surface. A study is needed to determine if the aquifers are unconfined (water pumping is needed) or confined (no need to pump the water) as well as the recharge ability and water quality of the groundwater before it is used.

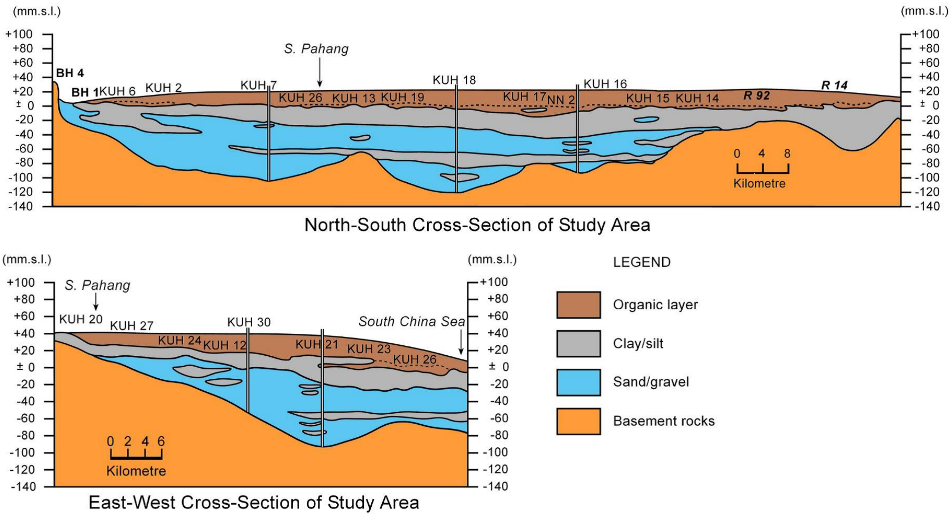


Figure 3-39: Hydrogeological cross-section of Kuantan-Nenasi showing sand/gravel layers that can be aquifers (Ismail & Ang, 1996)

The Peatland Restoration Agency in Indonesia (BRG) has also placed emphasis on rapid and inexpensive installation of deep wells in fire-prone peatland areas (see Dohong *et al.*, 2017). Such wells are sunk to reach groundwater aquifers below the peat. If confined aquifers can be reached, the water may come to the surface with its own pressure – otherwise pumping may be needed. **Figure 3-40** shows bores installed in Indonesian peatlands.

While such a system can in theory be useful in preventing or extinguishing fires in vulnerable peatlands - there are a number of disadvantages to this approach (Giesen W, Pers. Comm. 2018). Firstly, wells (and sprinkling of water on peat) does not mean that peat is really rewetted – there is a (very temporary) vertical circulation of water, but overall if a peatland is drained this means that peat oxidation and subsidence will continue unabated in spite of the presence (and temporary operation) of wells. Secondly, the use of pumps will be vulnerable to availability of funds and willingness of people to take the risk to operate pumps in peatland threatened by fires.

Figure 3-40: Groundwater bores constructed in Indonesia in fire prone peatlands.

3.5.2 PREPAREDNESS

Peatland fire preparedness includes a range of steps including:

- Assessment and monitoring of fire risk;
- Patrolling of fire prone areas;
- Maintenance and upgrading of equipment;
- Training of personnel;
- Deployment of equipment and personnel to fire prone sites.

Fire Danger Rating System (FDRS)

One aspect in the success of fire prevention measures is a system that provides information about the possibility of fire break-out, in which the information is distributed to all relevant stakeholders, including those in the field. With the help of modern technology (computers, telecommunications equipment and remote sensing), it is possible to develop a fire information system based on factors that affect the incidence of fire such as fuel conditions, climate conditions and fire behaviour.

One key fire information systems is the Fire Danger Rating System (FDRS) – which is an early warning system concerning the risk of fire occurring. This system was developed on the basis of indicators that influence the incidence of fire. The FDRS is a system that monitors forest/vegetation fire risk and supplies information that assists in fire management. The products of FDRS can be used to predict fire behaviour and can be used as a guide to land managers and policy-makers to take actions to protect life, property and the environment.

The meteorological variables used (temperature, relative humidity, rainfall, wind speed) are those measured at meteorological stations throughout the Southeast Asia region that are made available on the Global Telecommunication System (GTS). Spatial Analysis is carried out using the ArcView software.

Six codes and indices are produced with associated maps as follows:

a. **Fine Fuel Moisture Code (FFMC)** – an indicator of the risk of bush or grass fires;

b. **Duff Moisture Code (DMC)** – an indicator of the risk of fires burning in upper peat layers and drained peatlands;

c. **Drought Code (DC)** – an indicator of the risk of fire burning in deep peat layers or undrained peatlands;
d. **Build Up Index (BUI)** – a combined index on the vulnerabilities of grasslands, forest and peatlands;
e. **Initial Spread Index (ISI)** – an indicator of the likelihood of rapid spread of fire (e.g. as a result of strong winds); and
f. **Fire Weather Index (FWI)** – an overall indicator of the fire risk.

Fire danger levels are shown as low, moderate, high and extreme. A high index means that there is a high risk of fires starting and becoming established. However, for the fires to actually start they will need an ignition source – such as a land clearing fire or discarded cigarette – before the area will burn. As long as there is no ignition source – the fires will not burn. FDRS maps can therefore provide guidance on where to deploy personnel and resources to undertake fire prevention and monitoring activities. Once a fire starts the indices can show how quickly a fire may spread and how difficult it may be to control.

The Malaysian Meteorological Department (MMD) has been maintaining the FDRS for Southeast Asia on a daily basis since September 2003. The regional FDRS was adapted from the Canadian FDRS developed by the Canadian Forest Service. A more detailed FDRS for Malaysia is also prepared by MMD based on information from more than 160 automatic weather stations. The Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) and National Institute of Aeronautics and Space (LAPAN) of Indonesia also produce localised FDRS for the country. A pilot project on FDRS for Mekong was initiated by Thailand of which providing information to the Mekong countries.

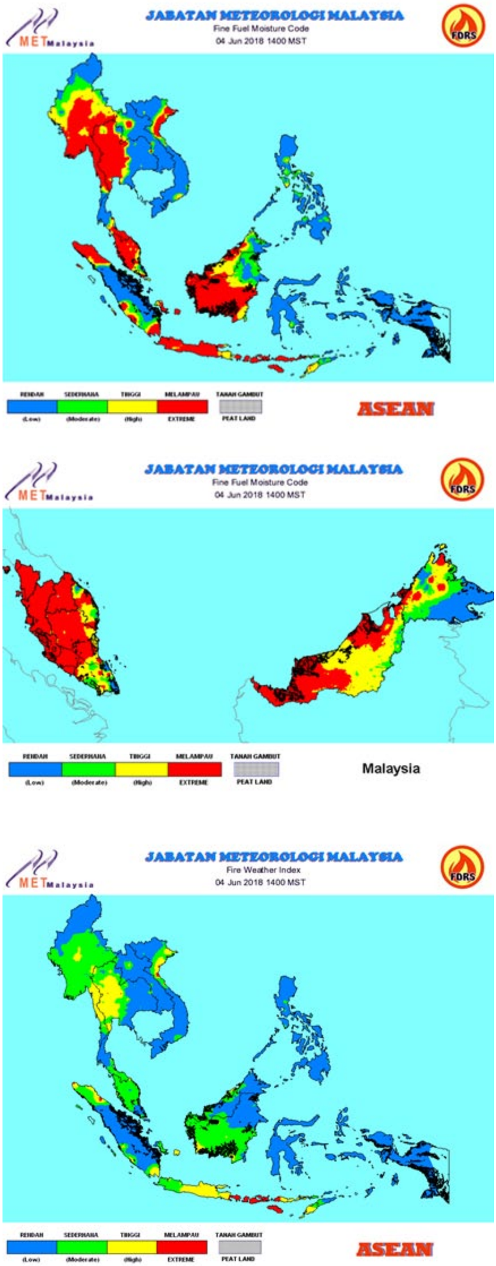


Figure 3-41: Series of images of FDRS for Fine Fuel Moisture Code and Fire Weather Index for Malaysia and Southeast Asia.

Daily maps of the regional FDRS for Southeast Asia are available at: http://www.met.gov.my/iklim/fdrs/afdrs.

The FDRS maps are also available as an overlay to Google Earth – which enables the location of high risk areas to be easily pinpointed in relation to roads, rivers, forests and other features. A sample of FDRS map is shown in **Figure 3-41**.

ASEAN Fire Alert Tool

The ASEAN Fire Alert Tool is an application that was developed by Global Environment Centre (Global Environment Centre, 2016) purposely to send notifications to alert the land managers when a hotspot occurs on their land and inform the land managers on fire risk level of the land. They are then able to verify ground conditions and take necessary action. The application allows users to determine their land boundaries and select Registration Points for monitoring changes of FDRS and Fire Weather Index (FWI). Features of this application can be seen in **Figure 3-42**. This tool is made possible with funding from USAID LEAF, data as provided by ASMC, MMD and LAPAN, and project designed by GEC and SIG. Enhancement of the tool was supported by the USAID-IFACS project and the LEDS AFOLU Working Group. Details can be found at www.aseanfirealert.org.

Figure 3-42: The ASEAN Fire Alert Tool smartphone application

The fire danger rating can also be calculated manually using meteorological data from the plantation or site concerned.

FDRS Signboards

FDRS warnings can be disseminated through FDRS boards (see **Figure 3-43**) displayed at strategic locations – such as fire-prone sites, access points or along roads. The boards need to be adjusted daily (by fire patrol teams) to show the FDRS warning. This can inform key stakeholders of the ratings. Ratings can also be disseminated through WhatsApp or SMS groups.

Figure 3-43: FDRS signboard

Establishment and Strengthening of Fire Management Teams

It is important to develop an organisational structure to handle fire control in a plantation company. Overall leadership should be provided by the Head of the Fire Protection Division (or similar division/department) and this person has the overall responsibility for managing fires in the plantation and coordinating fire suppression activities. The following personnel should be in place to support the fire management processes:

- **Information Unit:** develops and manages information related to fire danger risk;
- **Special Fire-Fighting Unit:** backs up the core fire-fighting units;
- **Guard/Logistics Unit:** mobilises equipment and handles logistics;
- **Sentry Units:** posted in places that are especially prone to fire;
- **Core Fire-Fighting Units (for each estate or division):** patrol units who have the task of surveillance over the whole block;
- **Water Management Sections:** to ensure high water tables are maintained especially in fire prone areas; and
- **Conservation Units:** to monitor and manage conservation areas.

Prior to each dry season all fire control equipment should be checked and serviced and training for personnel should be carried out. Patrolling and fire prevention measures should be specified. Any areas with land clearing of lowered water level should be prioritised for action. Awareness programmes should be undertaken with local communities and other stakeholders.

Following the 2015-2016 large scale peatland and forest fires, the Indonesian government introduced a system of integrated fire patrols to more than 700 fire prone villages. These patrols included a broad range of participants including military, policy, fire agency, local government, local communities and NGOs or media. These patrols visited fire prone villages before and during the dry season and gave warnings on the risk of fire and the penalties for those deliberately burning. These patrols are considered to have made a significant contribution to the reduction in peatland fires in the period 2016-2019.

3.5.3 PEATLAND FIRE RESPONSE

Where fire breaks out in a plantation, adjacent or nearby PSF areas become extremely vulnerable due to the nature of the peatlands. The 'Manual for the Control of Fire in Peatland and Peatland Forest' (Wetlands International – Indonesia Programme, 2005b) elaborates on a variety of concepts and practical measures for the prevention and suppression of fire and also draws from field experience in handling peatland and forest fires in Kalimantan and Sumatra, Indonesia. The following are important elements quoted from the Manual:

> **"Overcoming fire on peatland is extremely difficult, compared with fire in areas where there is no peat. The spread of ground fire in peatlands is difficult to detect because it can extend down to deeper levels or to more distant areas without being visible from the surface. In peatlands, if a fire is not quickly suppressed, or if it has already penetrated far into the peat layer, it will be difficult to extinguish. Moreover, the main obstacles to putting out the peat fires are difficulties in obtaining large quantities of water source nearby and gaining access to the site of the blaze. For these reasons, severe/extensive peatland fires can often only be extinguished by natural means i.e. long consistent periods of heavy rain or artificial measures which raise the water level to the surface."**

Fire suppression action should be taken as soon as possible when a peat fire occurs. The following strategies can be followed to ensure an effective fire suppression operation:

- Human resources support: plantation management together with various stakeholders including the community, NGOs, institutions and relevant agencies that involved in fire suppression action, in view of the fact that fire-fighting requires considerable human resources.
- Identification and mapping of water sources: water sources (surface water and ground water) in fire-prone peatland areas need to be identified and mapped. Identification should be carried out during the dry season so that when fires occur, there is a high probability that sources identified earlier will still contain water.
- Funding support: the availability of an instant fund is essential. This fund can be used to provide food and drink for fire-fighters in the field, to mobilise the community to help in fire suppression activities, to acquire additional fire-fighting equipment and provide medical facilities for fire victims.
- Supporting facilities and infrastructure: fire suppression activities must be supported by adequate facilities and infrastructure including:
    - Fire watchtowers
    - Communications equipment
    - Telescopes and compasses
    - Transportation
    - Fire engines and boats
    - Heavy equipment (bulldozers, tractors)
    - Other fire-fighting equipment such as fire beaters, axes, rakes, shovels, portable pumps
    - Protective gear and equipment for fire-fighters (fire-proof suits, boots, helmets, gloves, torches, machetes, etc.)
    - Emergency clinic, facilities for treating fire victims
- Organisation of fire-fighting teams: fire-fighting teams have an organisational structure so that each team member understands his/her role, task and responsibility when carrying out fire suppression activities.

Specific Guidance on Techniques for Suppression of Land and Forest Fire in Peatland Areas

a. Determine the direction in which the fire is spreading (this can be done by observation from a higher point or by climbing a tree);

b. If applicable, consider flooding the burning area by controlling water levels (i.e. adjusting weirs and water gates) or pumping water from nearby water sources;

c. Before initiating fire suppression, a water-saturated transect is made to slow down the spread of the fire, acting as a non-permanent fire break;

d. If there are no water sources in the area, boreholes must be sunk. If the water sources are far from the fire, water supply is obtained through a relay (using several water pumps);

e. Fire-fighters must walk with great care in burnt peat areas, to reduce risk of them sinking into holes/burned area;

f. Specialised equipment such as a peat spear, which is a 1-2-meter-long nozzle for fire hoses with a large number of holes in the last 50cm before the tip. The spear is jabbed into the smoking ground and water is sprayed through it into the smouldering soil layers below ground. Water is sprayed until the peat fuel takes on the appearance of porridge, a sign that it is saturated with water. This ground piercing is continued until the fire has been extinguished;

g. It is essential to extinguish all remnants of the fire, considering that such remnants, concealed beneath stumps and charred debris on peatlands, are often overlooked; and

h. The burned area should be inspected both several hours after and one to three days after the fire remnants have been extinguished, with the purpose of ensuring that the area is truly free from fire.

3.6 MANAGEMENT OF EXTRACTIVE USES

Extractive uses include the activities of local communities and indigenous peoples with legitimate claims to the areas within or adjacent to plantations. These areas may include PSFs and associated resources including NTFPs and fisheries. Management of access to the peatlands by local communities; minimising impacts to peat forest ecology and ensuring sustainable use of resources; and avoiding use of fire; are the priority issues to be tackled. Management plans for existing PSF areas should cover these aspects and appropriate operating procedures need to be in place to sustainably manage any potential extractive uses. Illegal logging needs to be curbed as much as possible, as this will only exacerbate fire risk since logging leads to forest and peat desiccation and in turn, provides more readily flammable fuel on the ground. Any management strategy for such resources should be developed in a participatory way with the local communities and also with the involvement of relevant local government agencies. For peatlands without a legal land title, it may be possible to have them zoned as Conservation Zones (e.g. Kawasan Ekosistem Essential (KEE) in Indonesia) or community forest under national regulation (e.g. Hutan Desa in Indonesia) which provides certain safeguards for the areas to be managed well and for communities to feel responsible and held accountable.

Management of rehabilitated peatland or forested peat swamp needs to undergo Free, Prior and Informed Consent (FPIC) processes if there is a local community existing within and adjacent to the peatlands. If should these areas will be zoned as conservation areas, the management and monitoring plan needs to include engagement of the local stakeholders and communities as required by the international and national standards/schemes.

3.7 AVOIDING FRAGMENTATION

Peatlands are perfect examples of the inter-connected nature of wetland and forest ecosystems. The inter-dependence of the entire ecosystem makes them especially vulnerable to a collapse from fragmentation. Subdividing the peatland due to establishment of canals, weirs (water gates), bunds and access roads constructed by oil palm plantations, and making them in to smaller fragmented units makes the peat more vulnerable to fire and degradation. Small areas of forest or wetland may be inadequate to enable large mammals such as tigers to survive as they normally have a home range of 6,000-40,000 ha (Priatna *et al.*, 2012).

Identification of peatland areas to be conserved/managed needs to take this factor into consideration. Areas that provide connectivity/ecological links between larger landscapes of PSFs should be prioritised. The size of the area should also be adequate to ensure the long-term ecological survival of the peatland. These corridors will also provide safe passage to wildlife and hence prevent potential human-wildlife conflicts in the future. In peatland areas, corridors are recommended to be at least 500m to 1km wide to reduce edge effects and provide space for undisturbed movement of wildlife.

4.0 REHABILITATION OF PEAT SWAMP FORESTS IN DEGRADED SITES

4.1 ADDRESSING THE ROOT CAUSES OF DEGRADATION

Understanding the root causes of degradation requires careful and honest assessment of the role of various stakeholders in the area that have an impact on the PSF. Often plantations operate in a landscape with alternating types of land uses in peatland areas. By taking a landscape approach to planning, it may be possible to reduce the impact of the plantations and prevent fragmentation of remaining forest areas. However, such work needs collective action as well as the support and participation from a broad range of stakeholders including local government, communities and other plantations.

Understanding root causes of degradation may require the participation of various stakeholders in the area, including community representatives, other industries (forestry, mining, fish farming, etc.), downstream users, other plantations and the government. This presents a potentially impossible task for a single actor like a grower to take on. However, without the participation of all stakeholders, plantations can still acquire significant information to derive at some root causes of degradation. Planning with participation from local NGOs and stakeholders, can produce information on both root causes as well as identify actions that a plantation can take to contribute towards the overall health of the PSF area.

The range of factors leading to degradation can change over time. In Berbak National Park, for example (see **Box 4-1**), a range of factors were identified as affecting PSF in 2001. In 2004, the main cause of degradation was found to be the widespread illegal logging in the National Park (NP) both by a logging company with a concession adjacent to the NP and by a transmigration village located adjacent to the park. To cover up illegal activities, fires were lit, which further added to the damage (Giesen, 2004). Subsequently a major cause of degradation in the park was the conversion and drainage of large areas adjacent to the NP to oil palm. The drainage for the oil palm led over time to significant changes in the hydrology of the park system as subsurface water flows were diverted to rivers outside the park – decreasing the water level in the park and increasing vulnerability to fires.

Box 4-1

Causes of peat swamp forest degradation on Berbak-Sembilang National Park, Indonesia

Berbak-Sembilang National Park

Berbak National Park (162,000 ha) was designated in 1992 as Indonesia's first Ramsar Site with a special emphasis on its representativeness for Southeast Asian PSF. In 2016, its management was merged with the adjacent Sembilang National Park (205,100 ha), also designated as a Ramsar Site, comprising one of the largest mangrove area (77,500 ha) of the Indo-Malayan region, the only one that still has an intact natural transition towards inland freshwater and PSF. The hydrological integrity of this transition is of crucial importance to the survival of the mangrove ecosystem and its biodiversity.

Both Ramsar sites are famous for their rich biodiversity, including many fish that are restricted or endemic to peat swamp black waters, as well as rare and endangered species, such as the Sumatran Tiger (*Panthera tigris sumatranus*), Malaysian Tapir (*Tapirus indicus)*, Malaysian Sun Bear (*Helarctos* *malayanus*), White handed Gibbon (*Hylobates lar*) and Siamang (Symphalangus syndactylus), False Gharial (*Tomistoma schlegelii*), Painted Terrapin (*Batagur borneoensis*), Storm's Stork (*Ciconia stormi*) and the White-winged Duck (*Cairina scutulata*). The Sembilang NP is one of the most important wintering sites for the Asian Dowitcher (*Limnodromus semipalmatus*) with a maximum count of 10,000 individuals at the Banyuasin Peninsula (Silvius et al., 2016, Giesen et al., 2016).

Land conversion and fires within the National Park

Encroachment in Berbak NP is regarded as the single greatest threat by the park authorities, as it directly leads to loss of forest (illegal logging), drainage and fires. Most encroachment has occurred to the north of the NP and from the villages along the coast. The level of encroachment has rapidly increased over the past 5-10 years in tandem with the rapid expansion of oil palm in the province. To the north, villages have encroached into the NP by almost 4km and extending over roughly 670 ha, while along the east coast the encroachment has extended into the NP by about 2km, extending over 690 ha. General disturbance from illegal logging and clearing, followed by fires, has extended much further from the coast to the Simpang Melaka, a tributary of the Air Hitam Laut river, over a length of more than 10km. There is also illegal conversion ongoing to the northwest of Berbak NP in the Tahura, where about 1,250 ha has been converted by smallholders, and to the southwest of Berbak NP on the edge of (but within) the logging concessions where a further 1,530 ha has been converted to oil palm.

Logging and fires within the National Park and peatland protection forests

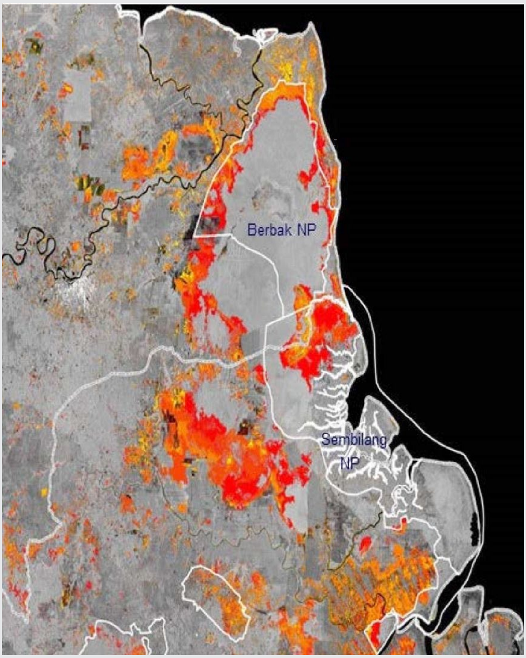


Figure 4-1: Fire scars (orange and red) around Berbak National Park and west of Sembilang NP, during the 2015-2016 El Nino as detected by Radar satellite June-December 2015.

Illegal logging has been ongoing in Berbak NP for many decades and at least since the early 1980s. It occurs all around the NP, but the largest, most organised and widespread illegal logging appears to occur via the logging concessions to the southwest of Berbak NP and to a lesser extent through the Tahura in the west. This is especially via the forestry concession (HPH) located south-west of the NP, that has been operational since about 1979. Logging trails (and possibly canals) lead from their concession area to areas within the NP and the peatland protection forest (HLG). The large degraded area in the central part of Berbak NP along the Air Hitam Laut river started with illegal logging in the mid-1990s, and expanded rapidly with major fires over 17,000 ha in 1997 (Giesen 2004) and fires in all dry years since, especially in El Niño years. The HLG that lies to the south-west of Berbak NP and extends over 20,000 ha has been logged to about 40-50% over the past 10-15 years. Two logging companies south-west of Berbak NP have a combined licensed area (HPH) of about 58,000 ha, and this area has a legal status of limited production forest (HPT). The southern license has been suspended pending an investigative audit, as the company has planted pulp species such as jabon (Neolamarckia cadamba) and sengon (Falcataria moluccana) and converted part of the concession to oil palm, which is against regulations for HPT.

Further details can be found in the report on the 2017 Ramsar Advisory Mission to Berbak (Silvius *et al.*, 2018).

In Central Kalimantan – the degradation of the PSFs was driven by the development of a 1.5 million ha rice production scheme (so-called the Mega Rice Project) in 1996-97. This involved the construction of 4,600 km of so-called irrigation canals through the PSF with expectation that they would carry irrigation water into the forest area from rivers. Unfortunately, the canals acted as drains and drained all the water out of the peat domes. In the 1997-98 El Nino – more than 500,000 ha of the PSF was burnt. In 1998 the project was officially abandoned as it was realised that the area was almost totally unsuitable for growing rice. However, for most years since 1998, between 100,000-200,000 ha of the area has burnt as a result of the increased vulnerability as a result of the abandoned drainage canals. Work was initiated on a pilot scale in 2003 (under the Climate Change Forest and Peatlands in Indonesia (CCFPI) Project) to block the abandoned canals using local materials and community action. This raised water levels, addressing the root causes of degradation leading to a reduction on peatland and forest fires and enhanced regeneration of the forest areas. This approach has been modified and expanded to other projects and now has been adopted by the Indonesian Government for rehabilitating the degraded peatlands.

It can be expected that each degraded site will present its own set of complex root causes of degradation and can be a combination of any of the above examples listed. Once root causes are determined, it is important that management plans are drawn up and appropriate actions taken to address these problems. Monitoring should also be carried out to track progress and determine any corrective actions needed.

Box 4-2 describes the approach by the Indonesian Peatland Restoration Agency (BRG) in addressing peatland restoration. As it is new and still being tested, the 3R approach is still evolving. The science behind the 3R approach has been evaluated for BRG by Giesen & Nirmala (2018), with the aim of summarising what is known and proven and identifying gaps in order for BRG to target further studies, especially under cooperation with both local and foreign universities and research institutes.

BOX 4-2

Restoring degraded peatland in Indonesia: the 3R Approach by Alue Dohong

Indonesia experienced one of the worst peatland and forest fires events in the country's history in the El Nino event in 2015. About 2.6 million hectares of peatland and forest burned out in this single catastrophe, with 33% of total area burnt on peatland. The disaster has incurred substantial economic, environmental, social, and health costs for the country. The World Bank estimated approximately USD 16.1 billion (IDR 221 trillion) of economic costs borne by the country due to this mega fire (World Bank, 2016). Logging, conversion of vast areas of peatland to industrial timber and agriculture plantations as well as drainage in association of this land use practices are perceived as major drivers of peatland degradation in Indonesia (Dohong *et al.*, 2017a). Unless major peatland uses policy and regulatory aspects are improved and wise use peatland practices are put in place; the "peatland" natural and economic assets will only create economic and environmental costs the country.

Indonesia hosts the largest tropical peatland in the world (Wahyunto *et al.*, 2016), however, around 50% of this area has experienced degradation ranged from mild to moderate and heavy. Restoration is a strategic effort to suppress peatland degradation and in turn, will improve the peatland ecosystem services.

Considering the importance of restoring degraded peatland functions and ecosystem services (notably hydrological), the President of the Republic of Indonesia enacted the Presidential Regulation Number 1 of 2016 concerning the establishment of Peatland Restoration Agency or known as Badan Restorasi Gambut (BRG). This ad hoc governmental agency is tasked to coordinate and facilitate the implementation of peatland restoration activities in seven provinces, namely Riau, South Sumatra, Jambi, West Kalimantan, Central Kalimantan, South Kalimantan, and Papua, with total area targeted of 2 million ha during the period of 2016-2020. However, having re-examined and synchronised the country maps on burnt areas, artificial drainage networks, concession permit areas, conservation areas as well as remaining pristine peat forest cover areas, BRG has developed a higher peatland restoration target of 2.4 million ha in the seven provinces.

To expedite its restoration target, BRG has introduced the 3R approach. The 3R stands for Rewetting of drained peat (R1), Revegetation of bare and secondary fragmented peatland (R2), and Revitalisation of local livelihoods (R3)(Dohong, A *et al.*, 2017b).

Rewetting of peat aims to improve hydrological properties of drained peatland through the establishment of peat rewetting infrastructures, such as canal blocking, canal backfilling and deep wells and other proper water management technologies. It should be known, however, BRG has differentiated the goal of hydrological restoration between cultivation and conservation peat ecosystem functions. In peat cultivation areas, the hydrological restoration goal is to manage water (water management goal), meanwhile, in the peat conservation function, the main goal of hydrological restoration is to conserve water (water conservation). These goal differences have implications to the technical designs and specifications of rewetting infrastructure used in both peat ecosystem functions. In peat cultivation areas, the water weir needs to be equipped with spillway or notch device to regulate the minimum water level to be maintained or retained (a maximum 40 cm below peat surface as required by Governmental Regulation Number 57 of 2016). Meanwhile, the water weir (dam) in peat conservation function, the water level regulator device (spillway) is not needed.

In the meantime, the Revegetation (R2) aims at to restore bare peat vegetation cover and improve peat swamp forest habitat quality through promoting the availability of seedlings, seed transplantation, and enrichment planting (Wibisono and Dohong, A., 2017; Sitipu, D. and Dohong, A., 2019). The provision of seeds is promoted through the establishment of nursery building for collected seeds bank, procurement of saplings through seeds, wildings, and stem cuttings. Typical seeds needed consist of indigenous and peat adaptive woody species.

Finally, Revitalisation of local livelihoods aims to provide livelihood alternatives for local communities with twofold goals: i) creating various livelihood alternatives as means for increasing income and welfare, and ii) improving participation of local people to operate and maintain rewetting infrastructures built in their respective sites. BRG initiates three bases for livelihoods development in its restoration target area. These bases are land, water, and environmental services. Land-based livelihood is promoted through the activities of planting paludiculture species both endemic and adaptive species; the water-based livelihood is developed via creating activities of silvofishery, aqua-culture and other water-based livelihood that suit with local conditions. Ultimately, environmental service-based is created through enhancing activities such as ecotourism, carbon management and so forth. BRG has developed a number of guidelines on different restoration techniques as shown in **Figure 4-2**.

By implementing the 3R approach consistently and appropriately, it is believed that peatland restoration in Indonesia will yield the best achievement of its target.

Figure 4-2: Guidelines and training manuals on peatland restoration developed by the Peatland Restoration Agency, Indonesia

4.2 GUIDING PRINCIPLES FOR REHABILITATION

Euroconsult *et al.*, (2008b), Giesen (2015), Graham *et al.*, (2016) and USAID-LESTARI have recommended a number of key principles and approaches for the PSF rehabilitation programmes:

Adaptive Management

It is neither possible nor desirable to provide a "blue-print" for implementation of plans. During implementation, lessons will be learned as to what works and what does not and these lessons should be included in future planning. Adaptive management promotes a process of "learning by doing" and integrates planning and design with ongoing monitoring, assessment and evaluation.

Adoption of an Integrated Approach

Implementation of plans will be complex and will involve a large number of sectors – each with its own interests and responsibilities. A major challenge will be to integrate and harmonise these needs so as to reduce any conflicts and to maximise synergies.

Planning and Implementation at a Landscape Ecosystem Scale

The different parts of the landscape should not be considered in isolation but integral components of a complex landscape mosaic, with each part having effects on its neighbours. The rehabilitation and revitalisation programme needs to take a resource-based approach to lowland management. In Indonesia – the importance of the landscape approach has been incorporated into the National Regulation for Protection and Management of Peatland Ecosystems (PP71/2014 amended to PP57/2016) which requires all peatlands to be managed as Peatland Hydrological Units (PHU) – which link together all peatlands in the same landscape.

Meaningful Involvement of Communities – obtaining free, prior, and informed consent (FPIC)

Communities in the project area should be aware of, and have a voice and role in, the planning within their environment. Communities, or their freely chosen representatives, should be involved in the entire process of peat management. This should start from socialisation and awareness raising of the issues surrounding peat management – and consequences of poor management, especially increased risk of fire; a social impact assessments on the ground to identify potential issues with peat (and drainage canal management); consultation on peat management strategies (including active inspection of canal block locations, if needed); consultation on the design of needed canal blocks accommodate community use of peatlands and access via canals where necessary; and through to construction of canal blocks in their respective areas and their continuous management. Importantly, monitoring feedback from local communities is essential to measure the effectiveness (or not) of the interventions and this will serve to constantly improve planning and future actions in conserving and protecting the PSFs. The USAID LESTARI project has had great success in consultation with communities and getting their input on canal block design and location that has resulted in well maintained canal dams, continued access to parts of the peat dome used by communities for fisheries, very significant reduction in fire incidence and some natural regeneration.

Guiding principles for the rehabilitation of PSFs drawing on experience in Central Kalimantan (Euroconsult MMD *et al.*, 2009) and other locations include:

(i) Socio-Economics

Local communities should be the key stakeholder involved in replanting, restoration and rehabilitation programmes. Where possible, species which bring benefits to local communities should be incorporated in the programmes. These species include species producing timber, species producing NTFPs, and multi-purpose trees (timber plus NTFPs).

In conservation areas the focus should be on those producing Non-Timber Forest Products (NTFPs) where any utilisation does not affect biodiversity.

Local communities should be given legal access and user rights to the NTFPs and there should be a binding benefit sharing agreement (e.g. between relevant authorities and local communities) for harvesting of timber species. Local communities and other stakeholders are to be involved in the planning and decision-making stages if restoration or rehabilitation is to be successful.

(ii) Beneficial Species

The focus of replanting should be on species that:

- provide NTFPs (such as jelutung, gemor and tengkawang) rather than timber species (such as *belangiran*, *ramin* and *geronggang*); this should closely involve discussion/consultation with the local communities; or
- are important as food species for key wildlife such as orang utan, gibbon and hornbills.

(iii) Hydrology

There should not be any artificial drainage in conservation areas as this will ultimately lead to loss of peat. In areas on the edges of peat domes, drainage should be very strictly limited because the effects of drainage will spread to the dome. Therefore, only plant species that do not require any drainage should be used in the rehabilitation programmes, and the emphasis should be on hydrological restoration prior or at least in parallel to the replanting programmes.

(iv) Biodiversity

Increase diversity in number of species used in PSF rehabilitation and restoration programmes as much as possible, as this will:

- Enhance overall biodiversity and increase/restore the biodiversity function of the PSF system; and
- Reduce the pest threat, as pests are more inclined to attack monocultures and natural habitats can support many predators of pest species.

With regard to aquatic biodiversity it is important that the recolonisation of rehabilitation areas is encouraged – other by maintaining or enhancing connections to remaining natural habitat or through translocation if the rehabilitated area is isolated. The PSF contains many rare and endemic species of aquatic biodiversity such as fish, amphibians and aquatic invertebrates. These can recover if the correct conditions are recreated. Some species can also survive or flourish in drains and water bodies in adjacent plantation areas. Any area of adjacent peatland aquatic habitats with RTE species should be identified and monitored as a potential source region for species to recolonise rehabilitation areas. Herbicide and pesticide must never be used in rehabilitated areas or in near waterways that flow into them.

With regard to birds, reptiles and mammals – it is important to maintain connectivity across the landscape to allow movements of these species and enable recolonisation of rehabilitated sites. Mammals and birds may also play a key role in the reintroduction of additional plant species though the transfer of seeds in droppings.

Long-term monitoring is needed to evaluate success of rehabilitation i.e. restoring vegetation may be insufficient; wildlife must be confirmed as returning to and inhabiting the rehabilitated area. A documented aquatic biodiversity programme should be put in place including an annual aquatic biodiversity sampling plan.

(v) No Exotic Tree Species

Only native species should be used in the rehabilitation programmes and the use of exotics should be prohibited.

Setting up any structures for rehabilitation should also utilise locally found materials i.e. gelam poles and peat etc. to avoid excess load/weight. The basic principle behind this is the ongoing consolidation of the peat layer under these structures should be approximately equal to the total unavoidable subsidence of the surrounding area. The practical consequence of this principle is so that the overburden pressure will be very low (e.g. for a water table of 0.25m, the overburden pressure should not exceed about 1kPa or 100 kg/m^2) (Budiman and Wosten, 2009).

(vi) Costs

The overall budget required for the rehabilitation is likely to be substantial. Hansson *et al.*, (2018) estimated the costs to be around USD 2,300 per hectare in the context of the Indonesian government ambition to restore 2 million hectares. According to Giesen and Nirmala (2018) cost for rehabilitation was depending on location, canal network density, logistics etc. This include: costs for compacted peat dams, vary from USD 600 (4m wide canal) to USD 1000 (8m wide) and USD 5000 (20 m wide), while cost of replanting at specified density (1100 seedlings ha, per GOI regulation) varies from USD 500-3000 per ha. Therefore, the rehabilitation programmes must opt for most cost-effective solutions – the end result must of course be successful rehabilitation, as this should not be compromised.

(vii) Measuring Success

Many past programmes have measured their impacts and rate of success on the number of planted seedlings or the hectares of degraded land that has been replanted. However, these are only inputs and it is much more important to assess success on the real impact (medium to long-term) of the rehabilitation. Implementers should therefore not only be held accountable for use of funds for planting trees and hectarage covered, but be responsible for survival of tracts of replanted PSFs. This means that monitoring and maintenance of replanted areas should be part and parcel of every rehabilitation programme and form the basis of measuring the rate of success. Development of new techniques of monitoring forest cover and reduced/reversed subsidence trends using satellite remote sensing technologies may provide useful future tools (e.g. Brown *et al.*, 2018 and Marshall *et al.*, submitted; Alshammari *et al.*, 2018).

4.3 PLANNING FOR PEAT SWAMP FOREST REHABILITATION PROJECTS

4.3.1 REHABILITATION STRATEGY

The stages of degradation need to be identified for the area to be rehabilitated as this will allow for a better assessment of the situation in the field, better matching of species selected for replanting and a selection of more appropriate interventions in general (Euroconsult Mott MacDonald *et al.*, 2009). Systematic fieldwork is required to develop a degradation typology for the area. Fieldwork should involve recording species composition, vegetation structure (including seedlings, saplings, trees) and densities, but also other parameters such as peat depth and maturity, light intensity, nutrient availability, site hydrology and fire history.

Once this information is gathered, intervention types required such as the following can be determined:

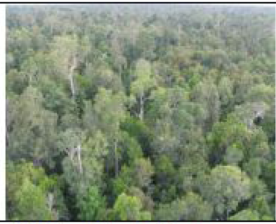
a. none required, for example in areas already regenerating naturally or in areas that are a lost cause (e.g. former peat areas that have become deep lakes),

b. assisted natural regeneration (e.g. hydrological rehabilitation and prevention of fires (see **Chapter 3**), or

c. active rehabilitation (see **Chapter 5**).

Giesen and Nirmala (2018) give guidance on peatland rehabilitation based on a combination of peat degradation class and proposed use or management objectives (See **Table 4-1**).

Table 4-1: Rehabilitation strategy in relation to level of degradation and proposed management (Note: Daerah budidaya is utilisation zone and daerah konservasi is conservation zone) (Source: Giesen, 2015)

Level of degradation:	**A. Moderately degraded peat swamp forest**	**B. Degraded peat swamp forest**	**C. Severely degraded peat swamp forest**	**D. Severely degraded peat swamp**
Description of degradation	Forest disturbed by logging and logging canals, but with largely closed canopy, usually not burnt.	Logging canals present, moderately to largely deforested (tree cover 5-20%), with most PSF tree species remaining, sometimes burnt, but very local.	Mostly deforested (tree cover 1-5%), often burnt multiple times (1-3x), history of drainage >10 years, occasional flooding	Areas severely degraded, tree cover usually <1%, often burnt ≥4-5x, long history of drainage and subsidence, frequent flooding, seasonal ponding/lakes
Visual examples:				
Types of intervention recommended in ***daerah budidaya***	**A.1 Peat-adapted silviculture** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, possibly enrichment planting of desirable timber (or other) species, timber harvesting using rail systems.	**B.1 Peat-adapted agroforestry** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, enrichment planting of economically desirable species.	**C.1 Paludiculture** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, planting of desirable, economically beneficial peat adapted species, either as monocultures or mixed planting.	**D.1 Ecological rehabilitation** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, planting of pioneer PSF species that grow rapidly and cope with flooding, drought & heat stresses.
Types of intervention recommended in ***daerah konservasi***	**A.2 Peat swamp forest regeneration** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, possibly local enrichment planting of ecologcically desirable species (e.g. fruit species for wildlife).	**B.2 Peat swamp forest restoration** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, signifcant enrichment planting of ecologcically desirable species (e.g. fruit species for wildlife).	**C.2 Ecological rehabilitation** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, replanting of large areas with PSF species, both pioneers & ecologically desirable species.	**D.2 Ecological rehabilitation** Hydrological rehabilitation (canal closure/rewetting), fire detection & prevention measures, planting of pioneer PSF species that grow rapidly and cope with flooding, drought & heat stresses.

Mapping of Degraded Areas

Mapping of the area needs to be in detail (and recent enough) to allow recognition and delineation of the various stages of degradation at a landscape level. The mapping should recognise units that require rehabilitation, assisted regeneration, natural regeneration and those that do not require any intervention. See **Figures 4-3** and **4-4** for examples of the degradation and site condition mapping.

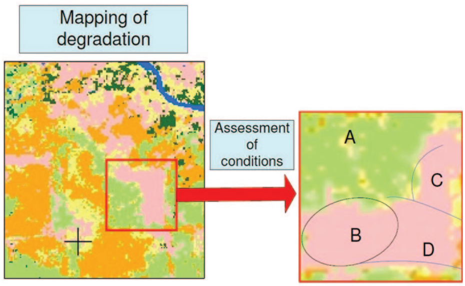


Figure 4-3: Example of mapping degradation and site conditions (Source: Euroconsult MMD et al., 2009). Area marked "A" shows an area with deeply (1.5m) flooded peat (2x burnt, 1.5m of peat has disappeared); areas marked "B" shows an area with moderately deep flooding (1m), 1x burnt, 1m of peat has disappeared; area marked "C" shows an area that is shallowly flooded (0.5m), 1x burnt, 0.5m of peat has disappeared; area marked "D" is similar to "C" but with riverine influence (nutrients, current and some erosion).

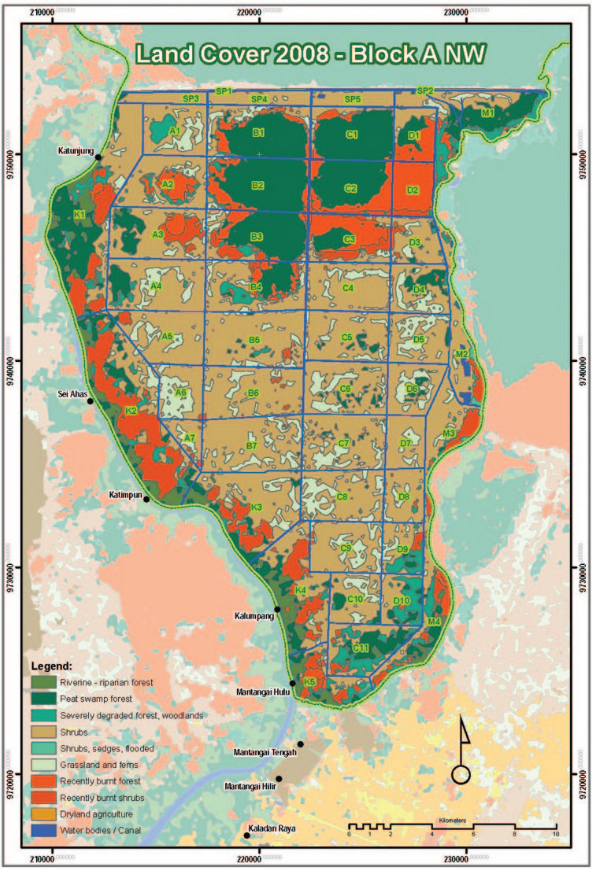


Figure 4-4: Sample land cover map from the Ex-Mega Rice Project in Central Kalimantan showing riverine forest, peat swamp forest, severely degraded forest, shrubs, grassland, recently burnt and agriculture areas as well as location of canals and water bodies (Source: Euroconsult Mott MacDonald and Deltares, Delft Hydraulics, 2009).

Canal Selection for Blocking

Selection of canals and locations for closure to increase and maintain water levels is very important during mapping. Canal blocking is best commenced in the upstream of the canals to avoid excess discharge and thereby gradually decreasing pressure on dams constructed at further downstream in the canals.

Rapid Survey of Site Conditions

Rapid surveys will be required in addition to the mapping, to assess site conditions, and determine the possible causes of the degradation. This will result in a further refining of information available about a site, so that the intervention can target what is required.

Physiochemical conditions need to be rapidly surveyed in each mapped intervention unit and this may result in a further refinement of the map, or at least a better understanding of the conditions at a given site. Parameters that need to be assessed include:

- water depth/availability, flooding depth/duration, distance from river bank,
- micro-topography (hillocks and depressions: what is the range, height and elevation),
- exposure (to sunlight; depends on existing tree/shrub cover, height and density),
- peat depth and maturity,
- occurrence, depth and pyrite concentration of Potential Acid Sulphate (PAS) soils, and
- nutrient-availability and pH of each of the mapped units.

Box 4-3

Example of planning and mapping for peat swamp forest rehabilitation projects from the Ex-Mega Rice Project Area in Central Kalimantan

Figure 4-5 is a map developed and used as part of the peatland rehabilitation plan for one of the planting blocks within the Ex-Mega Rice Area in Central Kalimantan. These planning maps are vital to the successful implementation of any PSF rehabilitation project.

Earlier field surveys revealed that while areas with remaining PSF do not require replanting, vast areas of shrub land, burnt shrub land and sedge-grass-fern vegetation may require 100% replanting with suitable PSF tree species. This includes shrub land that already has some small trees although replanting these areas could include more mature trees if these can be shaded. Patches of severely degraded PSFs were estimated to require 30-50% replanting, while burnt PSFs required an average of 50% replanting as trees often remained in patches in the latter areas. The areas targeted for the replanting according to these planting regimes (0%, 30-50%, 50% and 100%) are indicated in **Figure 4-5**.

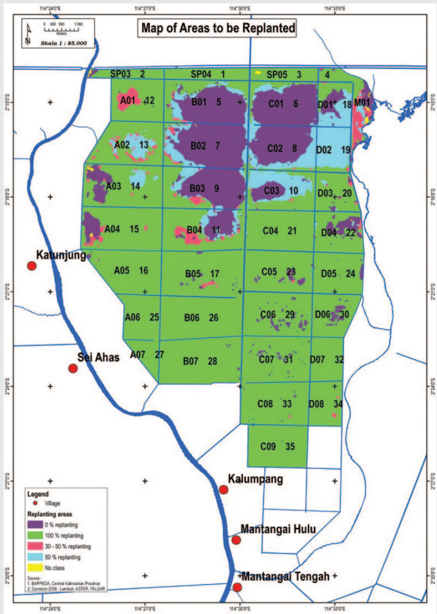


Figure 4-5: Sample map showing areas to be replanted as part of the peatland rehabilitation plan for one of the planting blocks within the Ex-Mega Rice Area in Central Kalimantan (Source: Euroconsult Mott MacDonald and Deltares, Delft Hydraulics, 2009).

BOX 4-4

Connecting conservation areas at PT. Tolan Tiga Indonesia/SIPEF Group (Source: Damanik *et al.* 2019)

After taking over a plantation under development on peat in North Sumatra, SIPEF Group identified two areas still reasonably forested to be kept as conservation areas. Given the relative small size of both areas (167 ha and 39 ha), and following consultation with HCV specialists, it was decided to connect the areas with a corridor of about 1.4 km in length (see **Figure 4-6**).

The objectives of the corridor are as follows:

- To increase habitat for wildlife as well as to facilitate movements and stabilise populations in a protected area; and
- To maintain and improve plant biodiversity, by increasing area available for re-growth and replanting of local species.

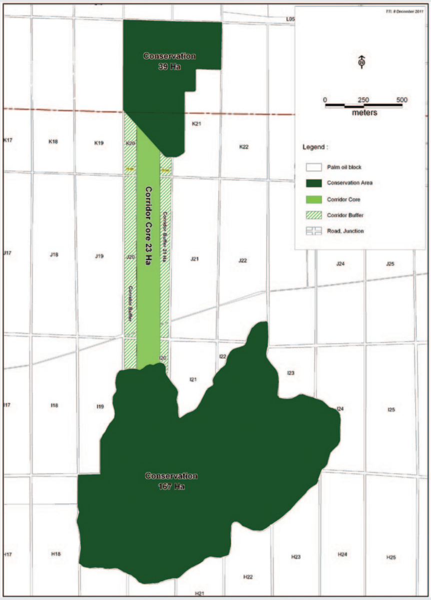


Figure 4-6: A map showing conservation areas connected by a wildlife corridor established by SIPEF Group.

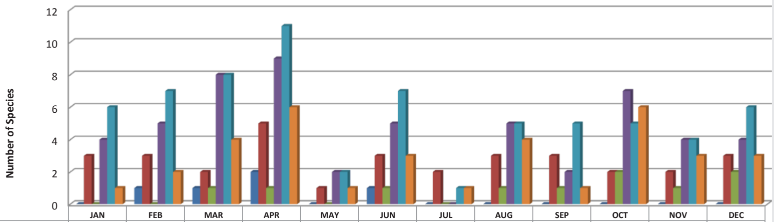
The corridor area had already been planted with oil palm for one year and blocks were orientated exactly in the direction of the corridor. It was decided to allocate the width of one block (300 meters) over the entire distance of the corridor for a total of about 44 ha. In the core area of 150 m width, young palms were removed and transplanted elsewhere. The buffer areas of 75 m on each side of the core area were left planted. In the buffer areas, pesticide applications will be reduced but otherwise, the palms will be managed normally.

The core area was replanted with species such as *Alstonia pneumatophora* (pulai), *Palaqium spp.* (mayang), *Shorea spp.* (meranti merah and meranti batu), and *Callophylum spp.* (bintangur). Planting material was prepared in part on the estate and in part sourced from the local forestry services. Trees were planted at 5 x 5 meters to anticipate natural mortality. After only a few months of installing the corridor, wildlife movements were already visible. The estate is monitoring survival rates of the trees.

According to the recent report by SIPEF Group (Damanik *et al.*, 2019)1 a total of 1890 seedlings from *Shorea* spp. were planted at the corridor between 2016-2018. Further evaluation of the corridor showed that besides *Shorea* spp. and *Alstonia pneumatophora* which were planted, there were other species which succeeded to dominate the corridor. Such of the species include; Trembesi (*Albizia saman*), Ketapang (*Terminalia catappa*), Tenggek Burung (*Melicope lunu-ankenda*), Kayu Ara/Beringin (*Ficus benjamina*), and Salam (*Syzygium polyanthum*). It is believed that these species came through natural seed dispersal from the corridor surrounding area.

Besides vegetation evaluation, wildlife monitoring also has been conducted during the period of January to December 2018. In general, numbers of mammals, birds and reptile have been successfully recorded during monitoring period. Using the live watching and observation technique, species then have been identified and classified according to their status under IUCN Red List and PERMENLHK No. 92 2018. **Figure 4-7** below shows distribution of species recorded during the monitoring period.

Second quarter year 2018 indicates the highest number species recorded with a total of 30 species, 3 classified endangered (IUCN) and 20 declared protected under PERMENLHK No. 92 2018. Birds contribute to the highest number species in record findings. Such of the species with repeated sighting includes; Bangau Bulwok (*Mycteria cinerea*), Bangau Tongtong (*Leptoptilos javanicus*), Elang Hitam (*Ictinaetus malaiensis*), Rangkong Papan (*Buceros bicornis*), Tiong Mas (*Gracula religiosa*) and Elang Brontok (*Spizaetus cirrhatus*).



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
EN (Endangered)	0	1	1	2	0	1	0	0	0	0	0	0
VU(Vulnerable)	3	3	2	5	1	3	2	3	3	2	2	3
NT(Near Threatened)	0	0	1	1	0	1	0	1	1	2	1	2
LC (Least Concern)	4	5	8	9	2	5	0	5	2	7	4	4
Protected (under Permenlhk no. 92 2018)	6	7	8	11	2	7	1	5	5	5	4	6
Not Protected (under Permenlhk no. 92 2018)	1	2	4	6	1	3	1	4	1	6	3	3

Figure 4-7: Total species according to IUCN and PERMENLHK Status

It is also a good practice to undertake inventory of flora and fauna and incorporate this information into the rehabilitation plans. For example, see Euroconsult Mott MacDonald and Deltares (2009). For an example of flora and fauna inventory, see **Box 4-5** for method used by WWF (Indonesia) for environmental biophysical evaluation in Sebangau National Park.

BOX 4-5

WWFI Inventory of Flora and Fauna

Method used by WWFI(Indonesia) for environmental biophysical evaluation in Sebangau National Park Measurements for environmental biophysical evaluation in Sebangau National Park were conducted on April 9-14, 2018. Site sampling for measurements was determined purposively in the restoration area of WWF's collaborative program with Sebangau National Park. Field measurements are carried out to obtain actual current data as per listed below.

1. Flora

A. LAND COVER

The land cover study was conducted by comparing land cover in series from planting period to evaluation period with remote sensing technique. The data obtained from the land cover study was in form of a land cover change that occurs from the year series, either in the form of changes in ecosystem types or changes in the extent of each type of land cover.

B. DENSITY DEPENDENCE AND DIVERSITY OF SPECIES

Data collection to obtain stand density and species diversity was done by using line transect method with 1 km lane length for natural ecosystem and 500 m for restoration area. This method of vegetation analysis is done on a plot divided into sub-plots.

The 20x20 m^2 plots were used for data collection of vegetation growth rate of trees, 10x10 m^2 plots were used for data collection of vegetation growth rates of poles, 5x5 m^2 plots were used for data collection of vegetation growth rates of saplings, and 2x2 m^2 plots were used for vegetation growth rate of seedlings.

The data collection for the lower plants was done by using an example unit based on the method of the plotted-line method. Each sample unit has a length dimension of 1000 m and a width of 1 m. Each sample unit will be divided into a plot of 1x1 m^2, placed at 50 m from the plot's centre point. The parameters taken for the lower plants included the type and number of individuals.

2. Fauna

A. BIRDS

Bird data collection was done by using the example unit of the combination of line transects with the variable circular plot (VCP). For natural habitat, the distance between the centre points of each plot is 200 m while the length of each transect was 1 km (6 plots). Meanwhile, for the restoration area, the distance between the centre points of each plot is 100 m and the length of each transect was 500 m (6 plots).

Observations of bird species were conducted at intervals between 05:45-07:45 for the morning period and 15:45-17:45 for the afternoon period. Recording of data was done by observing birds the entire area of observation circle, recorded in 5 minute intervals for 15 minutes for each observation point. The observations were conducted with two repetitions on each track.

Data collected in bird observations include: type, number of individuals of each species, location/position where observed (ground surface, forest floor, lower canopy, middle or upper canopy), and observer distance from the object/animal. To get additional information about the various species of birds within the study area, interviews with local community groups were conducted. The data obtained was then entered into the tallysheet.

B. PROBOSCIS MONKEY

For collecting data of proboscis monkey in the field, a census was conducted using a boat and concentration method in a river located in Sebangau National Park. The data collected were: number of individuals, number of groups, age structure, sex ratio, height of the proboscis position from the soil surface, the length of river as transect line and tree species where the groups were found.

C. ORANGUTAN AND ITS HABITAT

To measure the impact of the orangutan conservation programme and its habitat, transect lane method using orangutan nest calculation technique was equated with data collection of reforestation, peat rewetting and biodiversity. The number of paths, corresponding to the current number, by the length of the tracks taken 1 km and 500 m, the work steps required for survey by nest calculation was to collect data by tracing the line transect. In this orangutans nest calculation activity the data collected are:

- Location

Includes: a) Transect ID; b) Position of the initial Coordinate Point of the transect line to the end position of the Transect Line; c) The direction of transect; and d) Mileage per transect.

- Habitat Condition

Includes: a) Weather conditions during data collection; and b) canopy cover conditions (70-90% of relatively well forest, 50-70% of logged-over forest, 30-50% mixed or orchard gardens that have been abandoned and less than 30% of open fields or areas with relatively new conditions).

- Classes of nest

1st Class: Fresh, new nest, all leaves still green

2nd Class: The leaves are not fresh, all the leaves are still there, the shape of the nest is intact, the colour of the leaves is turning brown, especially on the surface of the nest, there is no hole seen from below

3rd Class: Old nest, all leaves are brown and even some leaves are gone; already seen a hole from the bottom

4th Class: Almost all the leaves are gone; already seen the structure of twigs.

- The height of the nest

Perpendicular height to the nest from the ground surface

- Nest Position

Includes: a) Position 1: at the base of the main branch; b) Position 2: in the middle or end of the branch; c) Position 3: at the top of the tree; d) Position 4: formed from branches of 2 different trees; and e) Position 0: on the ground.

4.3.2 ESTABLISHMENT OF AN APPROPRIATE HYDROLOGICAL REGIME

Restoring hydrological functioning should be the first consideration in the peatland rehabilitation. It is estimated that the hydrology is the most important environmental factor (50% relative importance) in controlling plant community structure (Graf, 2009). The hydrological regime is also the most important factor in establishment and maintenance of the PSF types and processes. According to Dommain *et al.*, (2010), the hydrological regime of degraded PSF's needs to be restored to enable recovery of the peat swamp forest ecosystem. Depression storage and surface detention is important to maintain moisture levels in the dry season. This can be re-established by stimulating the development of vegetation that can effectively reduce water discharge. In addition to blocking the canals, restoration should re-introduce buttressed trees by creating hummocks and re-plant areas especially in areas where surface slopes lead to rapid runoff. The hydrology greatly affects chemical and physical properties such as nutrient availability, soil salinity, sediment properties, pH and the degree of anoxia. Water inputs, if any, are a major source of nutrients. Restoring the hydrological regime is necessary for the establishment of target vegetation and nutrient cycling. A number of techniques used to restore wetland hydrology are outlined below:

- Blocking drainage ditches is an important step in restoring the wetland hydrology. This simple step will retain surface water and elevate the ground water level (see **Chapter 3.1**). Blocking of canals with multiple dams can be considered successful if blocked canal sections also hold water during the dry season;
- Berms or bunds along the edges of PSF to isolate them from low water levels in adjacent lands – e.g. peatland areas which have subsided due to over drainage or hydrological site (however care should be taken not to increase the water level too high in the PSF);

- Ensuring adequate water flow from upslope in the peatland – for example by putting outlets or overflows in boundary canals of plantations which may be upslope of the targeted rehabilitation areas; and
- The use of mulch or nurse plants increases the moisture level of the microclimate on the peat surface by increasing the relative humidity near the surface and decreasing the evaporation loss compared to a bare peat site.

It is not possible to create a universal formula for restoring the hydrology of the PSFs affected by disturbances. Each site has site-specific factors, which should be taken into consideration when rehabilitation strategies are being considered. It is generally recommended that the hydrological regimes should be restored to natural/original conditions prior to any disturbances (assessments can be done on healthy adjacent PSF areas to determine this) to ensure the long term ecological survival of the project area.

4.3.3 IDENTIFICATION OF SUITABLE SPECIES FOR REHABILITATION

The selection of tree species for the PSF rehabilitation should in the first place guided by suitability of the species for the site conditions. Certain PSF tree species appear to be more characteristic of deep peat while others occur on peat of shallower depth, while other species again seem to occur along the range of peat depths (Page and Waldes, 2005; **Table 4-2**).

Table 4-2: Main peatland tree species and ecological zoning (Principal tree species occurring in three PSF communities on peat of increasing depth across a peatland dome in the Sebangau catchment, Central Kalimantan adapted from Page and Waldes, 2005).

PRINCIPAL TREE SPECIES	MIXED SWAMP FOREST AT THE EDGE OF THE PEAT DOME	LOW POLE FOREST NEARER TO THE CENTRE OF THE PEAT DOME	TALL INTERIOR FOREST ON THE CENTRAL PEATLAND DOME
Palaquium ridleyi	X		
Calophyllum hosei	X		
Mesua sp.	X		
Mezzettia parviflora	X		X
Combretocarpus rotundatus	X	X	
Syzygium sp.		X	
Tristaniopsis obovata		X	
Shorea teysmanniana		X	X
Palaquium leiocarpum			X
Stemonurus secundiflorus			X
Neoscortechinia kingii	X		X
Palaquium cochlearifolium	X		X

Depending on the degree of degradation, conditions may differ considerably from the original PSF conditions, and this should be given due consideration. Former PSF areas that have been drained will be a lot drier than the original state, while areas that have been prone to (repeated) burning may also be subject to prolonged and/or deep flooding. Also, most degraded sites are also (much) less shaded than in the original PSF state. On the whole, species used for reforestation of the degraded areas will usually have to be able to cope with: i) more exposure to direct sunlight, ii) desiccation in the dry months, and iii) some degree of flooding in the wet season. Many species of mature PSFs will therefore not be suitable for the replanting of the degraded peatland, and the choice of species should during initial planting focus largely on those with a broad ecological tolerance, such as pioneer species (see **Table 4-3**).

Table 4-3: Pioneer/secondary PSF species in Sumatra and Kalimantan, Indonesia (Sources: van der Laan (1925), Giesen (1990), Bodegom et al., (1999), Kessler (2000), Giesen (2004), van Eijk & Leenman (2004) and Giesen (2008))

#	FAMILY	SPECIES	LOCAL NAME
1	Anacardiaceae	*Campnosperma coriaceum*	terentang
2	Anacardiaceae	*Campnosperma macrophylla*	terentang
3	Anacardiaceae	*Gluta renghas*	rengas
4	Anacardiaceae	*Gluta wallichii*	rengas manuk
5	Anisophylleaceae	*Combretocarpus rotundatus*	tumih, parapat, tanah tanah
6	Apocynaceae	*Alstonia pneumatophora*	pulai
7	Apocynaceae	*Dyera polyphylla*	pantong, jelutung
8	Arecaceae	*Licuala paludosa*	
9	Arecaceae	*Nenga pumila*	
10	Arecaceae	*Pholidocarpus sumatranus*	
11	Caesalpiniaceae	*Koompassia malaccensis*	kempas merah
12	Dipterocarpaceae	*Shorea balangeran*	belangiran
13	Ebenaceae	*Diospyros siamang*	eang
14	Elaeocarpaceae	*Elaeocarpus petiolatus*	
15	Euphorbiaceae	*Austrobuxus nitidus*	
16	Euphorbiaceae	*Glochidion rubrum*	
17	Euphorbiaceae	*Macaranga amissa*	
18	Euphorbiaceae	*Macaranga pruinosa*	mahang
19	Euphorbiaceae	*Mallotus muticus*	perupuk
20	Euphorbiaceae	*Mallotus sumatranus*	
21	Euphorbiaceae	*Pimelodendron griffithianum*	
22	Hypericaceae	*Cratoxylum arborescens*	geronggang
23	Hypericaceae	*Cratoxylum formosum*	popakan
24	Hypericaceae	*Cratoxylum glaucum*	bentaleng
25	Icacinaceae	*Stemonurus scorpioides*	pasir pasir
26	Lauraceae	*Actinodaphne macrophylla*	
27	Lecythidaceae	*Barringtonia macrostachya*	
28	Lecythidaceae	*Barringtonia racemosa*	
29	Melastomataceae	*Melastoma malabathricum*	senduduk
30	Melastomataceae	*Pternandra galeata*	
31	Mimosaceae	*Archidendron clypearia*	
32	Moraceae	*Artocarpus gomeziana*	
33	Moraceae	*Ficus deltoidea*	ara
34	Moraceae	*Ficus virens*	
35	Myristicaceae	*Knema laytericia*	pirawas
36	Myrtaceae	*Eugenia spicata*	ubah, kayu lalas
37	Myrtaceae	*Melaleuca cajuputi*	gelam
38	Myrtaceae	*Syzygium cerina*	
39	Myrtaceae	*Syzygium zippeliana*	
40	Pandanaceae	*Pandanus helicopus*	rasau
41	Rubiaceae	*Neolamarckia cadamba*	bengkal
42	Rubiaceae	*Timonius salicifolius*	
43	Rutaceae	*Melicope accedens*	
44	Theaceae	*Ploiarium alternifolium*	asam-asam
45	Ulmaceae	*Trema cannabina*	
46	Ulmaceae	*Trema orientalis*	landuhung

Many of the trials and the PSF reforestation attempts to date have mainly failed because the species used were unsuitable for the conditions at the specific location. **Table 4-4** gives an overview of the species tried to date in Southeast Asia, and the degree of success. As the degree of dryness and flooding can vary considerably (e.g. at various distances from a canal or burn scar), local conditions must be accurately mapped beforehand to guide species selection.

Table 4-4: Species used in restoration trials in Southeast Asia (adapted from Giesen, 2008).

#	FAMILY	SPECIES	LOCATIONS/ COUNTRIES	PERFORMANCE
1	Apocynaceae	*Alstonia spathulata*	Jambi	•
2	Dipterocarpaceae	*Anisoptera marginata*	Malaysia	•
3	Euphorbiaceae	*Baccaurea bracteata*	Thailand	•
4	Guttiferae	*Calophyllum ferrugineum*	Malaysia	o
5	Rhizophoraceae	*Combretocarpus rotundatus*	West Kalimantan	•
6	Leguminosae	*Dialium patens*	Thailand	o
7	Ebenaceae	*Diospyros evena*	Kalimantan	•
8	Bombacaceae	*Durio carinatus*	Jambi	o
9	Apocynaceae	*Dyera (lowii) polyphylla*	Jambi, Malaysia	•/o
10	Myrtaceae	*Eugenia kunstleri*	Thailand	•
11	Sapotaceae	*Ganua motleyana (syn. Madhuca motleyana)*	Thailand, Malaysia	•
12	Anacardiaceae	*Gluta wallichii*	Jambi	•
13	Thymelidaceae	*Gonystylus bancanus*	Jambi, Malaysia, Kalimantan	•
14	Malvaceae	*Hibiscus sp.*	Riau	•
15	Lauraceae	*Litsea johorensis*	Thailand	o
16	Euphorbiaceae	*Macaranga hypoleuca*	Riau	•
17	Euphorbiaceae	*Macaranga pruinosa*	Thailand, Malaysia	•
18	Myrtaceae	*Melaleuca cajuputi*	Indonesia, Thailand, Vietnam	•
19	Sapotaceae	*Palaquium sp.*	Jambi, Kalimantan	•
20	Verbenaceae	*Peronema canescens*	Kalimantan	o
21	Annonaceae	*Polyalthia glauca*	Thailand	•
22	Dipterocarpaceae	*Shorea balangeran*	Kalimantan	•
23	Dipterocarpaceae	*Shorea pauciflora*	Jambi	•
24	Dipterocarpaceae	*Shorea pinanga*	Kalimantan	o
25	Dipterocarpaceae	*Shorea platycarpa*	Malaysia	•
26	Dipterocarpaceae	*Shorea seminis*	Kalimantan	o
27	Icacinaceae	*Stemonurus secundiflorus*	Thailand	o
28	Myrtaceae	*Syzygium oblatum (syn. Eugenia oblata)*	Thailand	•
29	Theaceae	*Tetramerista glabra*	Jambi	o

*Note: • = good to very good (or >50% survival); o = poor to fair (or <50% survival)

Based on field experience and several surveys in Central Kalimantan, Giesen (2008) provides a preliminary list of species that have potential for the PSF restoration attempts, allocating these into four different flooding regimes:

1. Deepwater areas (deeply flooded for long periods),
2. Deeply flooded areas (frequently deeply flooded areas),
3. Moderately flooded areas (regularly, shallowly flooded areas), and
4. Rarely flooded areas

For each of these flooding types, a suite of potentially suitable species is listed (**Table 4-5**). The same suite can also be used for channel blocking programmes, with type (I) being equivalent to deep-sided channels, type (II) partially in filled channels, type (III) largely in filled channels, and type (IV) completely in filled channels. Over time, these types will naturally evolve from one into another. Studies in the PSFs show that deeper peat layers largely consist of *Pandanus* roots and stems, indicating that infilling of deeper waters may be an initial stage in natural peat formation in at least some areas. In deeply flooded former PSF areas, a similar succession may be attempted. In type (IV), once pioneer species have established a canopy, shade tolerant or requiring species can be planted as well, hastening the succession towards mixed peat swamp.

Table 4-5: PSF species suitable for rehabilitation programmes under various flooding regimes (adapted from Giesen, 2008)

#	GREEN CANAL BLOCKING	PSF RESTORATION	ENGINEERING SPECIES (I.E. ALSO SUITABLE FOR CHANNEL BLOCKING PROGRAMMES)	SPECIES	LOCAL NAME
1	Steep sided canals	PSF area deeply flooded during long period	TYPE (I): Deep water • *Hanguana malayana* • *Pandanus helicopus*	• *Hanguana malayana* • *Hypolytrum nemorum* • *Pandanus helicopus*	• Bakung • Rasau
2	Sloping sides (eroded or back filled) of canals	Frequently, deeply flooded PSF areas	TYPE (II): Deeply flooded • *Combretocarpus rotundatus* • *Lepironia articulata*	• *Combretocarpus rotundatus* • *Lepironia articulata* • *Mallotus sumatranus* • *Morinda philippensis* • *Psychotria montensis* • *Stenochlaena palustris*	• Tumih • Purun • Perupuk • Kiapak
3	Largely in-filled canals, with shallow pools	Regularly (shallowly) flooded PSF areas	TYPE (III): Moderately flooded • *Cratoxylum glaucescens* • *Ploiarium alternifolium* • *Shorea balangeran*	• *Blechnum indicum* • *Cratoxylum glaucescens* • *Ploiarium alternifolium* • *Shorea balangeran* • *Stenochlaena palustris*	 • Geronggang • Asam-asam • Belangeran/ kahui • Kiapak
4	Infilled canals	Flooding rare or absent in these PSF areas	TYPE (IV): Rarely flooded • *Alstonia spathulata* • *Dyera polyphylla*	• *Alstonia spathulata* • *Blechnum indicum* • *Dyera polyphylla* • *Macaranga sp.* • *Stenochlaena palustris*	• Pulai • Jelutung/ patung • Mahang • Kiapak
4b	As #4 above, with shade trees	As #4 above, with shade trees	TYPE (IV)B: Rarely flooded shade required	• *Alseodaphne coriacea* • *Baccaurea bracteata* • *Dialium patens* • *Diospyros evena* • *Durio carinatus* • *Ganua motleyana* • *Gonystylus bancanus* • *Peronema canescens* • *Shorea pinanga* • *Syzygium spp.* • *Tetramerista glabra*	• Gemor • Rambai • Uring pake • Durian hutan • Ramin • Punak

Once a suite of suitable species (i.e. species suited to the conditions of a site) have been selected, species selection can further be guided by guiding principles 2 Selection of beneficial species and 5 Avoiding use of exotic species. Beneficial species should be utilised where possible when the degraded areas that are being rehabilitated are located near villages, or belong to a particular community. The focus should not only be on timber species, as has often been the case to date, but on species that provide NTFPs. A preliminary list of potentially beneficial species – both for timber and NTFPs is included in **Table 4-6**. It should be remembered that restoration of the peatland hydrology is one of the key guiding principles, and that exotic species that require drainage are incompatible with this principle. Jelutung seedlings are shown in **Figure 4-8.**

Table 4-6: Peat swamp forest species suitable for timber and NTFPs. (Source: Giesen 2008 – see also Giesen et al., 2015)

#	FAMILY	SPECIES	LOCAL NAME	TIMBER	NTFP
1	Anacardiaceae	*Mangifera havilandii*	*resak rawa*	+	
2	Anisophyllaceae	*Combretocarpus rotundatus*	*tumih*	+	fuelwood
3	Apocynaceae	*Alstonia spathulata*	*pulai*	+	
4	Apocynaceae	*Dyera polyphylla*	*jelutong*	+	latex
5	Araucariaceae	*Agathis borneensis*		++	
6	Bombacaceae	*Durio carinatus*	*durian hutan*	+	edible fruit
7	Dipterocarpaceae	*Dipterocarpus verrucosus*	*karuing*	+	resin
8	Dipterocarpaceae	*Dryobalanops spp.*	*kapur naga*	+	
9	Dipterocarpaceae	*Hopea spp.*	*lentang bangkirai*	+	
10	Dipterocarpaceae	*Shorea balangeran*	*belangiran*	++	
11	Dipterocarpaceae	*Shorea leprosula*	*lentang*	+	
12	Dipterocarpaceae	*Shorea parvifolia*	*meranti batu*	+	
13	Dipterocarpaceae	*Shorea rubra*	*meranti bahandang*	+	
14	Dipterocarpaceae	*Shorea smithiana*	*lentang mahambung*	+	
15	Dipterocarpaceae	*Shorea uliginosa*	*lentang bajai*	+	
16	Dipterocarpaceae	*Shorea spp.**	*tengkawang*	++	illipe nuts
17	Euphorbiaceae	*Baccaurea bracteata*	*rambai*		edible fruits
18	Guttiferae	*Callophyllum grandiflorum*	*bintangur*	+	
19	Guttiferae	*Garcinia spp.*	*manggis hutan*	+	edible fruits
20	Hypericaceae	*Cratoxylum spp.*	*gerunggang*	+	
21	Lauraceae	*Alseodaphne coriacea*	*gemor*		bark for mosquito coils
22	Myrtaceae	*Melaleuca cajuputi*	*gelam*	+	fuelwood, oil
23	Myrtaceae	*Tristaniopsis maingayi*	*palawan/ balawan*	+	
24	Podocarpaceae	*Dacrydium pectinatum*	*alau*	++	
25	Sapotaceae	*Ganua motleyana*	*katiau*	+	
26	Sapotaceae	*Palaquium rostratum*	*nyatu/ nyatuh*		latex
27	Sapotaceae	*Palaquium leiocarpum*	*jangkang*		latex
28	Theaceae	*Ploiarium alternifolium*	*asam-asam*		edible young leaves
29	Thymelaceae	*Gonystylus bancanus*	*ramin*	++	

Notes: + Good timber species, ++ Excellent, valuable timber species

Figure 4-8: Jelutung seedlings at a nursery.

There are also several palm species that can be easily planted on peat e.g. red pinang palm (*Cyrtostachys renda*), salak hutan (*Salacca magnifica*), sago palm and some species of wild pandan.

Succession-Based Approach

Rehabilitation planting programmes should take a succession-based approach, first utilising pioneer species with a broad ecological tolerance, later adding climax species/species of mature/mixed PSFs species. The latter would be appropriate if, for example, the aim is to increase the density of certain beneficial species characteristic of mature PSFs, or if the aim is to increase biodiversity value if the area is adjacent, near or forms part of a conservation area.

Studies of succession in peat usually show a historic transition from either a freshwater swamp (with *Pandanus*) or mangrove to a mixed peat swamp forest. In terms of coping with increased flooding in degraded peat (e.g. after subsidence or loss of peat after fires), the approach would be to mimic the historic succession and start once again with very flood tolerant species such as *Pandanus helicopus*. Once a location becomes shallower or partially infilled, species that have some flood tolerance such as *Combretocarpus rotundatus* can be added. Possible suites of species with differing flood tolerance are listed in **Table 4-6**.

As peat accumulates over time, a particular site may develop a mixed PSF. Although containing less biodiversity than lowland dipterocarp forests, mixed peat swamp forests can attain a canopy height of 35-40 meters and include anywhere from 30-130 tree species at a given location (Giesen, 2004).

Light conditions in peatland vegetation also vary over time. In the degraded conditions, light conditions will be harsh and shade requiring species more common in mature PSFs will not flourish. In pole forest, light penetration is greater than in mixed/mature PSFs, and once again light conditions may be more harsh and contribute to unfavourable conditions for certain species. Little is known about light requirements of the PSF tree species, but one may assume that pioneer species have a high tolerance, while species that occur only in mature-mixed PSFs are likely to be less tolerant.

4.3.4 ENCOURAGING NATURAL REGENERATION

The basic principle behind encouraging natural regeneration is to assist nature to grow its own new plants by removing constraints. Native plants normally self-seed and re-grow new seedlings by themselves. This is called natural regeneration and it is the normal process in a healthy swamp. It is the most natural method and gives the best results in terms of biodiversity. Natural regeneration is usually the low input option. Plantation growers can assist this process by removing elements that threaten existing native vegetation. This involves controlling inappropriate weeds, putting up fences/barriers to protect the area or changing drainage techniques. Maintenance should not be required unless weeds prevent the regeneration of native species, in which case weed control becomes necessary.

Inventories of existing plants and ecological surveys of the area during the planning stage will provide information on whether encouraging natural regeneration will suffice to rehabilitate the area. If not, enrichment planting and/or active replanting (see **Chapter 4.7**) will be necessary.

It is also important to identify the barriers or the factors that impede recruitment and regeneration processes. These include identification of factors like seeds, dispersal patterns and establishment limitations. Various approaches to overcome these limitations are illustrated in **Figures 4-9** and **4-10**.

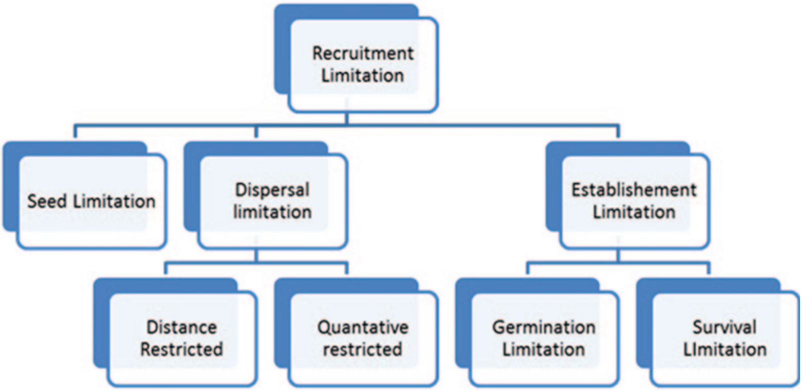


Figure 4-9: Factors that may limit regeneration of peat swamp forests.

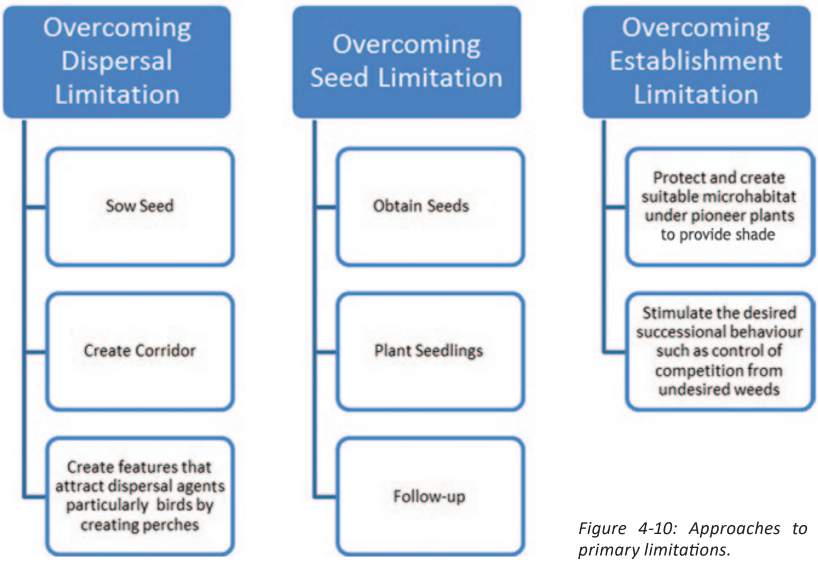


Figure 4-10: Approaches to overcome primary limitations.

4.3.5 ENRICHMENT PLANTING/REPLANTING

Enrichment planting or active replanting may be necessary depending on the degree of degradation of the peat swamp forest area. If the natural regeneration is not possible or insufficient, enrichment planting can be a useful intervention to assist the rehabilitation. Suitable species for enrichment planting will depend on the stage of succession currently in progress. If pioneer species are well established, shade tolerant or requiring species can be planted, hastening the succession towards a mixed peat swamp. If the area has been completely cleared or repeatedly burned, it may be necessary to implement a full-fledged peat swamp forest rehabilitation programme.

Detailed guidance on implementing such programme is provided in **Chapter 5**. It is useful to note that government research units are sometimes able to provide ready-to-plant material that is available in sufficient quantities at reasonable cost (see **Box 4-6** for an example of an offer in Indonesia).

BOX 4-6

Example of Seedling Offer in Indonesia

The following offer was provided by Koperasi Pegawai Negeri Sylva Balai Penelitian Kehutanan Aek Nauli (Address: Kampus Kehutanan Aek Nauli, Km 10.5, Sibaganding, Parapat, Indonesia) to an oil palm plantation company.

Table 4-7: Available seedlings for PSF rehabilitation.

#	TYPE	SPECIFICATIONS	STOCK	PRICE PER SEEDLING (IDR)
1	Meranti Batu	30cm height	20,000 seedlings	1.600, -
2	Meranti Merah	20cm height	10,000 seedlings	1.600, -
3	Bintangur	20cm height	40,000 seedlings	1.600, -
4	Pulai	30cm height	2,000 seedlings	1.800, -
5	Mayang	50cm height	20,000 seedlings	1.600, -
6	Arena	2-3 leaves	15,000 seedlings	4.000, -

NOTE:

- For seedling types numbered 1-5, the recommended spacing for planting is 3m x 3m.
- For seedling type number 6, the recommended spacing for planting is 6m x 6m.
- Prices above are as of June 2011.

4.4 PALUDICULTURE

Large-scale agriculture on tropical peatland is generally done using species that require drainage (i.e. *Acacia*, oil palm). Although these species contributed significantly to the local and national economies, it also comes with high environmental cost – e.g. peat subsidence, fires and associated haze, GHG emission, etc. To prolong economic lifespan of cultivated peatlands, there is a need to replace existing drainage-based agriculture with a land-use that does not need drainage.

Productive land use on rewetted peatland with crops that are adapted to the high water levels in peatlands is called 'paludiculture'. The PSF species are being used traditionally and there are over 400 species known which have productive use (Giesen, 2015). For centuries, the local populations have used paludiculture techniques to cultivate crops that are native to peatlands, such as sago (starch for noodles and cookies), rattan (for furniture), gelam (for pole-wood and medicinal oil), jelutong (for latex), tengkawang (illipe nut, for vegetable oil) and purun grass (for thatching and basketry). Their cultivation however, is mainly on small-scale and requires extensive trialling and up-scaling for it to become a viable solution for sustainable development needs for large areas. This is, however, a necessary investment to sustain productivity of the peatlands.

Cooperation with communities and local governments is important to get acknowledgements for new forms of cultivation. Buffer zones could be prioritised for piloting the different paludiculture species, to study agronomic, economic and political feasibility of such new business model.

4.4.1 POTENTIAL PALUDICULTURE CROP SPECIES

Information on potential paludiculture crop species is drawn mainly from the review by Giesen and Nirmala (2018). The potential for paludiculture in Indonesia was assessed by Giesen (2015) who used his database of indigenous peat swamp forest plant species in Southeast Asia as a starting point and compared this with useful species as recorded by PROSEA (Plant Resources of Southeast Asia), a programme that ran from 1990-2004 and set out its findings in 19 volumes. The results, which are summarised below, indicate that Indonesia's indigenous peat swamp flora holds a very significant potential for paludiculture. Since then, a guidebook on a limited number of key species has been produced by MoEF (FORDA) and Wetlands International (Tata & Susmianto 2016).

Giesen (2015) indicated the following key facts:

- 1376 higher plant species have been recorded in lowland Southeast Asian swamp forests;
- 534 species (38.8% of total) have a known use;
- 222 produce useful timber;
- 221 are known to have a medicinal use;
- 165 are used for food (e.g. fruits, nuts, oils); and
- 165 have been assigned "other" uses (e.g. latex, fuel, dyes).

Many are known to have multiple uses and 81 non-timber forest product (NTFP) species have a 'major economic use' (as reported by PROSEA - www.prosea.nl). An initial economic assessment indicates that based on returns, some indigenous peat swamp forest species are potentially competitive with oil palm and *Acacia crassicarpa*. Also, swamp jelutung (*Dyera polyphylla*) is potentially an attractive alternative for local communities as the return on labour may be greater than for oil palm (Sofyuddin *et al.,* 2012). However recent market studies indicate that this would need to be re-established for jelutung as the existing market folded following the steep decline in harvest from natural forests and availability of alternatives manufactured from oil.

A further assessment by the BGPP project (Kehijau Berbak, 2017) of these 81 NTFP species with a potentially 'major economic use' assigned these species to four categories:

- 'quick gain' species (6 species), which are mainly herbaceous species that produce quick results (but have a lower unit value, although the overall market may be good); species include *Eleocharis dulcis* (purun or water chestnut), *Ipomoea aquatica* (kangkung or water spinach), *Momordica charantia* (paré or bittergourd), *Uncaria gambir* (gambir or gambier, a climber), and *Nephrolepis biserrata* and *Stenochlaena palustris* (both pakis, edible ferns);
- proven commercial species (6 species), namely *Aquilaria beccariana* (gaharu, which produces incense after inoculation or whose leaves can be harvested for medicinal tea) (see **Figure 4-11**), *Melaleuca cajuputi* (kayu putih or gelam, that produces poles, honey, oils), *Metroxylon sagu* (sagu, producing flour/starch), *Dyera polyphylla* (jelutung, producing latex) and *Nothophoebe coriacea* and *Nothophoebe umbelliflora* (gemor, that produce bark used as insect repellent). These species have products of a known commercial value and are known to perform on (rewetted) peat;
- commercial species that require further performance tests on peat (11 species), namely *Garcinia mangostana* (manggis or mangosteen), *Nephelium lappaceum* (rambutan), *Syzygium aqueum* (jambu air), *Shorea stenoptera*, *S. pinanga*, *S. seminis*, *S. macrophylla* (tengkawang or illipe nut), *Aleurites moluccana* (kemiri or candlenut), *Pometia pinnata* (kasai or matoa), *Syzygium polyanthum* (salam, daun salam) and *Terminalia catappa* (ketapang). These species have products of a known commercial value and occur in natural peat swamp forest, but their performance (e.g. fruit production, growth rate) on peat is unknown.

- other species: many uncertainties: market studies, ecological studies (58 species); the remaining species have many uncertainties at present, but warrant further study as they appear to hold potential.

Figure 4-11: Gaharu (Aquilaria beccariana) a potential paludiculture species underplanted in former oil palm plantation in Selangor, Malaysia.

4.4.2 SELECTED PALUDICULTURE SPECIES

Further information is given below in selected species with good potential for paludiculture (drawn mainly from Giesen and Nirmala, 2018):

a. Swamp jelutung (*Dyera polyphylla*)

Swamp jelutung (See **Figure 4-12**) has been harvested from natural forests for many years and produces a latex similar to that of rubber – but which has a range of uses including for chewing gum, mouldings and high grade electrical insulation. It was cultivated on a larger scale near Sungai Aur village, Tanjung Jabung Timur district, in Jambi, Indonesia by the company PT Dyera Hutan Lestari, from 1991-2004. By 2004, a total of about 2,000 ha had been planted and latex tapping was already occurring (Muuss 1996, Giesen 2004). However, as the hydrology had not been managed properly, the plantation was destroyed by fires in 1997 and again in 2004 and subsequently abandoned. The company did demonstrate, however, that cultivation of the species on a commercial industrial scale is indeed possible. Since then, ICRAF, FORDA and the local forestry department have continued trial plantings with swamp jelutung and the species can be regarded as being well on the way to domestication (Tata *et al.*, 2016), although all hurdles have far from been cleared. Further information is also given in Perdana *et al.*, (2016).

Figure 4-12: Jelutong in Berbak landscape, Jambi, Indonesia being tapped for latex

b. Alternative pulp species

Alternative species for pulp and paper production on peat have been reviewed by Suhartati *et al.* (2000). The pulp and paper company Asia Pulp and Paper (APP - part of the Sinarmas group) has conducted trials, on alternative species to *Acacia crassicarpa* for pulp and paper production on rewetted peat. A 16 ha trial area was planted in a programme developed for them by Euroconsult Mott MacDonald in 2016 with four species: terentang (*Campnosperma coriaceum*), geronggang (*Cratoxylum arborescens*), gelam (*Melaleuca cajuputi*) and belangeran (*Shorea balangeran*), of which gelam seems the most promising in terms of growth rate and pulping properties (APP, 2017). In addition to these four species, APP aims to trial tumih/perapat (Combretocarpus rotundatus), sesendok (*Endospermum diadenum*), perupuk (*Lophopetalum multinervium*), bengkal (*Nauclea subdita*) and kess/bus putih (*Lophostemon* spp.). In addition, with assistance from University Gajah Mada, they are sourcing a second gelam species from Kalimantan (*Melaleuca leucadendra*) and she-oak species (*Casuarina equisetifolia*) from Pulau Belitung (APP, 2017).

c. Tengkawang (*Shorea spp.*)

Tengkawang or illipe nut produces high value fats/butter that can be used as a cocoa substitute or in cosmetics (See **Figure 4-13**). In 2017, the plantation company PT Tolan Tiga Indonesia (PT TTI) established trials with tengkawang species on 10 ha of rewetted peatland at Sungai Barumun in Riau. In all, five Shorea species were trialled, namely *Shorea stenoptera, S. pinan*ga, *S. seminis*, *S. leprosula* and *S. selanica*, of which the first three species produce tengkawang (illipe) nuts. These first trials faced lots of challenges, such as difficulties in sourcing propagation material, and their mortality rates were high (67% average). Nevertheless, PT TTI is optimistic that they can greatly improve plantings and can reach survival rates of 60% or more; they will continue their trials in the coming years (de Clermont-Tonnerre, 2017).

Figure 4-13: Fruit and "butter" of illepe nut

d. Sago

Sago (*Metroxylon* spp.) (See **Figure 4-14**) has been cultivated traditionally in parts of Sumatra for decades, if not hundreds of years, especially in Riau and Aceh as well as Peninsular Malaysia and Sarawak and extends over a total area of probably several tens of thousands of hectares. The starch is traded between Indonesia and Malaysia and Singapore, across the Malacca Strait as well as with Japan. In Papua, naturally-dense sago peatland forests exits providing the main staple food for local communities. In some parts of Sumatra, it has disappeared, such as in Jambi where it also was common until several decades ago. In Riau, it is commonly grown in peatland on the islands of Bengkalis, Padang and Tebing Tinggi, where cultivation goes back more than 100 years. Sago cultivation on Pulau Padang was studied by Sonderegger and Lanting (2011). On this island it forms the main commodity grown, together with rubber, as both extend over about the same area. Sago is grown extensively with low investments, nevertheless generating revenue of IDR 4.5 million (US$300)/ha/year. As mentioned in Giesen (2013), peatland is generally undrained, although small channels (parit) of 20-30 cm depth are excavated to allow easier access and extraction of the sago trunks.

Figure 4-14: Sago palm and sago processing

On adjacent Tebing Tinggi, the main peatland commodity is also sago, which is grown as a cash crop and for subsistence by communities living in the area. The inauguration of the Peatland Restoration Agency (BRG) was held in Sungai Tohor (on the north-eastern side of the island), as this village has been depicted as an "International Peatland Laboratory" (Widaretna & Janssen 2017). Sago has been grown by the community of Sungai Tohor at least for decades; it has been their staple food since the 1970s and sago plays a central role in the community's daily life. Processing of sago is conducted at home industry level, and delivers end user products such as sago starch, noodles, snack such as *sagu telur* and *sagu lemak*, while sago starch is commonly exported abroad. The community has had conflicts with external investors who would like to see sago replaced with oil palm or *Acacia*. The planting area of sago palms near Sungai Tohor is always wet peat, and although the community has constructed canals, this is for transportation purposes only and traditional canal blocks are made from wood to manage the water level (Widaretna & Janssen 2017). Due to the success of the sago planting in Sg Tohor, BRG had seen the potential for sago as the main species for restoration of degraded peatlands. The selection is in line with the President's Directive that restoring the degraded peatlands should bring economic value to the local community.

e. Rattan

Rattans are group of climbing palm, mostly living as a colony, which grows fast. It is easy to harvest, requiring simple tools, and is easy to transport. It is used for making furniture, baskets and souvenirs. A total of 20-odd rattan species have been recorded in PSFs, including 7 *Calamus* spp., 5 *Daemonorops* spp., 5 *Korthalsia* spp. and 2 *Plectocomiopsis* spp. Rattan requires trees to climb in and reach the canopy to catch the necessary sunlight. In Mendawai village, Katingan, Central Kalimantan, rattan has been cultivated since the 1970s. It is planted in pairs with Jelutung to have both swamp rubber and rattan harvests. This land-use system is applied in two-thirds of the village land covering almost 7,000 ha. The yield from rattan is the second largest source of income for the village. The rattan used to be exported to China but since the government of Indonesia has introduced an export ban, only domestic trade is possible.

f. Medicinal plants

A number of tropical peatland species have known medicinal properties and this could lead to potential beneficial use through paludiculture. The potential for bio-prospecting peat swamp forests for medicinal plants may however, be significant because peat swamp plants produce chemical compounds (e.g. alkaloids) to deter herbivory at a much higher level than species in non-flooded areas. This is especially evident, when the same species occurs both on mineral and peat soils: on peat they are more toxic (Lim *et al.*, 2014), and novel properties have been identified. Species of interest include:

i) **Kacip Fatima *Labisia pumila*** which is a traditional herb widely used as post-partum medication for centuries. Recently, extensive researches have been carried out on the phytochemical identification, biological and toxicological studies for the herb (Chua *et al.*, 2012). Phytochemicals found in the herbal extract showed high antioxidant properties and for addressing estrogenic deficiency and immunodeficiency diseases. Another finding that has considerable impact on natural product research is the contribution of *L. pumila* in promoting skin collagen synthesis. The performance of the herb as anti-aging agent due to natural aging process and accelerated by UV radiation.

ii) **Tengek burung *Melicope luna-ankenda*** which has anti-cancer and anti-diabetes properties (Eliaser *et al.,* 2018). Different parts of *M. lunu-ankenda* have been used for treatment of hypertension, menstrual disorder, diabetes, and fever, and as an emmenagogue and tonic. It has also been consumed as salad and as a condiment for food flavourings. The justification of use of *M. lunu-ankenda* in folk medicines is supported by its reported biological activities, including its cytotoxic, antibacterial, antioxidant, analgesic, antidiabetic, and anti-inflammatory activities. The species has been used in Malaysia as a fast growing peat swamp forest pioneer which is hardy and easily grown from seed or wildings and suitable for rehabilitation of severely degraded peatlands. Further development of its medicinal uses could enhance its value further.

iii) ***Calophyllum teysmannii (var. inophylloide)*** which occurs in peat swamp forests in Sarawak was found to have anti-HIV properties and a promising new line of coumarins used in chemotherapy was developed for medical purposes (Fuller *et al.*,1994).

4.4.3 ECONOMICS OF PALUDICULTURE

One important factor for the viability of paludiculture is the economic potential of the species concerned. **Box 4-7** is based on an assessment by Giesen (2015).

Box 4-7

Economics of peat swamp NTFPs (from Giesen, 2015)

There have been few economic studies on Non-Timber Forest Products (NTFPs) in peat swamps: on sago (*Metroxylon sagu*) and *Hevea* rubber (Sonderegger and Lanting, 2011) and swamp jelutung (*Dyera polyphylla*) (Sofiyuddin *et al.* 2012). Production figures are known for other commodities on mineral soil, such as tengkawang (illipe nuts), paperbark (gelam or *Melaleuca cajuputi*) and candlenut (*Aleurites moluccana*), and these can be interpolated for peat soils. Productivity on hydrated (wet) peat is often lower than on mineral soils, and sago, for example, is found to be 25% less productive on hydrated peat (Flach and Schuiling, 1989). Not all commodities are less productive on peat than on mineral soil. Asia Pulp and Paper manages *Acacia crassicarpa* plantations with an average production of 25 tons/ha/yr (max. 35 tons/ ha/yr), with the best results being on deep peat (pers. comm. C. Munoz, APP, 2013). **Figure 4-15** displays returns (USD/ha/yr) for plant products on peat, including rubber, palm oil, sago, swamp jelutung, gelam, illipe nut and candle-nut. These figures are from peatland studies (Duc and Hufschmidt 1993, Sonderegger and Lanting 2011, Sofiyuddin *et al.* 2012), or from studies on mineral soils, with production figures adjusted downward (-25%) to reflect a possible lower productivity on peat. Values have been corrected for inflation to reflect 2014 prices. In addition, illipe nut displays mast fruiting every 3-4 years, so the average non-mast return (460-3,000 USD/ha/yr) was combined with the average mast fruiting return (8,800-11,500 USD/ha/yr) on a 3.5:1 basis (Smythies 1961, BlicherMathiesen 1994). Therefore, returns vary from USD 480/ha/yr for extensive, low input sago on Padang Island (Sonderegger and Lanting, 2011) to USD 6800/ ha/yr for candle-nut (combined data from Manap *et al.* 2009 and Kibazohi and Sangwan 2011).

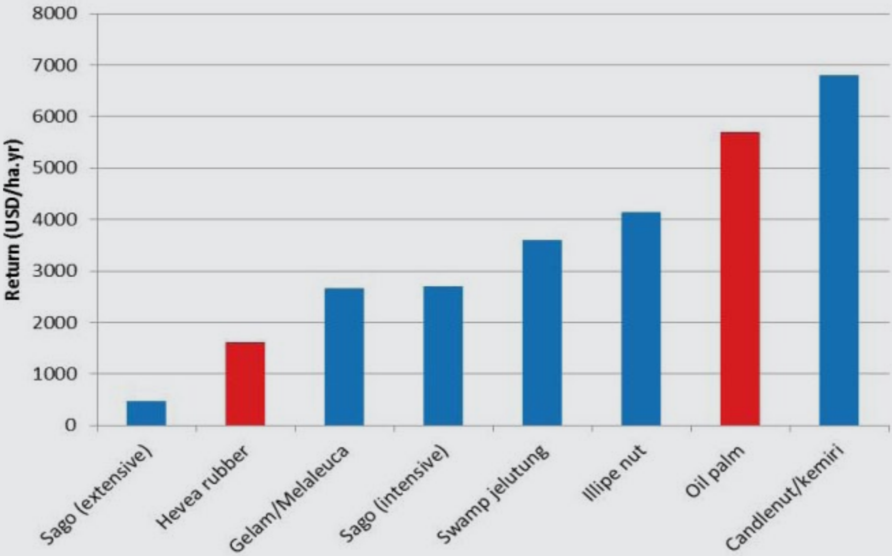


Figure 4-15: Financial returns of agricultural commodities grown on peat (Source: Giesen, 2015)

Several commodities (e.g. candlenut, illipe nut and swamp jelutung) appear in the same level as oil palm. Other economic aspects need to be taken into account too. In a comparative economic study of swamp jelutung and oil palm on degraded peat (Sofiyuddin *et al.* 2012), swamp jelutung returns were 37% lower than oil palm, but labour return was higher i.e. US$ 16.46 per person day for swamp jelutung against US$ 16.06 for oil palm. For smallholders with adequate access to land, return on labour is often more important than return per hectare per year, while for plantation companies the return per hectare is more significant, because licensing is usually area based.

Research and selection trials on swamp jelutung could further boost production, as commodities such as palm oil *Acacia* and *Hevea* rubber have benefited from many decades of research, selective breeding and cloning. Initial trials with indigenous swamp forest species have been undertaken, but yield optimisation with regards to swamp jelutong remains in its infancy and there is a great scope for further knowledge expansion. A study by Turjaman *et al.* (2006) in Central Kalimantan, for example, found that inoculation of growth medium with arbuscular mycorrhizal fungi boosts the growth rate of swamp jelutung.

Swamp jelutung, illipe nut and oil palm become less productive and need to be replaced over time; oil palm after 25-30 years (Basiron and Weng 2004), swamp jelutung after 30-40 years, while illipe produces nuts much longer, although it is not yet known how many years it will still be commercially productive. Replacement of any crop is an additional cost. For oil palm it means that the palms are uprooted and removed from the site. For swamp jelutung, however, the timber is much sought after for fine carpentry, carving and pencils and felling leads to added benefits. It can fetch up to US$ 700-800/m^3. Likewise, most of the *Shorea* species producing illipe nuts also produce a valuable timber (PROSEA, 1990-2004).

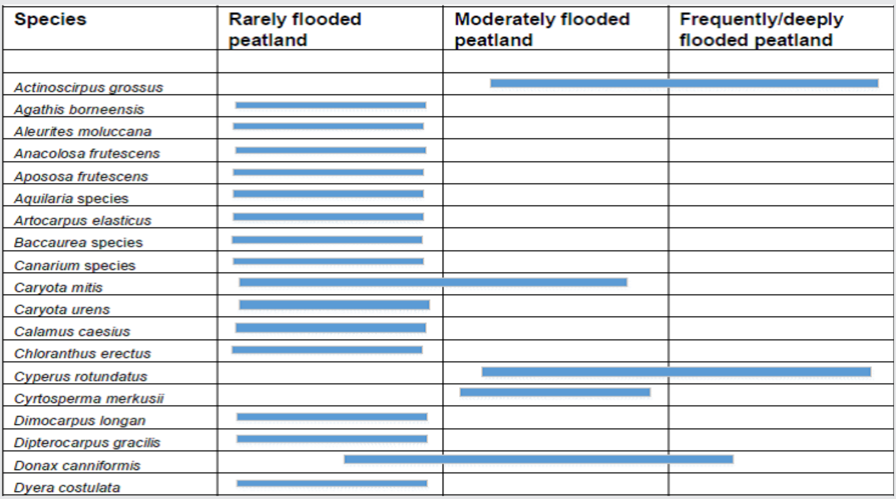
Additional benefits can be secured by using peat adapted species in programmes that include rehabilitating the hydrology of degraded peatland, thereby curbing and preventing peat loss. These benefits may be monetised, for example, on payment for carbon credits under an REDD+ scheme. Rehabilitated areas under a paludiculture programme will reducing the number of fires and associated smoke haze. This will generate health benefits and lead to fewer transport disruptions. Costs for regular deepening and upgrading of drainage are avoided under a paludiculture regime. This knowledge is also embraced by the palm oil industry, where the RSPO recently discouraged its members from peat development (Schrier-Uijl *et al.* 2013).

Note: The recent RSPO P&C 2018 has specifically encouraged the replacement of oil palm with paludiculture species based on the results of the RSPO Drainability Assessment. In addition, the Indonesian President issued a decree in 2016 to establish the Peatland Restoration Agency which includes development of paludiculture as one of its strategies.

Box 4-8 lists 42 potential paludiculture species in relation to their water/flood tolerance.

Box 4-8

Paludiculture species and flood tolerance (Source: Giesen & Nirmala 2018: Tropical Peatland Restoration Report: The Indonesian Case)



4.4.4 UPSCALING PALUDICULTURE

Currently multiple aspects have been identified that act as barriers to upscaling of paludiculture as a sustainable alternative of sustainable land-use including:

- **Gaps in technical knowledge of paludiculture species**
  This includes information about seed sourcing and treatment, nutrient requirements, intercropping possibilities, harvesting methods and intensities, product processing and so on (Giesen & Nirmala, 2018).

- **Lack of market incentives**
  Markets for paludiculture products are small, under developed or inaccessible. Expertise is needed to analyse market requirements for products ((uniformity in) quality and quantity) and gain access to these markets (logistics, standards required). The markets need to be local and those involved in growing these crops need to be able to realise added value from them. For example paludiculture crops should be processed locally rather than exported or sent in raw form to far away markets.

5.0 IMPLEMENTING PEAT SWAMP FOREST RE-VEGETATION

5.1 INTRODUCTION

Oil palm plantations have demonstrated clear leadership and excellence in breeding and producing healthy plants, nurturing them and ensuring their survival. With many oil palm plantations operating nurseries successfully, they would be a perfect partner for the establishment of tree nurseries to raise peat forest species for reforestation or rehabilitation. This provides a distinct advantage for rehabilitation of degraded peatlands.

The following detailed guidance on replanting activities in peat swamp forests is mainly adapted from the 'Manual on Peat Swamp Forest Rehabilitation and Planning in Thailand' (Nuyim, 2005), the "Guidelines for the Rehabilitation of Degraded Peat Swamp Forests in Central Kalimantan" (Giesen and van der Meer, 2009) and a guideline on revegetation for peatlands produced by the Indonesian Peatland Restoration Agency (BRG, 2016) as well as experience by RSPO members in undertaking rehabilitation work.

In terms of rehabilitation strategy, it is important to determine the root causes of the degradation of the site and ensure that these root causes will be addressed as part of the rehabilitation programme. If the root cause is over-drainage – then drains should be blocked or water control structures constructed to restore natural hydrology; if the root cause is encroachment by local community – this needs to be addressed through enforcement or negotiation before rehabilitating the site.

In addition, it is necessary to decide whether the rehabilitation will be undertaken through assisted natural regeneration or replanting or a combination of the two. In general, natural regeneration is preferable but may be slow (depending on site conditions) while replanting may generate faster initial results, but will be more expensive and in the long term may be less resilient.

5.2 SEED STOCK COLLECTION AND DEVELOPMENT OF NURSERIES

The choice of seedling is one of the major factors that determine the success or failure of reforestation efforts. Healthy, strong and proper-sized seedlings, when planted, are able to survive and grow to large trees. On the other hand, unhealthy seedlings will not survive – making it a waste of resources in terms of the preparation and additional time required for replacement planting. Poor planning during the preparation of seedlings may also result in shortage of seedlings for replanting for a particular year, causing a great loss to the rehabilitation programme.

It is also critical to select appropriate species for the rehabilitation work. As mentioned in **Chapter 4** there are a range of possible species that can be used for PSF rehabilitation. The selection should be linked to the level of site degradation and the ecology of the region. In degraded, open sites it is necessary to plant relatively fast growing species which are tolerant of open conditions. Species such as Mahang (*Macaranga pruinosa*), Gelam (*Melaleuca cajuputi*) and Tenggek Burung (*Melicope lunu-ankenda*) are fast growing pioneer species which can flower and fruit within two years enabling further natural regeneration. In sites where there are already pioneer species present, the focus may be on bringing in a broader range of species suitable for the nature forest.

5.2.1 SEEDLING PREPARATION

Figure 5-1: To supplement wild seed supplies, wild seedlings can be collected on-site or in adjacent areas.

Ensuring an adequate supply of quality seedlings requires planners to be well-informed of the types of seedlings to be used for the rehabilitation. Requirements include the planners' prior knowledge about the quantity of seedlings required for the planting including estimated replacement planting, size and height of seedlings suitable for the planting, time for the planting, as well as planting patterns and conditions. In addition, good planning for quality seedlings requires the planners to make additional efforts for collecting wildings or seeds, determining seed sources and the collection season (**Figure 5-1**). Certain seeds have to be sought from distant areas if the seeds are not available on-site. Planning for the production of seedlings of wild plant species requires more attention than the preparation of fruit tree seedlings or seedlings of economic species. Seedlings of fruit trees and economic plants are commonly found and can be acquired from other sources too. Wild plant seedlings are cultivated by only a few nurseries.

5.2.2 SELECTING PLOTS FOR NURSERY

A critical criterion for selecting a suitable plot for seedling nursery is that the plot should be located on flat land outside the PSF, or the plot area must not be waterlogged. The plot should be convenient for undertaking nursery work with for example sandy loam soil. If necessary, sand can be put on top of the soil to prevent the nursery plot from being soggy. Another factor to be considered is that the area must have easy access to water all year round, whether from the peat swamp or other natural sources such as marshes, canals or wells. More importantly, the plots should be accessible to vehicles all year round and preferably equipped with electricity. In addition, labour should be easily available in the area. A case study in Ketapang, West Kalimantan from PT SNA is included as in **Box 5-1**.

Box 5-1

Forest tree nursery PT. SNA Ketapang, West Kalimantan

A nursery with forest species for rehabilitation programme had been set up in the plantation concession of PT. BSS (one of the plantation companies of PT. SNA in Ketapang). The nursery raised approximately 15,000 seedlings of a variety of species from October 2016 – July 2017 see **Table 5-1** and **Figure 5-2**.

Table 5-1: Seedlings raised in the forest nursery of PT. BSS from October 2016-July 2017

SPECIES NAME	LOCAL NAME	NUMBER
Combretocarpus rotundatus	Perepat	4,570
Alstonia spp.	Pulai	2,550
Melaleuca cajuputi	Gelam	17
Macaranga pruinosa	Mahang	865
Shorea belangiran	Belangiran	6,892
Ploiairium alterniflolium	Asam-asam	30
Ficus spp.	Ara	50
Total		14,974

Figure 5-2: Seedlings at nursery

5.2.3 CONSTRUCTION OF NURSERY HOUSE AND SEEDLING NURSERY

After selecting the site for the seedling nursery, another criterion would be whether there is adequate shade and sunlight for the seedlings. Sunlight is an important factor in regulating growth and promoting the health of plants. Sunlight should be able to penetrate all seedling storage areas, and at least 50% of the open spaces. Seedlings that lack exposure to sunlight grow very tall and young branches break easily.

Initially, existing vegetation on the site should be cleared. Then, the area must be levelled and the nursery house built on the space. Large and strong poles should be used for building the nursery house. Once poles are piled into the ground, bamboo stalks or metal pipes should be placed on the top ends of the poles. Once the bamboo stalks or metal pipes are connected to the top ends of all poles, a shading plastic panel is attached on top of these stalks or pipes. Each roll of shading plastic panel can be connected to another by manual sewing with nylon thread of metal wire. Depending on the colour of these plastic panels, the shading capacity ranges from 30% to 50% to 70%. For nursing or seedlings, a 50% shading panel is applied.

A seedling nursery bed can be built using cement bricks to form a structure that looks like an open box. The bed is filled with sandy loam or crushed coconut fibre. This is for sowing seeds.

Figure 5-3: Example of nursery set up for a peat rehabilitation project by local community in Selangor, Malaysia.

5.2.4 ESTABLISHMENT OF WATER PROVISION

A temporary water tank should be installed in forest nurseries. Piping should be joined with the temporary water tank. The diameter of the pipe should be adjusted according to distance from the tank to the piping network. There are also other methods of water provision such as utilising a good quality water pump rather than a temporary water tank, and through inexpensive sprinkler systems, which can provide significant labour savings.

5.2.5 SOWING SEEDS AND REPLANTING SEEDLINGS

Most seeds of plant species in the PSFs are rather large (with the exception of certain species such as *Melaleuca cajuput*, *Melicope lunu-ankenda* and *Fagraea racemosa*). Large seeds are easier to sow than small ones. The seeds must first be sown in prepared seed pans. The seeds should be distributed evenly in the pan and not too close to each other. Fine sand is topped on the seeds and watering is carried out in the mornings and afternoons, using a watering can with a fine rose. If the sown seeds are small, the seedling pan should be covered with a transparent plastic sheet to prevent raindrops from dispersing the seeds. A label should be attached to the pan, stating the date of sowing and the plant species. The information should be recorded in a logbook. After the seeds germinate, the young seedlings are then transplanted into polythene bags filled with potting soil. The seedlings from small seeds should be allowed to grow at least one-inch-tall before they can be selected for transplanting. For the purpose of maximising genetic diversity, the seeds should be collected from good plant stocks and those from different stocks should be mixed when sowing to help lessen in-breeding among plants from the same stock.

Certain seeds are difficult to acquire, or are only available in small quantities. A good idea would be to cultivate plant stocks in natural forests or in prepared plots. Stocking plots should be properly managed so that required seeds are produced and gathered. It is found that almost all seedlings naturally grown in the wild can be transplanted into polythene bags and nursed with high survival and growth rates.

5.2.6 PREPARATION OF POLYTHENE BAGS

Polythene bags used for peat swamp forest seedlings need to be generally large and taller than the highest water levels. Water levels beyond the crown of the seedlings often result in seedling deaths. However, seedlings may survive even though the base of the seedlings was underwater for a period as long as 18 months (Nuyim, 2003). Transferring seedlings to planting sites can be rather difficult and especially cumbersome with large bags. Therefore, it is advisable to use polythene bags of mixed sizes.

Figure 5-4: Putting wildlings in polythene bags.

5.2.7 SOIL USED FOR FILLING POLYTHENE BAGS

Trees and seedlings growing in peat swamps thrive well on organic soil. Top soil from outside peat swamp areas mixed with rice husk and manure can also be used for cultivating seedlings in polythene bags. These seedlings may grow faster than those grown in bags filled just with organic soil.

To prepare soil for seedlings, one has to wait for the soil to become dry as it is difficult to dig for soil under wet conditions. Before filling the bags, workers have to pick out gravel, stones and pieces of leaves and branches. The soil is then mixed well with rice husks and manure, filled in the bags, compressed and put in rows. Storing blocks should have a space of 30cm at both ends in order for nursery workers to do weeding and watering.

Inoculation with Mycorrhizas

Arbuscular mycorrhizas improve the growth and nutrient uptake of plants and are formed in 80% of all land plants. Studies by Tawaraya *et al.* (2003) in peat swamp forest of Central Kalimantan, Indonesia showed that seventeen of 22 species showed arbuscular mycorrhizal colonisation. Inoculation of arbuscular mycorrhizal fungi can improve the early growth of some tree species grown in peat swamp forests and this will be expected as a key technology to rehabilitate disturbed peatlands. Turjaman *et al.*, (2011) demonstrated the positive effect of inoculation of native ectomycorrhizal (ECM) fungi on growth of *S. balangeran* in degraded peat swamp forest. ECM colonisation increased shoot height, stem diameter, and survival rates in inoculated seedlings compared to control 40 months after transplantation. The results suggest that inoculation of native ECM fungi onto indigenous tree species is useful for reforestation of degraded peat swamp forests.

5.2.8 NURTURING SEEDLINGS

The seedlings should be watered thoroughly twice a day, in the mornings and afternoons. Weeding should be done once a month. Bags with seedlings should be moved once every three months to prevent the roots of the seedlings from penetrating into the ground. Height grading should be carried out so that all seedlings are exposed to sunlight and shorter seedlings are not suppressed. These procedures will help accelerate growth and make it more convenient for selecting the seedlings for planting. Tall seedlings should be planted first.

Nursery workers should also look out for diseases and pests. If pests are found, the seedlings should be sprayed with appropriate chemicals. If there is a need for accelerating the growth of seedlings for planting, they should be treated with urea fertiliser – with a formula consisting of one handful of urea dissolved with 5 litres of water.

One month before the planting season, the shading panel should be taken away so that all seedlings are fully exposed to sunlight, thus promoting the hardening of the seedlings. If it is not possible to take away the shading panel, all seedling bags should be translocated to an open area preferably close to a main road. This will help to harden the seedlings, accustom them to real planting conditions and also easier for transportation to planting plots later.

5.3 PREPARATION OF REHABILITATION PLOTS AND PLANTING OF SEEDLINGS

Procedures and practices in the preparation of rehabilitation plots, planting and nurturing of the plantation are very important. The success of replanting and rehabilitation depends mostly on the work done during these stages. Different cultivating locations require different treatments.

5.3.1 SITE SURVEY FOR PREPARATION OF REHABILITATION AREA

After the site for the planting has been decided upon, the first stage is for the person/s responsible for planting to survey the plots. A preliminary survey should be made to collect basic information on the area, such as location, boundary, site history, distribution of plant and weed species, and signs of wild fires and domesticated animals. Planning should be done for temporary walkway or ditch crossings, blocking any ditches or drains in the area, calculation of the number of seedlings required and other necessary preparations. Measurements should be taken such as boundary and boundary posts should be erected to prevent encroachment. The planting location should be marked on a map with a scale of 1:50,000. A more detailed map showing the planting plots should be drawn on a letter-size paper (A4) with an appropriate scale. The map should include details about permanent physical features of the landscape such as roads and canals as well as other details. A preliminary survey provides information on suitable plant species to be cultivated and the quantity required for the planting. An area with large trees already growing should be planted with species that do not need much sunlight. Similarly, a waterlogged area should be planted with tall seedlings and the species should be well-suited for growth in the water.

5.3.2 PREPARATION OF REHABILITATION AREAS

Figure 5-5: Preparation of rehabilitation area

The bases of the seedlings must be buried when they are planted. In order for the seedlings to be able to outgrow the weeds, it is recommended that the seedlings to be planted should be more than one meter (1 m) tall – hence a need for land preparation. Cutting the weeds close to the ground requires a lot of labour and a specific technique. Firstly, the workers have to slash the weeds vertically to cut the parts that cover other plants. Secondly, they have to cut the weeds horizontally, as close to the ground as possible. The cut weeds are then broken into small pieces and stepped on to level the cut pieces on the ground surface. This procedure makes the preparation cost for planting in the PSF higher than that for other types of forests. Climbing weeds on large, naturally occurring trees should be cut and pulled down to allow the trees to grow freely. Extended and cumbersome crowns of original trees should be pruned to allow sunlight to reach the newly planted seedlings. The seedlings exposed to more sunlight grow better. In areas where weeds do not grow too densely, workers can use grass cutting machines for the preparation of the planting plots.

5.3.3 CONSTRUCTION OF TEMPORARY WALKWAY TO ACCESS PLANTING PLOTS

The PSFs are waterlogged and peat soil is loose and very sodden, the movements of labourers, and transportation of tools or seedlings into the planting site is rather difficult. For a planting area of more than 8ha, or if it is necessary to enter the planting site often, there may be a need to construct a temporary walkway to the site. Bamboo poles and fallen tree branches are laid on the ground to make the walkway.

5.3.4 POLING FOR PLANTING AND PLANTING SPACE

Very few studies have been carried out to determine the appropriate planting space for the PSFs; therefore, there has not been any specific formula for the space. Setting the proper planting space between trees is important because this will determine the operating cost. Planting space also dictates the number of seedlings required for planting. The number of seedlings dictates the number of positioning poles and pits to be dug for planting. A narrow space between trees means a larger number of seedlings are required, and a higher operating cost per ha as a result. The space between trees is determined by the crown size. For example, *Campnosperma coriaceum* has an extended crown. A planting space of 2 x 4 meters results in cramping of the crowns within 4 years. For the same planting space, it will take 15 years for the crowns of *Calophyllum sclerophyllum* to cramp. Therefore, the planting space of each plant species differs. On average, the most appropriate number of seedlings to be planted in the PSFs is 600-1,250 seedlings per hectare. According to Indonesian regulation on (Permen KLHK no. 16/2017) Technical Guidelines for Recovery of Peat Ecosystems, seedlings are to be planted at a density of 1100 / ha, with a minimal survival rate of 500/ha by year 3. Planting of the seedlings can be in rows especially in open sites which will need high maintenance and rows will enable the easy location of the seedlings. In sites where there is already a presence of scattered trees, the placing can be more random and focused on gap filling.

The advantage of poling the planting spot is that it makes it easier to notice the site to be planted. A seedling is set beside each pole before planting. By tying the seedling to the pole, the pole also serves as the support for the seedling to grow upright. Also, the pole is an indicator for the location of the planted seedling. This makes it convenient for workers to find the location of the seedling when they want to do weeding. The poles also make it easy for the workers to survey the seedlings for growth, survival or replacement planting. Planting poles or stakes may be made from bamboo (which can last for 2-3 years) or from Johnson grass or Arundo donax obtained on site (which can last for 6 months).

Figure 5-6: Planted sapling with bamboo pole and tag.

5.3.5 PREPARATION OF PLANTING PITS AND PLANTING

Good planting pits are essential for the survival of seedlings. They should be at the same level as the original soil. Mounding the soil can lead to problems when the water recedes in the dry season. The soil will dry, the roots of the saplings become dehydrated and the plants eventually die. However, growing certain plant species (which are less water tolerant) on a small soil mound at an elevated level above the water surface may result in a significantly better growth rate than growing at normal ground level. These plants include *Eugenia kunstleri* and *Eugenia oblata*.

In certain areas (which may be waterlogged because of subsidence, fire, or changes in natural drainage), limited or temporary drainage may be applied instead of constructing mounds. Both of these techniques share the same principle, i.e. mounds allow the roots of the seedlings to grow in soil above the water level, whereas drainage lowers the water level in the soil so that the roots are not in the water.

The dry season is a good time for making mounds because the water level in the peat swamp is low. The forest manager often mobilises the workforce to build mounds for the whole planting area during this season. The seedlings are planted early in the rainy reason. Such a practice differs from planting methods in other forests where the seedlings are planted immediately after making the planting holes or pits.

In planting the seedlings, use a knife to cut the polythene bag and remove it. Make a planting hole of the right size with a large stick. Carefully put the seedling into the hole; do not cause the soil covering the roots of the seedling to break. After that, cover and compress the base of the seedling with the soil. If there are weeds around the planting hole, remove the weeds first. Tie the seedling to the planting pole at 70% of the seedling height above the ground. This will help the seedling to grow upright. When tying the string, tie one end loosely to the seedling to allow it to grow freely and tie the other end tightly to the pole to prevent it from falling to the base. Removed polythene bags should be disposed outside the plantation to keep the environment clean and prevent wild animals from accidentally ingesting them as the bags may be mistaken for something edible. Before planting the next seedling, scoop water from around the planting hole and pour it onto the base of the newly planted seedling.

As for planting at the ground level, use a machete to weed the chosen location. In order to grow trees in a straight line, it is important to be consistent in making a lead hole, either to the left or to the right of the planting pole, so that the rows of the grown trees will be in straight lines. The next step is to remove the polythene bag from the seedling, and carefully put the soil-covered seedling into the prepared hole (see **Figure 5-7**). Similarly, tie one end of the string loosely to the seedling and the other end tightly to the planting pole to prevent slanting of the trunk. Water the seedling the same way as was done in the mound method.

Most seedlings of species from the peat swamp forest grow slowly. Depending on the site conditions, fertiliser applications may be necessary. It has been suggested to use 100g of controlled release fertiliser (15% N: 15% P_2O_5: 15% K_2O) in each planting hole.

To ensure that no planting poles are missed during the planting process, the seedlings should be planted in a row starting from the edge of one side of the planting area toward the opposite end.

Figure 5-7: Removing polythene bag from seedling to be planted.

5.3.6 SEEDLING TRANSPORTATION

The transporting of seedlings is a procedure that needs special attention. The well-prepared seedlings can be damaged while being transported due to lack of knowledge and proper attention in handling them. Healthy seedlings may have dried or leaf abscission and broken roots. It should be noted that transporting the seedlings takes a short time but it may affect the seedlings that have been prepared for a long time. Another point worth noting regarding transporting the seedlings is time. The seedlings should be transported from the nursery to the planting area in the shortest time possible.

A logistic plan should be mapped out carefully to avoid delay in transportation. The proper handling technique is to put the seedlings into large plastic bags with straps. It should be avoided at all times that roots are exposed to sunlight and wind as they will dry out and die off quickly then the seedling will have less chance of survival after planting. The plastic bags are then loaded on a truck; careful layering the seedlings on top of each other is permitted. Upon reaching the site, the bags are unloaded and transported to the planting area – carried by hand, on shoulders or by boat. A plastic shading panel is required to cover the seedlings when being transported by truck. This is meant to prevent the leaves from being damaged by the force of strong wind while the vehicle is moving. Without a shading panel, the seedlings being transported may suffer leaf abscission, which requires months for recovery. In transporting large plants of Palmae species, it is recommended that all the leaves are tied together before beginning the journey. This handling technique will prevent the seedlings from being disturbed. It should be noted that at every stage of seedling transportation, only the plastic bags should be handled, not the seedlings. Touching the seedlings may cause the covered soil at the base to break off, an action which may result in the death of the seedlings. For redistribution at the planting site, the seedlings may be transported by trailer, boat or on foot.

Figure 5-8a: Transportation of seedlings at the planting site.

Figure 5-8b: Transportation of seedlings at the planting site.

5.4 MAINTENANCE

5.4.1 REPLACEMENT PLANTING

The first month of field planting is crucial to determine the survival of the planted seedlings. This means that under normal climate conditions and without pests or diseases, most seedlings that survive the first month can grow further to become large trees. Major reasons for the seedlings not being able to survive after one month are: they are unhealthy; damaged by the planting procedure; not properly planted; or the soil is not suitable. The seedlings wither if dehydrated, or the leaves will fall when submerged in the water and eventually the seedlings will die. Symptoms of dying can be seen within 2 or 3 days for certain plants, whereas for others it takes time for the signs to surface. In order for the replaced seedlings to grow along with the original seedlings, it is advisable to carry out the replacement planting as soon as possible after a seedling is found dead. For large scale planting, it is rather impractical and costly to make a survey of the newly planted area every day. Therefore, replacement planting should be carried out one month after the first planting of the seedlings.

A certain number of seedlings should be set aside for replacement and these seedlings should be nurtured in the nursery to grow along with the ones already planted. Using the reserved seedlings of the same lot for replacement is a good idea, because the original seedlings and the replaced seedlings will be growing at almost the same height. This has the advantage of helping to prevent the replaced seedlings from being dominated or overshadowed by the originally planted seedlings. By moving the seedlings in the polythene bags twice a year, it is possible to prevent the roots of the seedlings stored in the nursery from penetrating into the ground. If the roots are firmly established in the ground, it would be harmful to prick off the seedlings for replanting. The nurtured seedlings are suitable for replacement planting in the second and third year. The success of reforestation depends significantly on natural factors, particularly the climate. Regular rainfall provides water required by the plants, resulting in a high rate of survival. On the other hand, a drought often results in a low survival rate for the plants. Replacement planting in favourable climate for three consecutive years will make reforestation more successful.

5.4.2 WEEDING THE PLANTING PLOTS

The peat swamp forest has adequate water and sunlight, which promotes the growth of certain weeds such as *Blechnum indicum*, *Stenochlaena palustris*, and some types of sedge, such as *Scleria sumatrensis*. Weeds will dominate the area if weeding is not done for 2-3 months and the condition of the area will return to a similar state as the pre-weeding period. Weeds are one of the major problems in planting and rehabilitating the peat swamp forests. By taking the plant's growth rate and weeding cost into consideration, the weeding twice a month was the most optimum practice in planting programmes in Thailand (Nuyim, 1995).

Maintenance of areas for planting and rehabilitation of the peat swamp forests require weeding of certain plants such as *Scleria sumatrensis*, *Blechnum indicum* and *Stenochlaena palustris*. This must be done in a cautious way so as not to damage the seedlings growing along with the weeds. Most of the seedlings are difficult to locate because they are overgrown by weeds. Workers should use machetes or sickles to cut the weeds as close to the ground as possible. Cutting only the upper parts of the weeds will allow the remainder of the plant to rapidly regrow, making it difficult for the seedlings to survive. The practice of burning to clear the weeds should not be allowed.

5.4.3 FIRE PREVENTION AND CONTROL

Most peat swamp forests are degraded and the major cause of degradation drainage and wildfire. Peat becomes easily flammable when dried. This is the reason why it is easy for wild fires to break out but difficult to extinguish in these forests. Fires also burn both above and below ground surface. The fire above the ground may be put out but the underground fire may still be burning or smouldering. When the fire spreads to a larger area and aggravated by a very low water level, extinguishing the fires through human intervention will be almost futile, although it may be possible to simply delay the spreading of the fire. A complete extinguishing of the fire can be done through filling the peat soil with water. However, using water pumps to raise the water level in the planting area to put out underground fires is a long and very costly procedure. Wildfires often break out during the dry season when the water levels are low. The only occasion where it is feasible to use water pumps is when there is a large reservoir or water source next to the forest. Ultimately, prevention is the best strategy to manage fires in the PSFs.

5.4.4 PEST AND DISEASE CONTROL

Problems of disease and insect infestation in peat swamp rehabilitation pilot projects in Southeast Asia have not been severe. This may be because of the planting strategy where mixed species are planted in the same plots. Such practice helps to prevent insects and diseases from affecting the plants. In addition, as most of the rehabilitation areas are of small scale and isolated, there is less risk of severe attacks by insects or diseases. However, care should be taken to monitor potential infestations by insect and rodents from adjacent oil palm plantations.

Some diseases and insect pests, which affect the plants during the planting stage, are rotten roots in the seedlings in the nurseries and early field plantings, termites devouring the bark of *Melaleuca cajuputi* seedlings and grasshopper damage on young leaves of *Metroxylon sagu* seedlings. Although diseases and insects may have a low risk, it is important to be aware of the potential threats from the diseases and insects, and to conduct studies on their effects. Wild boar has also been reported to damage sago seedlings by uprooting and eating the 'heart' of the seedlings.

5.5 EVALUATION OF REHABILITATED AREAS AND THE SETTING UP OF VEGETATION GROWTH STUDY PLOTS

5.5.1 EVALUATING THE SURVIVAL OF SEEDLINGS

To evaluate seedling survival, a survey should be carried out immediately after weeding. In evaluating the seedlings, evaluators simply walk along the planting plots in a systematic pattern for an area equivalent to 10% of the total planting area. Record the survival and death rates of each plant species. The record can be used in the calculation of the number of seedlings required for replacement planting.

5.5.2 SETTING UP OF PLANT GROWTH STUDY PLOTS

Study plots for examining the growth of plants are useful. The information acquired from the study plots can be used for evaluation of rehabilitation project and for identification of plant species suitable for planting in specific areas. The information acquired can also be used to determine the selection and improvement of the plant species to be used for the following year's planting. Technical information can be disseminated through lectures and publications to agencies or individuals interested in the PSF rehabilitation programme.

Figure 5-9: Tagging and monitoring of planted saplings.

Figure 5-10: Monthly maintenance by conducting weeding activity in the planted lane

A plot for studying the plant growth should be a permanent plot of at least 40 x 40 meters. Each rehabilitation area should have at least 4 study plots, sited at different locations in the area. Each plant in the plot is labelled with an identification number. The trunk size and crown height of each plant are measured. The trunk size is measured at 20 centimetres above the ground. A mark with red paint is made around the measurement point on the trunk. When the plant grows taller, measure the trunk at 1.3 meters above the ground. Repeat the measurement every year. A plan should be mapped out before collecting the data; all necessary tools such as notebooks should be prepared beforehand. Other information that should be collected includes a description of general surroundings, flowering and fruiting period, and diseases and insects found. To obtain reliable data on water, surveyors should install a water gauge and measure the monthly water level.

Box 5-2 gives a case study on the rehabilitation of Raja Musa Forest Reserve in Malaysia by the Selangor State Forestry Department and Global Environment Centre between 2008-2019.

BOX 5-2

Rehabilitation of Raja Musa Forest Reserve, Selangor, Peninsular Malaysia

The North Selangor Peat Swamp Forest (NSPSF) (**Figure 5-11**) is the largest remaining peat swamp forest complex in Selangor. North Selangor Peat Swamp Forest (NSPSF) is located in northwest Selangor State and covers an area of 81,304 hectares mainly within various forest reserves. Some 1,000ha in the RMFR have been illegally drained and burned for agriculture activities. In 2008, the Selangor State Forestry Department (SFD) and Global Environment Centre (GEC) established a partnership to enhance conservation of peat swamp forest, rehabilitate the degraded area through improvement of water management and replanting of seedlings as well as reduce the risk of peatland fires and haze in collaboration with other partners and communities.

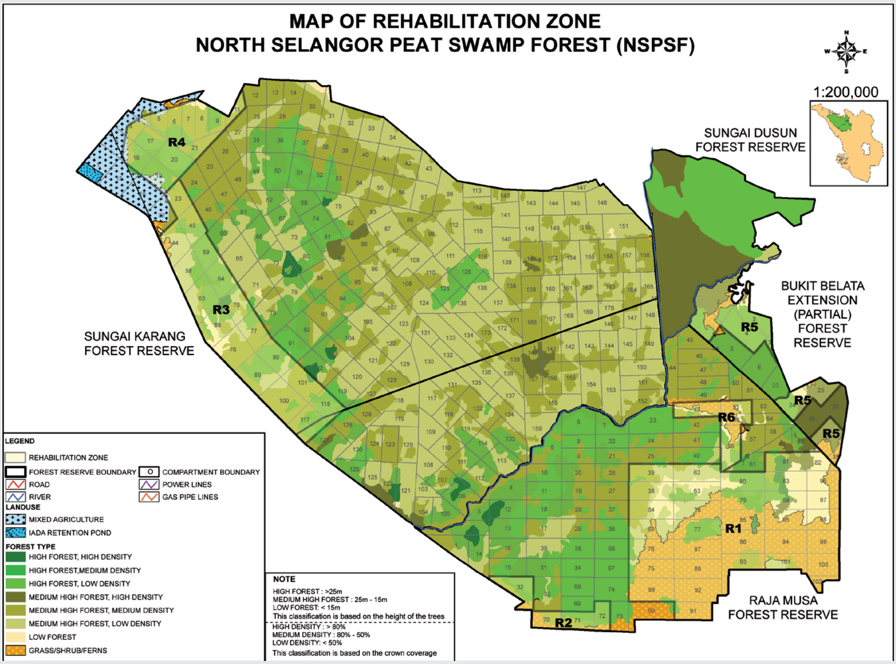


Figure 5-11: Map of NSPSF

A total of more than 40 partners have helped to block drainage canals, prevent fires, plant saplings and encourage natural regeneration in the forest. In addition, the Raja Musa Forest Reserve (RMFR) Rehabilitation Programme also focuses on capacity building, raising awareness and demonstrating community-based reforestation and fire prevention exercises to rapidly re-establish the forest and restore its biodiversity and prevent the peatland fire risk. As a result of these activities, much of RMFR as well as the other adjacent sections of NSPSF have remained intact despite extensive external development pressures (Charters *et al.*, 2019)

RMFR was gazetted in 1990. Prior to its gazettement, the area was part of stateland forest and was intensively subjected to logging since 1950s with little control and supervision from the State government agencies. As a consequence, the condition of the forest is heavily disturbed and the RMFR currently supports tree species with small to medium sized crowns, typically reaching 30 meters tall. Emergent trees are scattered throughout the area. Kempas (*Koompassia malaccensis*), Kedongdong (*Sphondias dulcis*), Kelat (*Syzygium* spp.) and Durian (*Durio carinatus*) are the dominant tree species within the forest. Ramin (*Gonystylus bancanus*), which was a common species in the peat swamp forest and highly prized timber species, is now very rare. Part of the north-east corner of RMFR is known for its high water table and is dominated by palms and *Pandanus*.

Forest Fires and Encroachment

Past surveys and studies showed that there is a correlation between heavily drained and degraded forest areas and fires in the NSPSF. Fires in NSPSF have been most frequent during prolonged dry spells. Deliberate burning as part of land clearing for agriculture outside the Permanent Reserved Forests, causes most fires in the NSPSF. Other causes are related to illegal encroachment activities e.g. hunting and general negligence in controlling campfires, cooking and smoking. In many cases, areas that were destroyed by forest fires were rapidly encroached-upon by people most of whom are involved in agriculture activities. Assessments made in 2008 showed that many people developing land inside the Permanent Reserved Forests were not poor local community members but residents of towns who had purchased lots from illegal land development syndicates. Subsequently, a special paper detailing the encroachment activities in RMFR and its adverse effects on the sustainability of forest areas in the state was tabled to the present Selangor State Government. Based on the paper, about 470 plots were cleared of cultivation in the site in December 2008 and forest rehabilitation and fire prevention activities undertaken.

Forest Rehabilitation Programme

As the first step towards forest rehabilitation in NSPSF, the Selangor State Forestry Department (SSFD) and Global Environment Centre (GEC) blocked old logging and drainage canals with more than 1000 blocks. These blocks however require proper and systematic maintenance to prevent water leakage and subsequent drying of the peat swamp forest, which have led to several forest fire incidences. To avoid the forest fire incidences, the SSFD and GEC through Friends of North Selangor Peat Swamp Forest have enhanced patrolling and enforcement activities along the forest reserve boundary. Many of the degraded areas were left to recover naturally after undergoing major hydrological restoration. Some heavily degraded sites were rehabilitated by adopting the following measures:

- Planting of fast growing tree species in grassland/shrubland areas
- Enrichment planting in areas with good initial recovery

To date the SSFD tree planting programme has focused on heavily burned and degraded forest compartments with a history of human encroachment. GEC through Friends of North Selangor Peat Swamp Forest programmes have been carried out a series of tree planting in collaboration with NGOs local interest groups, other government agencies, private sector, students from schools and higher learning institutions (mostly from Klang Valley) and involving the local communities from nearby villages surrounding the RMFR.

In collaboration with SSFD, Friends of North Selangor Peat Swamp Forest, private sectors and 30,000 volunteers, GEC has planted more than 280,000 saplings in 190 hectares of peat swamp forest. The seedlings consists of four main species; namely, Mahang (*Macaranga pruinosa*) and Tenggek Burung (*Melicope lunu-ankenda*) – which makes up 90% of the planting, Mersawa Paya (*Anisoptera marginata*) – 4%, and the balance 6% with Ramin (*Gonystylus bancanus*). From monthly monitoring of the growth of planted seedlings, it was noted that Mahang and Tenggek burung (secondary forest species) performed much better than the other two timber species. Trial planting using Kelat Paya (*Syzygium incarnatum*) has also yielded positive results.

The tree seedlings (of about 1 meter in height) were systematically planted in lines (See **Figure 5-12**) with a distance of 5m x 5m apart – mainly in open grass fields or scrubland. So far, very basic fertiliser has been applied to the growing plants (such as rock phosphate, N:P:K and Trace elements) together with maintenance of planted trees by regular weeding and replacement of dead trees.

Figure 5-12: Community tree planting for peat swamp forest rehabilitation at North Selangor Peat Swamp Forest, Malaysia.

Lessons Learned

Financial and human resources

The availability of sufficient financial resources is very crucial for successful implementation of forest rehabilitation programmes. Initial costs related to securing the perimeter of RMFR and hydrological restoration was absorbed by the SSFD. Later activities in relation to tree planting were supported by GEC either through regional project funding or enticing local corporate sponsorship. In 2010, a formal arrangement, in the form of memorandum of understanding was signed between SSFD and GEC. This has enabled GEC to secure longer term finance from the private sector namely - Bridgestone Tyre Sales Malaysia Sdn. Bhd. HSBC Malaysia, Sime Darby Foundation and Innisfree. Support was also provided through the EU-supported SEApeat Project especially for community and stakeholder engagement.

Availability of seedlings

The procurement of large numbers of suitable saplings was urgently required for the rehabilitation of RMFR as the area to be rehabilitated is quite extensive (ca. 1000ha). SSFD faced difficulties in getting adequate supply to sustain the planting activities and so a SHGSU/local community nursery was established in partnership with the local community and a local school.

Several other peat swamp tree species commonly found growing in open areas with degraded peat were identified by GEC team during field assessments. Information on the characteristics and planting of these species e.g. *Alstonia spathulata*, *Campnosperma coriaceum*, *Cratoxylum glaucescens*, *Ploiarium alternifolium* are available in Nuyim (2005) and are suggested for future planting trials at RMFR.

Preparation for planting and clearing of weeds

Large areas within RMFR's planting site are covered by dense vegetation in the form of grasses like Lalang (*Imperata cylindrica*) and shrubs mainly dominated by Senduduk (*Melastoma malabathricum*). Clearing this dense vegetation in the degraded peat swamp area is the first step in the preparation of the planting area and this requires a lot of labour and can be very time consuming. Therefore, preparation costs for planting in degraded peat swamp areas can cost at least RM2000/ha. Furthermore, these areas are also prone to fire during dry seasons.

Tree planting activities

Planting of saplings (as was the case in previous planting events) in such areas evidently resulted in heavy mortality and surviving plant seedlings can be suppressed by the over-grown vegetation and become difficult to locate. In this case, weeding will be required of certain plants such as Rumput purun (*Scleria sumatrensis*), Paku resam (*Blechnum indicum*) and Paku midin (*Stenochlaena palustris*). It is therefore advisable that in order for seedlings to out-grow weeds, seedlings should be one-meter-tall during planting. Similarly, waterlogged areas should be planted with tall saplings (more than 1m) that are well-suited for growth in high water table areas.

Very few studies have been carried out to determine the appropriate planting space for peat swamp forests. Setting proper planting space between trees is important because this determines operating costs. Planting space also dictates the number of seedlings required for planting. For the planting area, a 5m x 5m distance between trees was established with the option of introducing other species in between. The advantage of poling planting spots is to make it easier for workers to notice pits that are to be planted. Using bamboo poles for planting is most practical because they can last 2-3 years and are relatively cheap.

As peat swamp forests are waterlogged and peat soil is loose and very sodden, the movements of volunteers/labourers and transportation of tools or saplings to the planting site can be difficult. Some people may face discouragement because they have to wade waist-deep into the peat and water in order to access the planting sites. Constructed walkways and make-shift bridges provided more convenient access to planting sites.

As part of rehabilitation strategy, it is suggested that planting activities take note of the ecological succession of vegetation types in the following order:

i. Open grassland → Shrubland → Secondary forest → Regenerating forest

ii. Water dispersed → Wind dispersed → Bird dispersed → Small mammal dispersed

Accordingly, planting should only consider plant species that are common/native to the area and is found in abundance. The latter is to ensure sufficient planting stocks for mass planting.In general, it is helpful for both planting activities and selection of species for planting to enhance and support the natural succession and selection process. To do it in any other way will only result in higher mortality rates of the planted seedlings.

Overall progress was good with a significant area rehabilitated by a combination of planting and natural regeneration (see **Figure 5-13**).

Figure 5-13a: RMFR rehabilitation site in 2008.

Figure 5-13b: RMFR rehabilitation site in 2011.

Figure 5-13c: RMFR rehabilitation site in 2018.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6.0 PARTNERSHIPS BETWEEN PLANTATION COMPANIES, GOVERNMENT, LOCAL COMMUNITIES AND NGOs

6.1 INTRODUCTION

Experience from rehabilitation activities has shown that rehabilitation requires wider support, direct commitment from key players (i.e. local government, communities and the private sector).

To ensure the success of the rehabilitation project, wider participation and involvement of stakeholders is crucial in the following:

a. The establishment of an area where rehabilitation can occur in as close to optimal conditions as possible (i.e. minimise fire threat, encroachment, conversion, etc.).

b. Providing management of the area and rehabilitation process (i.e. monitoring, water table management, other inputs, etc.).

c. Long-term protection from conversion or unsustainable exploitation of the rehabilitated area.

During the establishment of a peat swamp forest rehabilitation area, the role of the oil palm plantation includes nursery work, mapping and planting. Local community support is necessary for identifying key sites, generating local support and in enrichment planting. Government and NGOs can play important roles in helping to minimise threats to the area by monitoring and enforcement. In cases where significant areas are being identified for rehabilitation, government plays a crucial role in providing incentives like land-swaps to degraded lands.

In the management and maintenance of the rehabilitated area itself, plantations again play critical roles in monitoring various parameters like plant health, diversity and water levels. The role of government becomes wider now as the need for protecting the area from factors like negative upstream activities, designation of conservation arras, law enforcement to protect rehabilitation zones etc.. Local community support for sustainable activities that do not jeopardise the area is also important. This would extend well into the long-term outlook as government planning should be cognisant of the need for integrating wider land use and economic development with sustainability.

FPIC and community involvement in planning stages of peat restoration with local communities to gain consent and support for rehabilitation is essential to ensure future success. If you primarily focus on bio-physical aspects, peat restoration will be more expensive and have a higher likelihood of failure. An example of the value of the FPIC process is given in **Box 6-1**.

BOX 6-1

FPIC for peat restoration work in Central Kalimantan

In 2017, the USAID-funded LESTARI project supported a Free, Prior and Informed Consent (FPIC) process for developing canal blocks in five villages within the C-2 block (55,733 hectares) of the former Mega-rice Project Area in Central Kalimantan, Indonesia (Lestari, 2017). This peatland is part of an area that covers less than 5% of the province yet accounted for 30% of all fire impacts in 2015. The work involved local governments and communities, the Peatland Restoration Agency (BRG) and the Water Management Centre. Of the 5 (five) villages engaged, 1 (one) village declined to have canal blocked while 4 (four) villages agreed to build canal blocks with BRG funding. FPIC facilitation ensured that communities are well informed about canal blocking; have an opportunity to provide inputs; and give their willing consent to construct, maintain, and protect the dams. Notably, local communities were able to influence the design of dams so that their small boats can pass through spillways in order to maintain their livelihoods. The total canal blocks successfully constructed totalled 178 canal blocks between 2017 and 2018. The cost needed for each block was approximately IDR 30 million (US$2,000) per block, with canal design adjusted from the standard proposed to accommodate community access. BRG contracted-out canal blocking in the remainder of Block C without a community engagement process (FPIC).

Based on the results of evaluation after the construction of canal blocks in 2017 and 2018 through FPIC, the number of fire hotspots within the C-2 area decreased from 944 hotspots in 2015 to 1 hotspot in 2018 (Lestari, 2019). The construction of the canal blocks provided increased production of fish in canals that were blocked - providing economic benefits. Community involvement at the site level has resulted in well maintained canal blocks (compared to adjacent areas where communities were not engaged and many canals have failed). Given the social and economic complexity of peatland restoration, canal blocking engaging communities through FPIC method and in construction is advocated.

6.2 LANDSCAPE APPROACH

It is very important to take a landscape approach when rehabilitating peatlands. As described in section 3.2, peatlands frequently occur in large blocks or peatland hydrological units these may cover areas of a few 100 hectares up to 1 million ha or more. Each portion of these hydrological units is affected by activities elsewhere in the unit – so it is essential for successful peatland conservation or rehabilitation take place based on an understanding of the whole hydrological unit. Such landscape approaches require the engagement of a broad range of stakeholders including government, local communities and plantation companies across the landscape. Examples of the landscape approach are given in **Box 6-2** and **6-3**.

BOX 6-2

Conservation of peatlands and wildlife corridor by Bumitama Agri Limited

Bumitama Agri Ltd (Bumitama) has 234,000 ha of oil palm plantations in Indonesia, mainly in Kalimantan. It has initiated an ambitious conservation initiative in two plantations - PT Gemilang Makmur Subur (GMS) and PT Damai Agro Sejahtera (DAS) in the north of Ketapang Regency in West Kalimantan. The plantations are adjacent to and within the Sungai Putri Landscape, a 55,000 ha peatland landscape of which about 40,000ha is still covered in good quality forest.

A population survey of Bornean orangutans (*Pongo pygmaeus*) conducted in 2013 by YIARI and Borneo Nature Foundation (BNF) indicated that a population of around 900-1250 individual orangutans live in the Sungai Putri landscape, at densities of between 1.64 to 2.27 individuals per km^2 (as published in Utami - Atmoko *et al.*, 2017). This is the largest orangutan population in the Ketapang district, and the third largest in West Kalimantan Province.

PT DAS was an existing oil palm plantation purchased by Bumitama in December 2016. A High Conservation Value (HCV) and High Carbon Stock (HCS) survey in early 2017 (Aksenta, 2017) indicated that 52% of the total concession area of 9,436 hectares was forested and supported 76-112 orangutans or about 10% of the entire Sungai Putri population. Subsequently, Bumitama decided to establish a conservation area of about 6,840 ha (72%) to include 3,030 ha of HCV, 1579 ha of HCS and 2231 ha of other conservation areas (including all areas which were cleared and drained but not planted by the previous owner). Plans are in the process of being developed to block the drainage in the peat swamp forest and adjacent forest areas and support natural and enhanced regeneration of the forest. This represents a very significant conservation contribution.

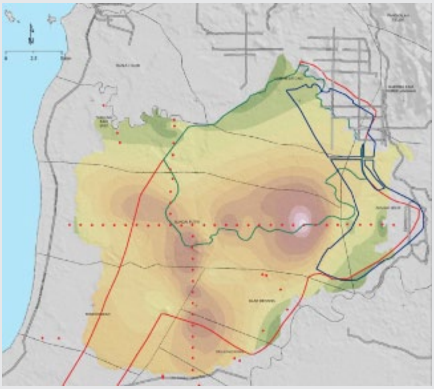


Figure 6-1: Map of Sg Putri Peatland overlain with PT DAS boundary (dark Blue) (Source: Bumitama/YIARI)

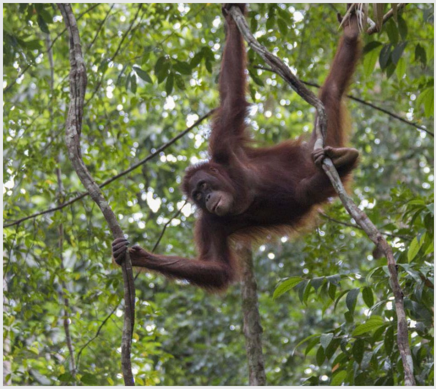
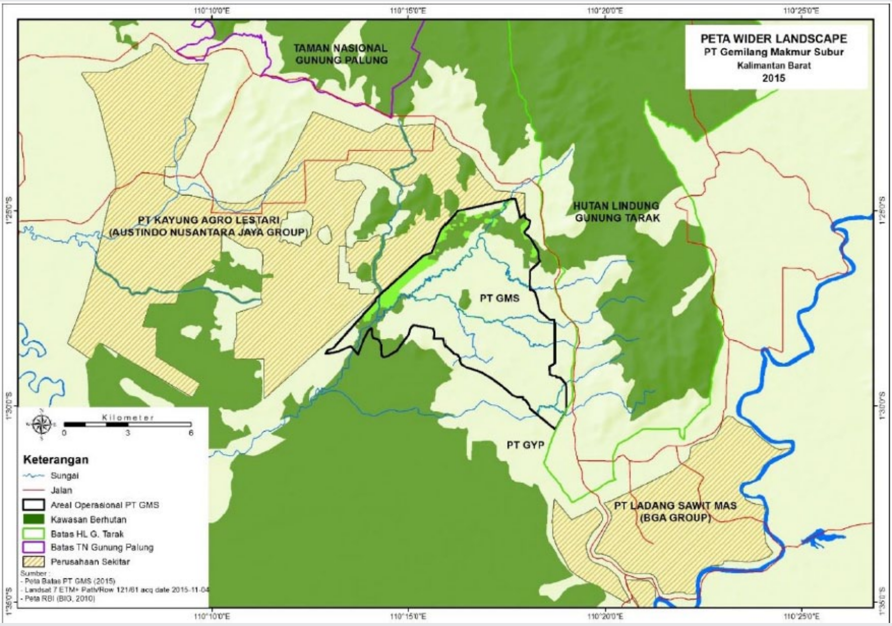


Figure 6-2: Orangutan

Figure 6-3: Peat swamp forests in conservation area of PT DAS

PT GMS was also an existing oil palm estate that was purchased by Bumitama in June 2016. An HCV assessment (Aksenta, 2016) indicated that the area included a natural forest corridor covering about 1,000 ha linking Sungai Putri and the Gunung Palung - Gunung Tarak landscape, which together form part of the broader wild orangutan meta-population, representing one of the most significant populations in Kalimantan. Bumitama, on taking over the management, initiated the Bumitama Biodiversity and Community Project (BBCP) to support the conservation and enhancement of the corridor including the establishment of patrolling teams, partnership with local communities, development of forest trails and development of a forest tree nursery. In the past two years, significant progress has been made – stopping most forest encroachment activities in the corridor and initiating rehabilitation of several areas (8,391 seedlings were planted in 2018 and 15,000 are planned for planting in 2019). Rehabilitating the corridor forests could support up to 25 orangutans, and connect the 900-1250 orangutans in Sungai Putri with the 326-482 individuals in Gunung Tarak. Re-connecting the two populations will allow for transfer of genetic materials, thus preserving the populations' integrity and prevent inbreeding.



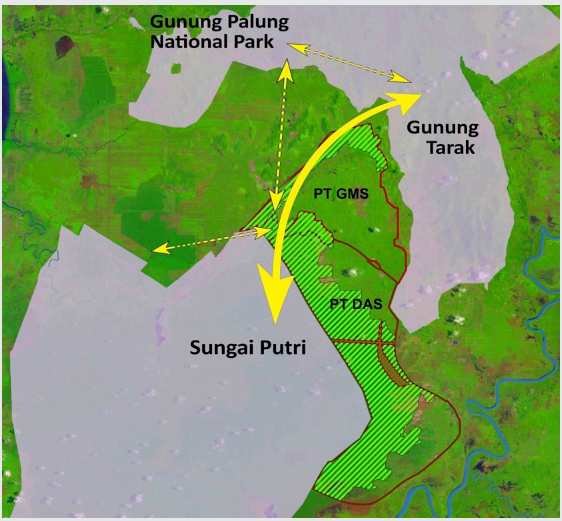


Figure 6-4a (above) and 6-4b (right): Maps to show the corridor through PT GMS connecting Sg Putri Peatlands and Gunung Tarak.

Figure 6-5: Forest corridor adjacent to PT GMS estate (on right) connecting to Gunung Tarak (in background)

BOX 6-3

South Ketapang Landscape

The South Ketapang Landscape covers about 750,000ha in the southern portion of Ketapang District, West Kalimantan. A quarter of the landscape is in formal conservation areas while 60% is manged by oil palm and forest plantation companies. Thirteen oil palm plantations covering 171,832ha are under the management of companies associated with RSPO members (IOI, Cargill and Bumitama Agri and Sampoerna Agro Groups) which have made commitments for HCV, HCS and peat protection and also to taking landscape approach to conservation. The landscape contains significant forests and peatlands as well as extensive lakes, rivers, floodplains and gresslands (see **Figure 6-6**). Many of the peatlands are riverine or basin peatlands (see **Figure 6-7**) which are quite rare in Indonesia and as such represent important ecological diversity. Endangered species such as the orangutan and sun bear.

In 2018, IOI Corporation, Aidenvironment and Global Environment Centre initiated the development of the South Ketapang Landscape Initiative in association with the local government of Ketapang District and the Provincial Nature Conservation Agency (BKSDA). The initiative is still under development, but a number of the oil palm and forest plantation companies have indicated strong interest in partnership in the Initiative.

The area of the South Ketapang Landscape is approximately 751,741 hectares (see **Table 6-1**).

Nearly 23% of the landscape is in government designated conservation areas including the Cagar Alam Muara Kendawangan Nature Reserve, Sg Keramat Protected Forest (Hutan Lindung) as well

Figure 6-6: Extensive floodplains in South Ketapang Landscape

Figure 6-7a: Forested valley or basin peatlands between fire-prone grasslands on sandy podzolic soils in South Ketapang landscape

Figure 6-7b: Satellite image of basin peats in landscape (Source: planet.com)

Table 6-1: Land-use types of the South Ketapang Landscape

LAND-USE TYPES	AREA (HA)	PERCENTAGE (%)
Oil Palm Plantations	262,358	34.9
Industrial Tree Plantations	185,408	24.6
Conservation Area (Cagar Alam Muara Kendawangan, Hutan Lindung, Danau Gelinggang and Danau Belida)	169,781	22.6
Village/Other Land-uses	134,194	17.9
TOTAL	**751,741**	**100 %**

as Gelinggang and Belida Lakes (Danau Gelinggang and Danau Belida). Nearly 60% of the landscape is within Oil palm (34.9%) and industrial tree plantations (Hutan Tanaman Industri, HTI) (24.6%). Administratively, the Landscape is located within 53 villages in four sub-districts of Ketapang District (see **Figure 6-8**).

There are several characteristics of the area that require a landscape approach to be addressed and changed.

- The area is one of the most fire prone areas in West Kalimantan province. This is caused by drainage within concessions as well as by intentional burning in conservation areas and community land. Fires threaten existing conservation areas such as the Cagar Alam Muara Kendawangan, Hutan Lindung gambut, forest and peat areas.
- The introduction of large plantations in the area is in general welcomed by the local communities because it provides opportunities for earn a stable cash income. The development however, challenges community rights to land, smallholder estates and resources. The loss of conservation areas or increased conflicts between communities and companies are very likely if the issue is not addressed.

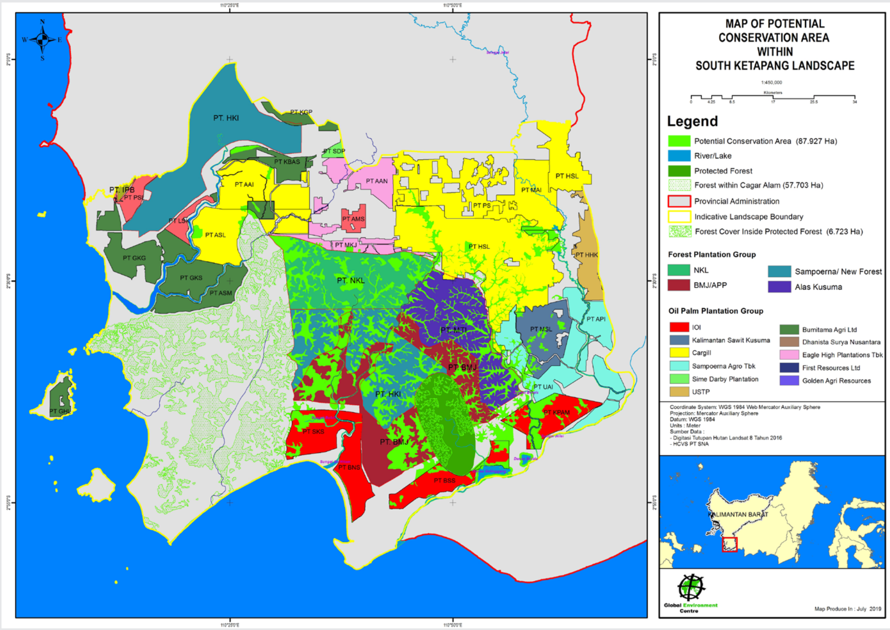


Figure 6-8: Distribution of oil palm and forest plantation companies and forest and peatland ecosystems in the South Ketapang Landscape

- Natural areas like forests and peatlands have decreased in the area to make room for plantations. Many smaller areas however are still present, albeit not managed in an integrated way. This results in loss of quality of natural areas and potential for enlarging habitats of animals such as orangutan, or sun bear.
- Plantations are vulnerable to flooding which affects productivity seriously. This is caused partly because of drainage and thus disruption of peat hydrology systems. Water and flood management is required to maintain natural water regimes and to manage water levels in dry and wet seasons.
- Infrastructure development is weak and connections with rest of the district is highly problematic. Some villages are inaccessible during the wet season which affects them for food supply and emergency situations.

Several options for collaborative activities between the stakeholders in the landscape include:

- Conservation of the Cagar Alam Muara Kendawangan, a 150,000 ha nature reserve, the boundary of which is shared by seven different plantaion companies.
- Collaborative fire management including joint prevention, monitoring and control measures (see **Figure 6-9**)
- Sharing of experiences and lessons learnt in conserving and rehabilitating the valley peatland ecosystems (see **Figure 6-10**)
- Collaborative measures to enhance community development for the 52 villages in the landscape
- Addressing common problems of roads, education, market access and healthcare in the landscape

Figure 6-9: Collaborative fire control measures between two companies in the landscape

Figure 6-10a: Degraded peat in April 2016 in PT BSS (part of IOI/SNA Group).

Figure 6-10b: Same location in August 2018 following rewetting and fire prevention.

6.3 COMMUNITY INVOLVEMENT

Community engagement is often critical to the effective conservation, rehabilitation and sustainable use of peatlands. Local communities are often dependent on the peatland resource for food, fibre, and income. Degradation of peatlands can lead to the loss of important livelihood options and negatively impact community welfare. Sometimes local communities are perceived as being responsible for peatland degradation through hunting, land clearing or starting fires in peatland areas. However, at the same time, local communities as the traditional stewards of the land are often in the best position to play an important role in the longer term protection and sustainable use of the systems.

There has been significant positive success from engagement of local communities in the protection and rehabilitation of tropical peatlands. An example from Malaysia is given in **Box 6-4**.

BOX 6-4

Partnership with Friends of North Selangor Peat Swamp Forest in forest rehabilitation activities

Local community participation is a key part of management of protection and rehabilitation of peat swamp forests as well as peatland fire prevention and control. A local community association called Sahabat Hutan Gambut Selangor Utara (SHGSU) or "Friends of North Selangor Peat Swamp Forest (FNSPSF)" was established in August 2012 with support of Global Environment Centre (GEC) to empower the local community in conservation of the adjacent North Selangor Peat Swamp Forest (See **Box 3-1**).

SHGSU provides a platform for the local community to be actively involved in various tasks required for the rehabilitation of North Selangor Peat Swamp Forest (NSPSF) and the management of the buffer zone activities. Members are drawn from four communities adjacent to the forest reserve which are Kg Raja Musa, Kg Bestari Jaya, Kg Seri Tiram Jaya and Kg. Ampangan. What has been shown by the SHGSU in NSPSF is another notable example of best management practices of peatland management in relation to the community participation and involvement.

Figure 6-11a: SHGSU Community members

Figure 6-11b: SHGSO Logo

SHGSU actively participates in the peat fire prevention (including daily dry season patrols) and firefighting operations which are led by the Fire and Rescue Department and Selangor State Forestry Department (**Figure 6-12a**) as well as supporting forest rehabilitation activities (**Figure 6-12b**).

SHGSU also participates in various outreach events organised by the SSFD, GEC and other relevant agencies such as the public talks, roadshows / exhibition, and other activities (**Figure 6-13**).

Local community involvement in peat swamp forest rehabilitation has become an essential strategy towards sustainable forest resources management in NSPSF.

Figure 6-12a: Adjusting FDRS signbard during SHGSU patrolling.

Figure 6-12b: Supporting tree planting activity.

Figure 6-13: SHGSU Secretary briefing UNDP Administrator and Selangor State Environment Executive.

SHGSU roles include:

- Act as 'eyes and ears' for SSFD and other related agencies (such DOE/ Fire & Rescue Department (BOMBA) / Local Authorities)
- Organise forest fire monitoring and prevention in buffer zone areas of the forest reserve on a daily basis during dry season
- Establish and operate a community nursery - to supply peat swamp tree species for the forest rehabilitation and support the socio-economic activities of the local community at Kg. Bestari Jaya (buy-back system)
- Be a facilitator for monthly tree planting activity
- Developing the ecotourism packages
- Participation in exhibition & creating awareness

Sustaining the conservation and preservation of a peat swamp forest is highly dependent on the involvement of local communities. Their involvement will determine the reduction of impact to the peatland ecosystem and effectiveness of community based rehabilitation programmes being undertaken. Hence, a comprehensive mechanism should be established to attract and secure the direct involvement of the local community in sustainable management of peatland for continuously.

SHGSU NURSERY

The SHGSU nursery (**Figure 6-14**) was established with the aim of supporting the RMFR Rehabilitation Programme. Small grants and training are given to participants to enable them collect wild seedlings as well as set up and manage their own nurseries. Saplings are then purchased from these nurseries for tree planting activities. Community members also are engaged in the planting and maintenance of replanted areas. The nursery provides a socio-economic opportunity for SHGSU members, as an alternative livelihood option. The wild seedlings are mostly collected from the forest fringes and often found growing within the palm oil plantations, originated from the nearby peat swamp forest. The nursery provides the saplings for native species of


Figure 6-14: SHGSU community nursery.

Tenggek Burung and Mahang. To date, more than 50,000 saplings have been produced to support the community-based rehabilitation programme generating an income of about RM 250,000.

SHGSU MINI HANDICRAFT STALL

The local community, the women in particular, were encouraged to venture into the handicrafts production using peatland resources or cottage industry. Training was provided through the National Academy for Handicrafts.

Members of SHGSU have started producing attractive handicrafts made of peat tree stumps, rattan, bamboo and pandanus leaves (**Figure 6-15**). These handicrafts can be used as decorative items for daily use or home / office / establishment, gifts or souvenirs and so on. Therefore, a SHGSU Mini Handicraft Stall were established to promote and sale the SHGSU handicraft products. Annual gross income received is of RM 6,000 - RM 8,000 (as an alternative / part time income).

Figure 6-15: Handicraft activities and products by SHGSU.

ECOTOURISM DEVELOPMENT IN NSPSF

NSPSF is close to Kuala Lumpur – the main tourism arrival point in Malaysia and is in proximity to a number of established tourism sites such as Kuala Selangor and the Kampong Kuantan Fireflies. Currently a growing number of domestic and international tourists are visiting NSPSF – especially using the entry point of the COE, Agrotourism Homestay Sg Sireh and the Sg Tengi. With proper development of facilities and improved access - it is believed that the number of visitors can be significantly increased and this will generate revenue for the state government and local communities.

SHGSU members from Kg. Ampangan through Agrotourism Homestay Sg Sireh actively involved in promoting peat swamp forest as tourist attraction destination including providing homestays facilities and various packages such as boat cruising, fishing, kayaking and jungle trekking activities in the peat swamp forest. On an average of every year, approximately 15,000 - 18,000 local and foreign tourists visit and participate in activities offered by homestay management (see **Figure 6-16**).

Figure 6-16: Ecotourism Activities to peat swamp forest organised by SHGSU.

6.4 RESEARCH, EDUCATION AND AWARENESS

It is important to encourage education, research and outreach on conservation and rehabilitation of peatlands. Such actions enhance the understanding of key stakeholders on the importance of peatland ecosystems. Research is critical for an understanding of the tropical peatland ecosystems, the root causes of degradation and the effectiveness of conservation and rehabilitation measures. Education and awareness programmes are important to education not only to educate younger generations but also to inform and change attitudes among local communities and decision makers.

Such activities may be spearheaded by research institutes, civil society organisations or networks. They may also be facilitated by education or research centres developed in peatlands. The Princess Sirindhorn Peat Swamp Forest Research Centre in Southern Thailand (**Figure 6-17**) was one of the first centres established in the ASEAN region. The centre is part of the Royal initiative on peat swamp forest and is overseen by the Royal Forest Department. It conducts research in the peat swamp forest of Pru Toh Daeng in Southern Thailand in Narathiwat Province. The centre was one of the first to undertake research on the rehabilitation of peat swamp forests in Southeast Asia which was described in Thai by Nuyim (1995 and 2003) which was later translated into English (Nuyim, 2005) and supported the development of similar research and practices in Indonesia and Malaysia. The centre has also stimulated the development of other centres of excellence such as the Selangor State Centre of Excellence for Peat Swamp Forests (**Figure 6-18**).

Figure 6-17: Princess Sirindhorn Peat Swamp Forest Research Centre, Narathiwat Province, Thailand

Figure 6-18: Selangor State Centre of Excellence for Peat Swamp Forests.

Figure 6-19: Briefing of the Science Advisor to the Malaysian Prime Minister at the Selangor Centre of Excellence for Peat Swamp Forest.

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ANNEX 1: GLOSSARY AND ABBREVIATIONS

ASEAN Association of Southeast Asian Nations

BMP Best Management Practice

BRG/PRA Badan Restorasi Gambut / Peatland Restoration Agency

CKPP Central Kalimantan Peatland Project

DID Department of Irrigation and Drainage

Dipterocarp
Chiefly tropical Asian trees with two-winged fruits; yield valuable woods and aromatic oils and resins.

Ecology The science of the relationships between organisms and their environments.

EIA Environmental impact assessment

EMP Environmental Management Plan

ERWG Emission Reduction Working Group

ESA Environmentally Sensitive Area

FDRS Fire Danger Rating System

FPIC Free, Prior and Informed Consent

FR Forest Reserve

FSC Forest Stewardship Council

GA General Assembly

GHG Greenhouse Gases

GPS Global Positioning Satellite

GWL Ground Water Level

HCV areas High Conservation Value areas necessary to maintain or enhance one or more HCVs:

1. Species diversity; Concentrations of biological diversity including endemic species, and rare, threatened or endangered (RTE) species that are significant at global, regional or national levels.
2. Landscape-level ecosystems, ecosystem mosaics and Intact Forest Landscapes (IFL) that are significant at global, regional or national levels, and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance.
3. Ecosystems and habitats; RTE ecosystems, habitats or refugia.
4. Ecosystem services; Basic ecosystem services in critical situations, including protection of water catchments and control of erosion of vulnerable soils and slopes.
5. Community needs; Sites and resources fundamental for satisfying the basic necessities of local communities or indigenous peoples (for livelihoods, health, nutrition, water, etc.), identified through engagement with these communities or indigenous peoples.
6. Cultural values; Sites, resources, habitats and landscapes of global or national cultural, archaeological or historical significance, and/or of critical cultural, ecological, economic or religious/sacred importance for the traditional cultures of local communities or indigenous peoples, identified through engagement with these local communities or indigenous peoples.

HGU Hak Guna Usaha (Cultivation Rights Title, Indonesia)

HGB Hak Guna Bangunan (Right to Build, Indonesia

HLG Hutan Lindung Gambut: peatland protection forest

HPH license for selective logging in an official forestry concession

HPT Hutan Produksi Terbatas: limited production forest

IUCN International Union for Conservation of Nature

KHG Kesatuan Hidrologi Gambut

HP Hak Pakai (Right of Use, Indonesia)

ISPO Indonesian Sustainable Palm Oil

IUP Izin Usaha Perkebunan (Plantation Business License, Indonesia)

IUP–B Plantation Business Permit for Cultivation

IUP–P Plantation Business License for Processing

MPOB Malaysian Palm Oil Board

MPOC Malaysian Palm Oil Council

MSPO Malaysian Sustainable Palm Oil

MWL Mean Water Levels

NPP National Physical Plan (Malaysia)

NTFP Non-Timber Forest Products

Oligotrophic
Relatively low in plant nutrients and containing abundant oxygen in the deeper parts

Ombrogenous
Describes a peat-forming vegetation community lying above ground water level: it is separated from the ground flora and the mineral soil, and is thus dependent on rain water for mineral nutrients. The resulting lack of dissolved bases gives strongly acidic conditions, and only specialised vegetation will grow. Ombrogenous peat is generally deep peat

P&C Principles & Criteria (RSPO)

PA Protected Areas

PASS Potential acid sulphate soil

Phasic Communities
Much work has been done by Anderson (1963) on the floristics of the peat swamps of Sarawak and Brunei. In the domed peat swamps, Anderson described six phasic communities (PC1-6) of plants proceeding from the edge to the centre of the dome. Anderson described them as phasic communities because pollen analysis of bore samples on a peat dome just west of Marudi indicated that the change in vegetation up the dome was paralleled by the same sequence of vegetation types with depth of peat; i.e. a succession in time. The features of each community are described briefly here:

PC1: Mixed peat swamp forest
This community occurs on shallow peat at the periphery of the peat domes and on shallow peat. This is the most species rich of the communities, although lower in species than mixed dipterocarp forest. The canopy is uneven and 40-45m high. Prominent tree species are *Dyera lowii*, *Alstonia pneumatophora*, *Parishia* sp., *Palaquium* sp., *Diospryros evena*, *Combretocarpus rotandatus*, *Dactylocladus stenostachys*, *Gonystylus bancanus* and *Lophopetalum multinervium*. The ground layer varies greatly – in wetter areas, Eleiodoxa conferta forms thickets whilst where the canopy has been opened, Pandanus andersoni becomes common.

PC2: Alan Batu forest
The composition of this community seems to be very similar to that of PC1, with the exception of the appearance of very tall (to 60m) individuals of *Shorea albida* (alan). These are stag-headed and have hollow trunks and are considered excellent timber, being classed as a medium hardwood.

PC3: Alan Bunga forest
The entire canopy is composed of Shorea albida at a height of 50-60m. The stems of alan bunga are solid, although the timber is considered not as good as that of alan batu.

PC4: Padang Alan forest
There is a closed canopy of 35-40m high composed mainly of *Shorea albida*. The forest is much more pole-like than the preceding communities.

PC5: Padang Paya
This is a much lower type of forest, with a canopy of 15-20m high. The trees are small in girth and the forest very dense. The dominant trees are *Tristaniopsis* spp., *Parastemon* sp., and *Palaquium* spp. *Shorea albida* is more or less absent.

PC6: Padang keruntum
This community is markedly different from the preceding ones in that it is very open and strictly speaking would not be classed as a forest type. It is found on the central bog plain of the most highly developed zones. *Combretocarpus rotandatus* (keruntum) is the only species that can be called a tree and does not rise above 15m in height. *Dactylocladus stenostachys* is present, but is more shrub- like than tree-like. Plants which obtain nutrients from sources other than the soil water are common, such as *myrmecophytes* and *Nepenthes* spp. The appearance is very xeromorphic. It is worth noting that PC5 and 6 only occur in the Baram/ Belait peat swamps in the Marudi area. In other areas of Sarawak, PC1-4 only is found. The major trends in the stature of the forest along the peat dome are thought to be concerned mainly with decreasing fertility, increased incidence of periods of water stress and problems with uptake of water very high in leached plant defensive compounds.

PHU Peatland Hydrological Unit

PLWG Peatland Working Group

Pneumatophores
These are specialised aerial roots that enable plants to breathe air in habitats that have waterlogged soil. The roots may grow down from the stem, or up from typical roots. The surface of these roots is covered with lenticels, which take up air into spongy tissue, which in turn uses osmotic pathways to spread oxygen throughout the plant as needed.

PNG Papua New Guinea

Podzols Soil that is characterised by an upper dark organic zone overlying a white to grey zone formed by leaching, overlying a reddish-orange zone formed by the deposition of iron oxide, alumina, and organic matter.

PP Peraturan Pemerintah (Government Regulation – Indonesia)

RSPO Roundtable on Sustainable Palm Oil

R&D Research and Development

SE Asia Southeast Asia

SK Surat Keputusan

ANNEX 2: SUMMARY TERMS OF REFERENCE FOR THE SECOND RSPO PEATLAND WORKING GROUP (PLWG-2)

SCOPE OF WORK

- Monitor trends in oil palm cultivation on peatlands
- Propose refinement related to peatlands in RSPO tools, standards and guidance (PalmGHG, GHG assessment procedure, P&C 2013, NPP, RSPO Next, auditing etc.)
- Review and analyse the experience in implementing RSPO BMPs on peatlands
- Review and update the guidance in the RSPO Manual on Best Management Practices (BMPs) for Existing Oil Palm Cultivation on Peat
- Review and update the guidance in the RSPO Manual on Best Management Practices (BMPs) for Management and rehabilitation of Natural Vegetation
- Oversee development of Guidance on drainability assessments for peatlands
- Develop additional guidance and explore incentive options on rewetting and rehabilitation/ conservation in peatlands
- Provide guidance for smallholder cultivation on peat.
- Guidance on regionally appropriate definition and practices
- Develop or guide appropriate outreach and capacity building programmes related to the BMP manuals.

EXPECTED OUTPUTS

i. A review assessing trends in Oil palm cultivation on peat and use of BMPs.

ii. Updated version of the RSPO Manual on Best Management Practices (BMPs) for Existing Oil Palm Cultivation on Peat.

iii. Updated version of the RSPO Manual on Best Management Practices (BMPs) for Management and rehabilitation of Natural Vegetation associated with Oil Palm Cultivation on Peat.

iv. New guidance on drainability assessments for peatlands.

v. New guidance for smallholder cultivation on peat.

vi. Outreach and capacity development materials.

vii. Inputs to other RSPO processes

PLWG MEMBERS

The following members of the PLWG2 participated in working group meetings and provided specific inputs or references to support the work of the group. Affiliations were correct at the time of involvement in preparation of manual.

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Growers (Malaysia)	1. Jason Foong, KL Kepong Berhad (KLK) 2. Raymond Alfred, IOI Group (IOI)	12. Arif Sugandi / Tey Sey Heng,, Applied Agricultural Resources (AAR)
Growers (Indonesia)	3. Joshua Mathews, Bumitama Gunajaya Agro (BGA) 4. Gotz Martin, Golden Agri Resources (GAR)	13. Lim Sian Choo, Bumitama Gunajaya Agro (BGA) 14. Richard Kan, Golden Agri Resources (GAR)
Grower (ROW)	5. Ian Orrel, New Britain Palm Oil Ltd (NBPOL) 6. Shahrakbah Yacob, Sime Darby(SD)	15. Sim Choon Cheak, Sime Darby (SD)
Social NGO	7. Jason Hon, World Wide Fund Malaysia (WWFM) 8. Wida Nindita, Sawit Watch (SW)	16. Riza Harijadudin, Sawit Watch (SW)
Environmental NGO	9. Faizal Parish, Global Environment Centre (GEC) 10. Arina Schrier/Kheizrul Abdullah, Wetlands International (WI)	17. Serena Lew/Julia Lo/Muhamad Faizuddin (GEC) 18. Almo Pradana World Resources Institute (WRI)
Palm Oil Processor and Traders	11. Chin Kaixiang, Bunge Loders Croklaan (BLC)	19. Rianto Sitanggang, Bunge Loders Croklaan (BLC)

ANNEX 3: RSPO PEAT AUDIT GUIDANCE FOR RSPO P&C 2018 INDICATOR 7.7.7

INDICATOR 7.7.7 (C) All areas of unplanted and set-aside peatlands in the managed area (regardless of depth) are protected as "peatland conservation areas"; new drainage, road building and power lines by the unit of certification on peat soils is prohibited; peatlands are managed in accordance with the 'RSPO BMPs for Management and Rehabilitation of Natural Vegetation Associated with Oil Palm Cultivation on Peat', version 2 (2018) and associated audit guidance. (as included in this BMP 2nd Edition published in 2019)			
AUDIT ISSUE	**AUDIT REQUIREMENT**	**GUIDANCE**	**SIGNIFICANCE**
Conservation of peatland set asides	1. There is an assessment and management plan developed and implemented for the peatland areas to be rehabilitated and/or conserved. This plan can be established separately or as part of an integrated management plan for all conservation areas" 2. Degraded peatlands (if present) are being rehabilitated through restoration of hydrology, fire prevention, naturalrevegetation or planting of indigenous trees.	1. Check the report and management plan and verify its implementation at site 2. Check monitoring reports of conservation areas to ensure implemented as per plan 3. Site visit to verify implementation of rehabilitation measures (f applicable)	High
Maintenance of natural water regimes in conservation areas and adjacent lands on peat	1. Measure is taken inside the plantation's boundary that avoids drainage of peatland conservation areas as well as HCV or conservation areas adjacent to the plantation. a. Water table is maintained at near natural levels in peat conservation areas and along plantation boundaries adjacent to HCV and conservation areas. b. Water management (refer to 7.7.4 in audit guidance) within the plantation should not increase the fire risk of areas adjacent to the plantation	1. To check records of water table maintenance at the boundary canal. 2. Mechanism to control the accessibility by land or water.	High
Fire prevention and control (Conservation areas)	1. Fire prevention and control plan for conservation areas is available 2. Adequate firefighting equipment for peat fires available. 3. Personnel have been trained to prevent and control peat fires in conservation areas. 4. Active fire patrols and monitoring in conservation areas.	1. The fire prevention and control plan is available (as a separate plan or integrated with planation plan) and is being implemented (including issue of consultation as necessary with adjacent stakeholders) 2. The plan covers both fire prevention and control 3. FDRS signage is in place, used for fire warning and prevention and warning level regularly updated 4. Regular training for personnel on fire prevention and response. 5. Specialised firefighting equipment is available and properly maintained (check records etc.) 6. Records of patrols and monitoring and follow up action if any incidents.	High

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