SUMMARY:

RSPO MANUAL ON BEST MANAGEMENT PRACTICES (BMPs)

FOR EXISTING OIL PALM CULTIVATION ON PEAT

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Roundtable on Sustainable Palm Oil

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TABLE OF CONTENTS

1.0: INTRODUCTION

The 'RSPO Manual on BMPs for Existing Oil Palm Cultivation on Peat' was prepared in response to the decision by the 6th Roundtable on Sustainable Palm Oil (RSPO) General Assembly (GA6) in November 2009 to provide guidance to improve yields in existing oil palm cultivation on peat and to address issues related to GHG emissions, water management, subsidence and other impacts that affect the potential sustainability of oil palm cultivation on peatlands.

The Manual was prepared through a consultative process facilitated by the RSPO Peatland Working Group (PLWG). The PLWG held six meetings in different parts of Malaysia and Indonesia during the period April 2010 to September 2011. The PLWG collated experiences from RSPO members and non-member companies, visited oil palm plantations and smallholders on peat as well as organized public stakeholder consultation fora in Sumatra, Peninsular Malaysia and Sarawak to gather input for the preparation of this Manual. Preparation of the main draft was facilitated by Peter Lim of PT Bumitama Gunajaya Agro but amendments and contributions were received from a broad range of other PLWG members and external parties. Drafts were circulated for comment to a range of stakeholders. This manual was finalized after 12 revisions to ensure broad consultation with balanced and practical views are taken into account.

The objective of the 'RSPO Manual on BMPs for Existing Oil Palm Cultivation on Peat' is to provide a set of practical guidelines for BMPs that are important for enhancing the management of existing oil palm cultivation on tropical peat, while at the same time reducing environmental impacts especially Green House Gas (GHG) emissions and subsidence. This manual is applicable to existing large plantations and also medium and small-scale cultivation of oil palm on peat.

The Manual draws on more than 30 years' experience in South East Asia (SE Asia) of cultivation of oil palm on peatlands as well as recent research on GHG emissions and water management. It also draws on and refers to existing national regulations and guidelines especially from Malaysia and Indonesia – the countries with the largest areas of oil palm cultivated on peatland.

The Manual is an initial step taken by RSPO to guide its members, particularly producers in responding to stakeholder concerns to promote the implementation of BMPs and reduce negative impacts related to oil palm cultivation on peat. It is also hoped that readers of this Manual will better understand the constraints of oil palm cultivation on peat and the long term implications especially of subsidence, which will in many sites limit the potential long term life span of plantations.

Although the existing cultivation of oil palm on tropical peat has brought about economic and social benefits in Indonesia and Malaysia, great precautions are still needed in existing plantations to minimize GHG emissions and potential impacts to the environment, especially if BMPs are not effectively implemented. The RSPO Principle on commitment for continual improvement should always be emphasized. It is also recognized that the smallholder sector will need more technical guidance and financial support to be able to implement BMPs effectively.

BACKGROUND OF OIL PALM CULTIVATION ON PEAT

Over the last 30 years, oil palm cultivation has rapidly expanded in SE Asia (particularly Indonesia and Malaysia) and currently covers about 12.5 million hectares. Initially oil palm cultivation focused on mineral soils and peat soils were considered less suitable – partly due to poor experience with initial cultivation. These problems were largely due to the lack of understanding of the structure and hydrology of these peatlands.

In the early 1960s, plantation crops such as rubber and subsequently oil palm were planted on peat soils. Again, success was limited due to the use of large drains to remove excess water. In 1986, the pioneering work of United Plantations in Peninsular Malaysia (Gurmit *et al.*, 1986) to introduce water control and nutritional management significantly increased the potential for successful cultivation of oil palms on peat.

In the past 20 years, a combination of development of new technologies for water management and agronomy for cultivating oil palm on peat as well as government planning decisions in some regions has led to the expansion of oil palm on peat. Currently it is estimated that there are about 2.4 million hectares of oil palm cultivated on peat representing about 20% of oil palm in the SE Asia region and covering about 10% of the region's peatlands. To date 666,038 hectares of peatlands in Malaysia (Sarawak – 437,174 hectares, Peninsular – 207,458 hectares, Sabah – 21,406 hectares) (Omar *et al.*, 2010) and about 1,710,000 hectares in Indonesia (Sumatra – 1,400,000 hectares and Kalimantan – 310,000 hectares) (Agus *et al.*, 2011) have been developed for oil palm cultivation.

Peat soils are diverse in physical and chemical properties and not all are productive and easy to manage. Considerable skill, planning and implementation of BMPs as well as knowledge and understanding of peat are required to reduce some of the impacts caused by oil palm cultivation on peat while enhancing yields. Long term environmental considerations and social aspects need to be taken into account in peat-planting especially minimizing subsidence and reducing emissions of greenhouse gases.

It is generally understood that cultivating oil palm on peatland requires significantly more effort and associated costs in comparison to planting oil palm on mineral soils. Increased operational costs for oil palm cultivation on peatlands are a result of additional land preparation works, road/drain maintenance and water management.

2.0: NATURE AND CHARACTERISTICS OF TROPICAL PEAT

DEFINITION OF PEAT

There are several definitions for peat and the most appropriate for tropical peat (modified from Soil Survey Staff, 2010) is:

Tropical peat soils (Histosols) are defined as organic soils with 65% or more organic matter and a depth of 50cm or more.

They are characterized by woody fibers and in undrained conditions are saturated with water for 30 cumulative days or more during normal years.

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 production from the 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).

In contrast to temperate and sub-arctic peat soils, which are mainly formed from Sphagnum mosses consisting of very fine fibers, tropical peat develops under forest vegetation and is derived from coarse, woody material. It is formed at a much faster rate (most peat in Southeast Asia started forming 4,000-7,000 years ago) and decompose more rapidly when exposed to aerobic conditions (Paramananthan, 2008). However, peat soils can vary greatly according to their genesis and hydrology. One major distinction is between ombrogenous and topogenous peat. Topogenous peat is usually smaller in area, shallower and in closer proximity to surrounding upland areas than ombrogenous peat.

Anderson (1961) studied the structure of the peat swamps in Sarawak by means of level surveys and borings to the substratum. In many systems there is a general rise in elevation of the peat in the areas in between adjacent rivers (see ***Figure 1***). It is important to note that these dome-shaped peatlands get their water solely from rain and not from groundwater. As a result, they are nutrient-poor or oligotrophic.

PEAT DEPTH, HORIZONS AND TOPOGRAPHY

Under its natural state, peatlands generally have a high water table and are invariably waterlogged with woody components remaining intact under sustained anaerobic conditions. Once the peat is drained, the oxidation process sets in resulting in the decomposition and mineralization of the organic matter. Thus, it is common to see the soil profile of drained peat consisting of three horizons differentiated by sapric (mostly decomposed), hemic (partially decomposed) and fibric (raw, not composed). Deeper peats especially in Sarawak tend to be less decomposed (more woody), but as peatlands are drained and developed, decomposition increases. The thickness of these three horizons varies depending on the water table and cultivation practices. The sapric layers could extend deeper in drained peat.

Being close to coastal areas, the underlying substrata are usually marine clay (often sulphidic), riverine alluvium or sand. The classification of peat according to depth as shown in ***Table 1*** is widely accepted (Lim, 1989).

Class	Depth (m)
Shallow	0.5 - 1.0
Moderately deep	1.0 - 3.0
Deep	> 3.0

Table 1: Classification of peat (according to depth phases).

Tropical peat has a characteristic dome-shaped topography. Peat depth usually increases towards the centre of the basin. Most peat swamps are generally elevated 4-9m above adjacent river courses. Surface slopes vary between 1-2m per km (Melling and Ryusuke, 2002).

See ***Figure 1*** for an illustration of a typical peat cross-section.

Figure 1: Schematic diagram of peat cross-section (Source: M. J. Silvius, Wetlands International).
NOTE: In reality, the slope of the peat dome is much gentler.

PHYSIO-CHEMICAL PROPERTIES AND FERTILITY OF DRAINED PEAT

The physical properties of peat are those related to the colour, humification level, loss on ignition, bulk density/porosity and its water holding properties. These are generally summarized by Mohd Tayeb (2005) as follows:

- dark colour generally brown to very dark brown (depending on stage of decomposition;
- high organic matter content (>65% loss on ignition value) including undecomposed to semi-decomposed woody materials in the forms of stumps, logs, branches and large roots;
- high water table and often inundated under its natural state, thus an anaerobic environment;
- high moisture content and water holding capacity of 15-30 times of their dry weight (Tay, 1969). This leads to high buoyancy and high pore volume leading to low bulk density (about 0.10g/cm^3) and low soil bearing capacity;
- undergoes oxidation, shrinkage, consolidation and subsidence upon drainage;
- low bulk density (0.10-0.15g/cm^3) of drained peat, resulting in the high porosity (85-90%) and soft ground condition. The initial infiltration rate is very high, ranging from 400-500cm/hour (Lim, 2005a). High leaching of fertilizers is expected during rainy seasons.

The chemical composition of peat is influenced by peat type. The older and thicker the organic horizon, the more impoverished are the surface layers. If the soil is regularly flooded, it has a higher amount of mineral content and is more fertile.

The fertility of drained peat is variable depending on the degree of woodiness, state of decomposition and physio-chemical properties. Tropical peat is acidic (pH 3-4): the inherent Mg and Ca contents of peat are very high compared to K. The total nitrogen content of drained peat is generally high for the first generation of cultivation on peat. With an organic carbon content of more than 40%, the C/N ratio is also high, affecting N mineralization in peat. The release of N in peat for palm growth is influenced by soil moisture, being more available under moist but not water-logged conditions.

PEAT SUBSIDENCE

Under natural conditions, peat swamps are invariably water-logged with high water tables at or near the surface. To use peatland for oil palm cultivation, controlled drainage is required to remove excess water and lower the water table to a depth required by oil palm under best management practices, which is about 40-60cm from the peat surface (water level of 50-70cm in the collection drains).

An important effect of drainage is the subsidence of the peat surface. Subsidence is the result of consolidation, oxidation and shrinkage of the organic materials as a result of drainage. In tropical peatlands, biological oxidation is the main contributor to subsidence (Andriesse, 1988) with estimated long term contributions up to 90% (Stephens *et al.*, 1984; Hooijer *et al.* 2012). These impacts cannot be stopped as long as the water table is below the peat surface (Tie, 2004). In general, the lower the water table, the faster the subsidence. However, water table depth is not the only control on subsidence as it has long been well known that peat oxidation is also controlled by soil temperature and other factors (Stephens *et al.*, 1984; Andriesse, 1988). Substantial subsidence will therefore continue as peat oxidation cannot be stopped even at the highest water levels utilized in plantations.

Subsidence also involves GHG emissions. The oxidation process described above as a result of drainage leads to CO_2 emissions of 35 to more than 80 tonnes of CO_2/hectare/year (depending on peat type, drainage depth, soil temperature and other factors) and thus removal of the soil carbon resulting in subsidence. Therefore, minimization of drainage is important to reduce GHG emissions. However, even with an optimal drainage of 40-60cm in the field, oil palm plantations will still have a significant carbon footprint of about 60 tonnes of CO_2/hectare/year (derived from Page *et al.*, 2011, Hoojier *et al.*, 2012, Jauhiainen *et al.*, 2012). In general, maintaining a high water level as much as the oil palms can tolerate will help to reduce peat subsidence and CO_2 emissions.

The challenges to cultivating palms in peat soils have been documented by pioneers in this area, specifically United Plantations. In areas of deep peat (e.g. Sarawak, Malaysia) the challenge becomes more acute, while the required attention to good management of subsidence over the entire life-cycle is crucial to extend the life span of the plantation.

The rate of subsidence varies strongly depending on the peat type (stage of decomposition, bulk density and mineral content), drainage depth, rainfall conditions, soil temperature, vegetative cover and land management. The more fibric the peat, with lower bulk density and ash content, the higher the subsidence rate and the less the slowdown in subsidence in the long term.

The most practical way of minimizing subsidence, once a plantation has been established on peat, is to maintain the water table as high as crop and field requirements permit. This is to enhance the long term cultivation of oil palm plantations on peat. Open burning during land preparation must be avoided as it will cause rapid and uneven subsidence and oxidation of the peat surface. By minimizing the rate of subsidence, the economic life span of a drained peat area can be prolonged for oil palm cultivation. With good management of water levels and compaction, CO_2 emissions and accidental peat fires can also be minimized. However, in the long term, the demise of the drained peat soil layer is inevitable, and it is thus important – as part of Best Management Practice – to stop further drainage for oil palm cultivation well before undrainable conditions are reached and so minimize further loss or degradation. This is especially important in areas where the drainable peat layer is underlain by potential acid sulphate soil or is below (or may subside to below) the 5-year flood level.

Over-drainage (water table >60cm from the peat surface or 70cm in collection drains) will accelerate the rate of subsidence. In addition, burning and drying of the surface in areas with low vegetation cover can lead to irreversible drying of the organic colloids forming hard granules during prolonged dry seasons resulting in a physically and chemically poor growing medium. Maintaining a ground cover of natural vegetation e.g. *Nephrolepis biserrata* or moss will help to keep the surface peat moist and minimize irreversible drying.

CONSTRAINTS OF OIL PALM CULTIVATION ON PEATLAND

In its natural state, some peat soils (depending on peat type) are less suitable for oil palm cultivation as it they do not provide adequate anchorage and nutrients for the palms. For improving management of existing plantations, these limitations must be addressed in order to enhance the productivity of the plantation and minimize its environmental impacts (Mohd Tayeb, 2005).

The main constraints in the cultivation oil palm on tropical peat can be summarized as follows:

Water management	Presence of elevated peat dome areas that have tendency of over-drainage, flooded patches that are difficult to drain by gravity and rapidly fluctuating water table pose great challenge to effective water management, which is important for high oil palm yields on peat.
Subsidence	Peat subsidence upon drainage greatly affects palm anchorage and the economic life span of peat for oil palm cultivation. Continuous subsidence can cause some areas that can initially be gravity drained become undrainable after several years of oil palm cultivation. Intensive water management is needed to minimize the subsidence rate. Deep planting and compaction are required to reduce the palm leaning problem.
Soft ground conditions	The soft ground condition of peat greatly interferes with mechanization and increases the cost of road and drainage construction/maintenance. The initial cost of development on deep peat is therefore significantly higher compared to that on mineral soils.
Low and imbalanced nutrient content	Peat has a low and imbalanced nutrient content. The K is very much lower compared to Mg and Ca content. This has an antagonistic effect on the K uptake by oil palm on peat. There is also problem with trace element fixation especially Cu and Zn, which is significantly influenced by peat type and water availability, being more serious under over-drained situation. Right timing of fertilizer applications to avoid rainy seasons and proper agronomic management are important for optimizing fertilizer-use efficiency on peat.
Pests	The moist and woody nature of deep peat is very conducive for a number of important pests of oil palm especially termites, *Tirathaba* bunch moths and rhinoceros beetles. Weed growth is also more rapid on peat.

MITIGATING LONG TERM ENVIRONMENTAL IMPACTS

The cultivation of oil palms on peatland is not only a challenge from an agronomic perspective. There are also wide potential impacts that can result from the development of oil palms on peat. These impacts are often specific to the peatland environment or ecosystem. The range of potential social and environmental impacts specific to oil palm development on peatland includes soil subsidence, flooding, water shortage and pollution, fires and air pollution, habitat loss and biodiversity change as well as socio-economics.

The following topics are crucial elements for mitigating the long term environmental impacts of oil palm cultivation on peat.

REDUCING SUBSIDENCE

The continuous lowering of the peat surface can cause areas that can initially be gravity drained, to become undrainable after several years of lowering the water table. Such areas may be widespread, especially in the coastal lowlands of SE Asia where tectonic movements over the last 8000 years have reduced the elevation of many coastal lowlands (east coast of Sumatra, coastal plains of Sarawak, west coast of West Malaysia) and through sea level rise, causing the base of up to 70% of peat domes to be located now below MWL of rivers and sea. This means that in the long term many oil palm plantations on peat may become prone to flooding and salt water intrusion (Andriesse, 1988). In order to reduce this problem and to postpone the loss of drainability, drainage needs to be minimized or stopped before the area becomes undrainable.

It is important to note that implementation of good water management and other BMPs will reduce subsidence but will not stop it, leading over time to long-term drainability problems. Therefore in the medium to long term (depending on local hydrological circumstances), alternative uses will need to be identified for many of the areas now developed as plantations may need to be identified.

ASSESSMENTS PRIOR TO REPLANTING

Assessments should be made prior to any replanting to estimate the potential benefits and costs including a drainability assessment to identify any issues relating to presence of shallow peat layers underlain with unsuitable/problem soils such as potential acid sulphate soils, sandy soils, etc. A key aspect of such assessments would be to identify and avoid replanting on those areas that are less productive and currently flood prone or will later be subject to flooding from the surrounding landscape. The assessment should assess the potential lifespan of the plantation in relation to subsidence impacts and future potential uses. Such assessments should involve proper hydrological and soil investigations as well as modeling of subsidence and potential flooding impacts.

ASSESSING THE DRAINAGE POTENTIAL

The drainage potential of the domed peat soils depends on gravity drainage towards the adjoining rivers. A minimal water level slope in the drainage system is required of about 20cm/km canal length to enable sufficient drainage potential. Through continued subsidence peatlands may lose their potential for gravity drainage. Pump drainage is not an option for tropical peat soils as the costs for pumping of excess water are too high in tropical rain forest climates. Measurements of the actual topographical levels, including the depth to the mineral subsoil, are required to determine the drainage potential (van den Eelaart, 2005). These measurements should include the topographical levels of the water levels in the adjoining river during the peak of the wet season. Using modeling (Duflow) the drainage canal lay-out and its connection to the adjoining river, the actual drainage potential can be determined. The modeling should be created for the different land uses and its required groundwater level and should use the hydrological measurements and the expected daily rainfall, during the rainy season. Because the actual drainage potential might not be sustainable for the future, the Duflow modeling should be repeated based on the expected subsidence of the peat layers at respectively 10 years, 20 years and 40 years after reclamation. This Duflow modeling will provide the best estimates for the sustainability of the present or proposed land use on the ombrogenous peat domes.

AFTER-USE PLANNING

In cases where assessments at the end of the plantation cycle (or even during the plantation cycle) have indicated that some portions of the plantation are not drainable or may soon become undrainable due to subsidence, or are underlain with acid sulphate soils or quartz sand it may be decided that these areas are unsuitable for continued operation as oil palm plantations. Rather than just abandon these areas it is important to consider appropriate after-use. Appropriate after-use could include restoration of peat swamp forest tree cover or planting of indigenous peat swamp tree species with commercial value.

3.0: BEST MANAGEMENT PRACTICES (BMPS): OIL PALM CULTIVATION ON PEATLAND

To mitigate the negative impacts of existing oil palm plantations on peat, BMPs should be carried out. BMPs on peat can be defined as practices, which result in minimum GHG emissions and subsidence as well as environmental and social impacts while maintaining a high economic yield. In order for BMPs to be effective, good implementation, monitoring and documentation are essential. Where possible, BMPs should be measured and quantified.

WATER MANAGEMENT

Effective water management is the key to high oil palm productivity on peat. Good water availability and management is important for healthy palm growth and high yield. Too little or too much water in the palm rooting zone will adversely affect nutrient uptake and FFB production (see ***Figure 2***). Most palms' feeder roots are concentrated in the top 50cm of the peat; therefore this zone must not be water-logged. For this reason, a peat basin must not have conflicting land-use, which requires differential water-levels. It is also important to note that water management is site specific and needs to consider wider implications on surrounding areas as well as to avoid undrainable situations, especially in areas where the mineral subsoil is below Mean Water Levels (MWL).

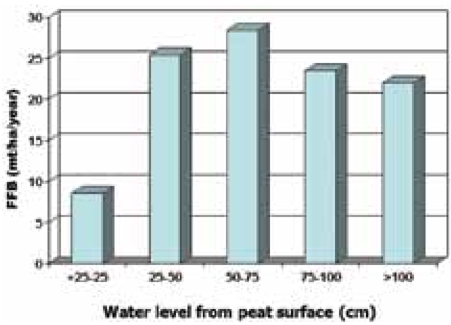

Figure 2: FFB yields (1998 planting) in relation to water levels in a peat estate in Riau, Sumatra, Indonesia.

A good water management system for oil palm on peat is one that can effectively maintain a water-level of 50-70cm (below the bank in collection drains) or 40-60cm (groundwater piezometer reading). It should be able to remove excess surface and sub-surface water quickly during wet seasons and retain water for as long as possible during dry spells. The moist peat surface at this water level will also help to minimize the risk of accidental peat fire.

It is also advisable to cooperate with local communities when implementing a water management system as local knowledge on the subject can be invaluable. While coordinating water level management with local communities is important, it is noted that oil palm plantations should have the in-house proficiency to develop and implement good water management plans that also takes into account impacts on surroundings.

Well planned and executed drainage systems with water control structures should be used for drainage and effective water management. Water-gates and/or weirs should be installed at strategic locations along the main and collection drains for effective control of the water table at an optimum level. Automatic flap-gates are usually installed at the main outlets, which are subjected to tidal variations. It is generally not recommended to install permanent water management structures (made of concrete) as subsidence will ruin the system. Use natural materials such as wood or sandbags for constructing weirs/stop-offs. See ***Figure 3*** for an example of a controlled drainage system.

MAINTENANCE OF THE DRAINAGE SYSTEM

Drain maintenance must be carried out regularly or when required, to keep the drainage system working properly. Poor maintenance of the drainage system can be a cause of flooding in peat estates although it is often a consequence of subsidence relative to the surrounding landscape. Desilting of drains to required depths is best carried out prior to the rainy season. However, care needs to be taken to avoid cutting drains too deep in peat areas.

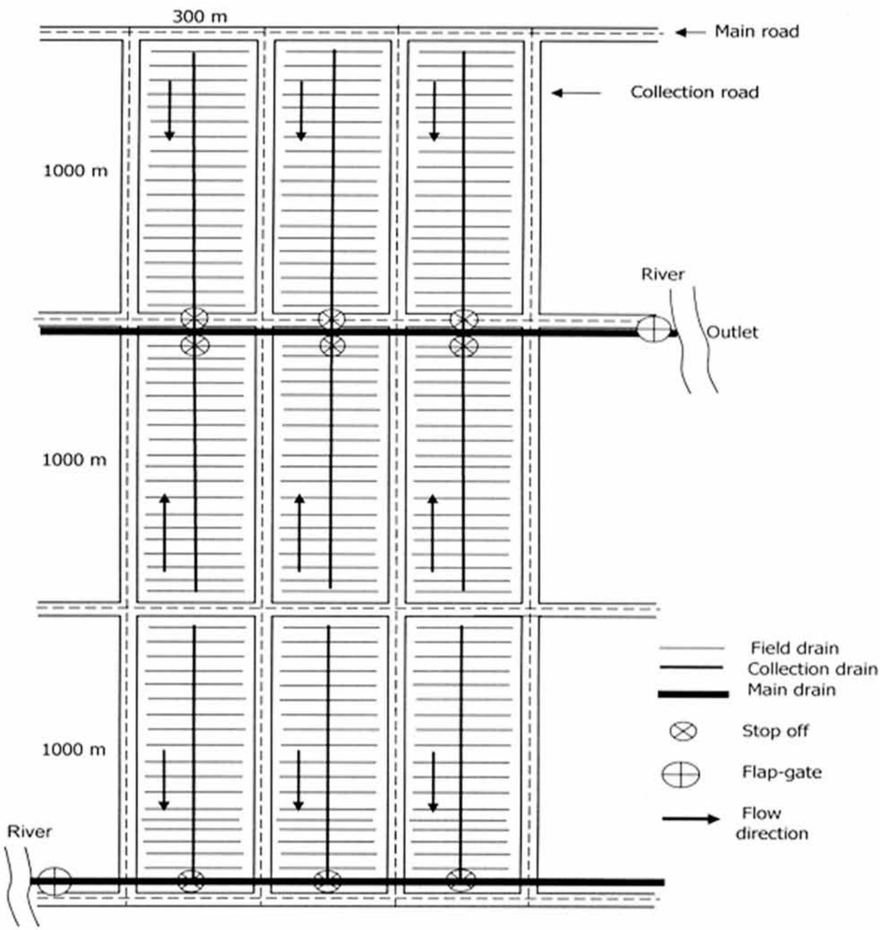

Figure 3: Example of controlled drainage system.

CONSTRUCTION AND MAINTENANCE OF BUNDS

Bunds are important protective structures in coastal areas to prevent the inflow of excess or saline water into the fields. Suitable bunding materials are loamy or clayey soils but these are often difficult to obtain in most peat areas. Clay soils used should not have potential acid sulphate soil (PASS) properties as leaching of the acid from acid sulphate soils can have serious environmental impacts.

Bunds need to be checked and reinforced regularly especially before rainy seasons. This is to minimize bund breakage that will result in flooding and crop losses.

UTILIZATION OF WATER MANAGEMENT MAPS

For more effective supervision and timely actions, each peat estate should have a detailed water management map indicating the directions of water flow, flood-prone fields, locations of water-gates, stop-offs, water-level gauges, bunds, etc.

For higher efficiency in water management, it is important to have water management maps for the both dry and wet seasons. These maps should be calibrated every few years in relation to possible impacts on waterflow from subsidence. It should be noted that higher water levels (e.g. <40cm from peat surface) may reduce yields but would reduce GHG emissions and subsidence as well as increase the lifespan of a plantation that could over time reach an undrainable situation or an acid sulphate soil.

MANAGEMENT OF WATER LEVELS

The optimum water level for high oil palm yield on peat is 50-70cm (in collection drain) and 40-60cm (groundwater piezometer reading) from the surface (see ***Figures 4 and 5***). Again, it is important to note that higher water levels would reduce GHG emissions and subsidence. However, if the water table is too high, fertilizer input will also go directly into the groundwater instead of being taken up by the oil palms. A flooded field will also hinder all estate operations and add to methane/nitrogen oxide emissions so that situation should be avoided (see ***Figure 6***).

Figure 4: Optimal water level management at 50-70cm (in collection drain) results in a yield potential of 25-30mt FFB/hectare/annum. This photo shows the main drain running through an estate.

Figure 5: Over-drainage in main drain in a peat dome area during dry seasons may result in high CO_2 emissions and subsidence rates.

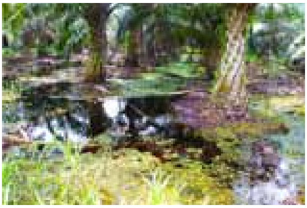

Figure 6: A flooded field will also hinder all estate operations and add to methane/nitrogen oxide emissions.

Weirs or water control structures with over-flows should be installed at strategic locations along the main and collection drains to achieve this water-level (see ***Figure 7***). It is important to ensure that this water level is present in all collection drains. The number of weirs will depend on the topography. They are best installed at every 20cm drop in elevation (see ***Figure 8***). Soil bags and logs can be used to construct such weirs.

Figure 7: An example of a water control structure.

Figure 8: One weir installed at every 20cm drop in water level to enable water retention along collection drains.

Figure 9: Water level gauge for water level monitoring in collection drain.

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 numbered water level gauges at strategic locations and at the entrances of collection drains behind each stop-off (see ***Figure 9***). Ensure that the level is set at zero on the planted peat surface. Negative values indicate water levels below the peat surface and positive values indicate flood levels. Readings are to be taken daily to monitor changes in water level in relation to rainfall. When the water level in a collection drain is less than 25cm from the peat surface, take action for drainage and if it is lower than 65cm from the peat surface, take action for water retention.

To enable more precise water level control, a piezometer can be installed in the middle of each estate block. Normally the water level in the piezometer is about 10cm higher than the water level in the collection drains.

It will be useful to have a full-time water management officer supported by a water management team 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.

FERTILIZER AND NUTRIENT MANAGEMENT

Next to water management, adequate and balanced fertilization is vital for high productivity of oil palm on peat. Due to the high porosity and infiltration rate of peat, minimizing fertilizer leaching is vital for cost efficiency. This is especially important in areas with high and frequent rainfalls e.g. in Sarawak with 3,000-5,500mm and 180-220 rain days per year. Under such circumstances, strict timing of fertilizer delivery and application to avoid high rainfall periods is important especially when applying boron and potassium fertilizers, which are easily leachable in peat. In view of the escalating fertilizer prices, it is useful to maximize nutrient recycling especially through pruned fronds by placing them between the palms, just outside the palm circles. Wider use of bio-fertilizers especially those developed from the by-products of palm oil mills like decanter solids and composted empty fruit bunches is encouraged.

Peat is a decomposing medium with changing available nutrient content especially nitrogen, which is generally high in first generation peat. However due to the very high organic carbon content (>40%), the carbon/nitrogen ratio is high and this delays the mineralization rate. For relatively young plantings, the response to nitrogen is generally good (Manjit *et al*., 2004). The mineralization and release of nitrogen in peat is also influenced by soil moisture, being more available under good moisture regime. The nitrogen fertilization on peat therefore needs to be well regulated with the potassium inputs, to avoid nitrogen/potassium imbalance problems such as the white-stripe symptom, which will affect FFB yield (Lim, 2005a). The emission of nitrous oxide, which is an aggressive greenhouse gas, on fertilized peatlands especially under wet conditions, is a significant GHG impact of oil palm plantations on peat. It is important to note that excessively high nitrogen inputs (more nitrogen provided than the plants will absorb) will lead to undesirable high nitrous oxide emissions. This can be avoided through better fertilizer management.

Plantation companies with large scale planting of oil palm on peat are encouraged to carry out fertilizer trials to determine site-specific fertilizer requirements for their peat types and environmental conditions. Care should be taken to avoid over-application of fertilizers and season of application (i.e. rainy or dry weather) should be taken into consideration. A prescriptive range of fertilizer recommendations and leaf analyses are encouraged for smallholders and larger plantations respectively.

INTEGRATED PEST AND DISEASE MANAGEMENT

With planting of oil palms on large contiguous areas of peat, a number of pests have adapted themselves to the woody and moist environment. If not properly controlled, pest outbreaks can occur, resulting in economic losses due to reduction in yield and stand. Considerable costs and management inputs will be required to control these pests during outbreak situations. In essence, oil palms on peat and mineral soils encounter the same set of pests but on peatland, pests arrive at earlier stages and outbreaks occur more frequently so implementing regular monitoring/census and early warning/ indicator systems are key.

To be cost-effective and environment-friendly in the control of major pests, Integrated Pest Management (IPM) on peat should be adopted (Lim, 2005b). IPM is defined as a pest management system that utilizes suitable techniques in a compatible manner and maintains the pest population at levels below those causing economic injury and crop losses. Good understanding of pest biology and ecology is needed in making the correct choice of physical, cultural, chemical and biological control methods. It is important to look for weaknesses in pest life cycles for targeting control.

In IPM, the amount of chemicals is reduced, to minimize the impact on beneficial and non-target organisms. Chemical treatments are only carried out by using selective pesticides at low rates and timely applications to ensure minimum impact on the biodiversity and environment. The key success factor in IPM is early detection by regular census and rapid treatment. In this respect, all peat estates should have permanent pest census teams. With effective implementation of IPM, expenditures on pest control on deep peat can be greatly reduced.

TERMITE CONTROL

Termites are a very important pest of oil palms planted on peat, causing death to numerous palms if not properly controlled. There are many species of termites found on peat. Most of termites are carrying out beneficial ecological functions of breaking down dead woody materials and converting them into organic matter while releasing nutrients to the palms. However, one species, *Coptotermes curvignathus* has been identified to attack oil palms planted on peat. Termites attack palms as early as seven to eight months after planting and infestations of immature plantings could reach 8-9 per cent with 3-5 per cent dead palms per year if not quickly treated. On mature areas, more than 50% of the palms can be killed by termites before age 10 years if not properly controlled. Negligence in termite control can lead to failure in a peat planting.

For effective termite control on oil palms planted on peat, an early warning system with monthly census on every palm (100% census) and speedy treatment is recommended.

The recommended chemical for termite control is fipronil (5.0 % a.i.) at 2.5ml product per 5 liters of water. Application volumes of the above recommended chemical solution:

Palms > 1 year – 5.0 liter/palm

Palms < 1 year – 2.5 liter/palm

Half the solution is to be sprayed using a knapsack sprayer on the basal region of the spear and crown while the other half is to be sprayed around the bole of the infested palm as a barrier. Where the mudwork is thick, slightly scrape it before spraying. The mudwork on the infested palms gradually dry up when the termites are killed. Application is to be repeated upon detection of reinfestation.

Tirathaba Bunch Moth Control

The bunch moth (*Tirathaba mundella*) is becoming one of the most important pests on oil palms planted on peat both in Indonesia and Sarawak. Poor sanitation, especially presence of unharvested rotten bunches on the palms and weedy field conditions, enhance infestations. More severe infestations are generally found on palms approaching maturity and young mature palms of 3 to 5 years. On tall palms > 5m, infestations are normally lower.

For effective control of the *Tirathaba* bunch moth, early detection and regular census are important. Early detection of *Tirathaba* bunch moth damage is normally obtained by observing harvested bunches on FFB platforms during routine grading. When the infested bunches on the FFB platforms in a block is more than 5%, systematic census on 10% of palm population in the block (all palms in every 10th row) is carried out by a team of trained Pest and Disease (P&D) workers.

An infested bunch is identified by its non-glossy appearance and covered with frass (faeces) compared to a healthy one, which is shiny. Census must be carried out on the percentage of palms with symptoms of infestation and on the percentage of infested bunches on each infested palm. Three categories of infestation are as follows:

Categories of infestation	% Palms infested	% Bunches with infested symptoms	Spray method
1 – Low	> 5-25	> 5-25	Selective
2 – Moderate	> 25-50	> 25-50	Selective
3 – High	> 50	> 50	Blanket

For Category 1 and 2, spot spray infested palms and bunches selectively with *Bacillus thuringiensis (Bt)* at 1g product/liter of water at 2-weekly intervals. Use relatively clean water with low suspended dirt. Avoid using old product stocks more than 1 year old. Target spraying on developing bunches and female flowers that have damage symptoms. Avoid spraying during rainy days. If it rains heavily after spraying, a repeated spray on the next day is required.

For Category 3, blanket spray all palms and bunches as above. Carry out sanitation of all badly infested and rotten bunches prior to spraying.

Management of Leaf-Eating Caterpillars

Under normal conditions, leaf-eating insects are kept under control by natural enemies such as predators (e.g. predatory wasps), parasitoids, parasites, fungal and viral pathogens. Under conditions when natural control is inadequate, outbreaks can happen. Palms of all ages are susceptible to attack by leaf eating caterpillars, especially mature palms more than 5 years old when overlapping fronds speed up the spreading of caterpillars from palm to palm.

The main species of leaf-eating caterpillars are:

- Bagworms – *Mahasena corbetti*, *Metisa planaa* and *Pteroma pendula*. They are called bagworms because they cover themselves with casings made of leaf tissues.
- Nettle caterpillars – *Darna trima*, *Setora nitens* and *Setothosea asigna*.
- Hairy caterpillars – *Dasychira spp.* and *Amathusia phidippus*.

Outbreaks of leaf-eating caterpillar infestations are monitored in 3 stages namely:

- Alert (early recognition of infestation signs is important as the pests can spread quickly, especially in mature areas).
- Identification of species involved and stages of development.
- Census to determine if the pest population levels have reached threshold values for chemical control.

It will be useful to plant beneficial plants (especially *Cassia cobanensis*) on the road sides for biological control (see ***Figure 10***). *Cassia cobanensis* establishes well on peat under non flooded condition. It produces nectar from flowers and leaf stipules throughout the year and is therefore effective in attracting predators and parasitoids for biological control of leaf-eating caterpillars especially bagworms.

Figure 10: Planting Cassia cobanensis to attract natural enemies for biological control of leaf-eating caterpillars (Inset: Close-up of Cassia cobanensis flower).

Rat control

Rats are important vertebrate pests in oil palm plantations on peat. They cause damage in both mature and immature plantings. On mature palms, rats feed on loose fruits and developing fruit bunches. They also attack the inflorescences. Crop losses due to rat damage were estimated at 7-10% if not properly controlled (Liau, 1994).

For immature palms, rats chew on palm bases and consume the meristematic tissue, killing them in advanced cases. Rats also attack oil palm seedlings in nurseries, causing severe retardation or death to the seedlings.

Regular censuses on a block-by-block basis and baiting without delay (when required) are the key to successful rat control in oil palm plantations (Chung and Sim, 1994). This is because rats with access to good nutrition sources in oil palm plantations reproduce very rapidly.

The 3 main species of rats causing economic damage are:

- *Rattus tiomanicus* (Wood rat, white belly)
- *Rattus argentiventer* (Paddy field rat, grayish belly)
- *Rattus rattus diardii* (House rat, brown belly)

Where possible, use of barn owls (*Tyto alba*) for biological control can be practiced. In the use of barn owls for biological control of rats, nest boxes are provided at 1 unit per 5 to 10 hectares to encourage build-up of the owl population (Duckett and Karuppiah, 1990; Ho and Teh, 1997). However, it is unlikely that the owls will keep the rat population under control indefinitely. As such, intervention via baiting will still be necessary from time to time.

Management of Rhinoceros Beetle

The rhinoceros beetle (*Oryctes rhinoceros*) is an important insect pest of immature oil palms on peat. The beetles breed in rotting woody materials where the grubs feed and develop in. In the Riau area, rhinoceros beetles in peat areas are often migratory from the nearby coconut plantations.

The use of aggregating pheromone integrated with chemical spraying is an effective IPM tool for monitoring and controlling rhinoceros beetles in immature and young mature oil palm fields.

***Ganoderma* Management**

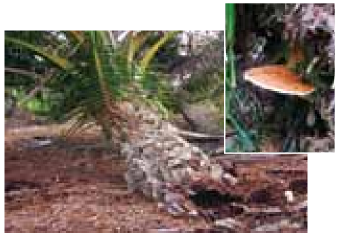

Figure 11: Basal Stem Rot (BSR) caused by Ganoderma infections (Inset: Close-up of Ganoderma fungi).

Stem Rot caused by *Ganoderma boninense* and *Ganoderma zonatum* is a major disease of oil palm planted on peat (see ***Figure 11***). On first generation oil palm from logged-over forests, normally *Ganoderma* infections are rare during the first 6-7 years after planting. Thereafter, disease incidence will increase especially in areas with low water levels >75cm from the peat surface (Lim and Udin, 2010). The pattern of disease distribution by enlarging patches indicates that the disease is spread mainly by root contact from primary disease focal points or inoculum sources.

There is currently no effective cure for *Ganoderma* infections in an existing stand. Three to six monthly censuses of *Ganoderma* infections are recommended. For efficiency, estate workers like loose-fruit collectors and sprayers can be integrated to do these censuses.

On peat areas, it is important to maintain a water level of 50-70cm from the peat surface to minimize *Ganoderma* infections and spread of this deadly disease on oil palms planted on peat.

WEED MANAGEMENT

The moist environment in peat favors luxuriant growth of weeds especially in areas of high rainfall such as Sarawak (3,000-5,500mm/year). However newly drained peat is relatively weed-free for about 6 months after land preparation. Due to the fast weed growth in peat areas, any delay or neglect in weed control will lead to rapid deterioration of field conditions, especially in immature areas.

MANAGEMENT OF LEANING AND FALLEN PALMS

Palm leaning is one of the major problems of planting oil palms on tropical peat. Random leaning and in severe cases, fallen palms, are due mainly to peat subsidence. The low bulk density of peat (0.10-0.15 gm/cm^3 and the less extensive root system of oil palm planted in peat are also contributory factors to leaning and fallen palms. About 40-50% of the palms planted on peat can lean at various angles and directions at the age of about 7-8 years. The number of fallen palms increases thereafter due mainly to excessive root exposure, desiccation and breakage caused by the weight of the palms. Depending on the severity of leaning and fallen palms, a yield reduction of 10-30% can occur due to root damage and poorer interception of sunlight for photosynthesis. Different directions and degrees of palm leaning also interfere with harvesting due to differential palm height. A practical approach to rehabilitate leaning and fallen palms is to carry out soil mounding to minimize root desiccation and promote new root development.

Good water management to maintain the water level at 50-70cm (from water level in collection drains) or 40-60cm (groundwater piezometer reading) is crucial to minimize peat subsidence and reduce palm leaning.

REPLANTING PRACTICES

Replanting is normally carried after 20-25 years when yield is below economic level. However accelerated replanting may be required due to illegitimate planting materials or low productive stands caused by *Ganoderma* infections. Yield of second generation palms on peat is generally better than in the first generation palms as peat is more compact and better decomposed (Xaviar *et al.*, 2004).

In the Manual, detailed guidance is provided for the following replanting practices: assessments prior to replanting, assessing the drainage potential, replanting approaches, deep planting and compaction (see ***Figure 12***), reducing emissions from replanting and after-use planning.

NURSERY MANAGEMENT

Good nursery practices are required for effective replanting. It is important to produce the best selected seedlings for high yields. For this reason nursery works should not be contracted out.

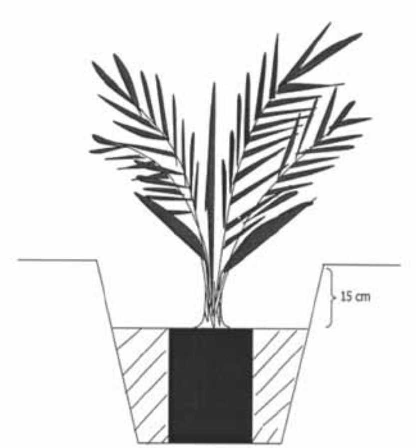

Figure 12: An illustration of deep planting on solid peat surface.

4.0: BEST MANAGEMENT PRACTICES (BMPS): OPERATIONAL ISSUES

ENHANCING YIELD

Low yielding oil palm plantations on peat can be due to a number of reasons specific to each location. The main reasons for low yield are poor water management with over-drained areas, inadequate manuring, inadequate labour, poor field supervision and management, poor pest control especially termites, leaf-eating caterpillars and *Tirathaba* bunch moths, poor planting materials and vacant points or abnormal palms (best to supply/replace before age of 5 years). If the limiting factors are poor planting material, low productive stand and high *Ganoderma* infection, it is best to carry out accelerated replanting.

TRANSPORT SYSTEMS

Effective transport systems are often referred to as the backbone of any oil palm plantation operation. Road transport is still regarded as the most important option although this can be supplemented by other modes like water transportation. It is important to note that the focus of this Manual is on existing plantations, which will already have developed a transport system. However, some guidance is provided for the actual construction/establishment of various transport systems in the event that estates envision restructuring their transport systems during replanting periods.

LABOUR AND MECHANIZATION

Oil palm cultivation is labour intensive especially on peat areas. Labour shortage, especially skilled harvesters, is a major constraint now, not only in Malaysia but also in Indonesia. This has resulted in substantial crop losses. To maintain a stable and productive workforce on peat estates, proper housing with basic amenities and satisfactory income are vital. Another area that can mitigate the labour shortage situation is further mechanization.

TRAINING AND FIELD SUPERVISION

Technologies for oil palm cultivation on peat, especially deep peat, are increasingly available due to greater R&D efforts by both the private and public research organizations. New techniques for more effective pest control, early fire detection and control, safety measures and mechanization need to be disseminated quickly to all levels. This is best done through structured training programmes, ranging from managers, senior assistants, assistants, field conductors, *mandores* to general workers. Most large plantation companies in Malaysia and Indonesia now have their own in-house training centres to carry out training systematically and effectively. This is important to minimize the risks of any serious mistakes during oil palm cultivation on peat, which is usually expensive to correct. Stringent supervision by all levels of the estate management is also vital to achieve higher efficiency on peat estates.

5.0: BEST MANAGEMENT PRACTICES (BMPS): ENVIRONMENTAL AND SOCIAL ISSUES

CONSERVATION, MAINTENANCE AND REHABILITATION

Tropical peat swamp forests are a critically endangered category of forested wetland characterized by deep layers of peat soil and waters in which a high diversity of plant and animal species is found with unique adaptations to their specific waterlogged and acidic conditions and do not occur in the other tropical forests of Asia. These unique forests play key roles in preserving water supply, regulating and reducing flood damage, providing fish, and other resources for local communities, and regulating the release of greenhouse gases by storing large amounts of carbon within peat. They also support a host of globally threatened and restricted-ranged plants and animals (Wetlands International – Malaysia, 2010).

River reserves or greenbelts 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, river reserves/ greenbelts that are intact and functional are important habitats for biodiversity and provide ecosystem services.

The following are the main reasons why peat swamp forests and river reserves/ greenbelts within and adjacent to oil palm plantations need to be conserved, maintained and rehabilitated: water quality improvement, flood mitigation, High Conservation Value (HCV), endangered and endemic species, wildlife corridor and buffer zone, aquifer or water catchment/retention area, prevention of hydrological disruptions to adjacent peat swamp forests, fire prevention, riverbank stabilization and fisheries.

Oil palm plantations have a role to play in identifying, managing and enhancing river reserves and peat swamp forests 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/greenbelts and other areas unsuitable for oil palm or have high conservation value in the long-term. For plantations that have already planted oil palms on river reserves, steps must be taken to restore these areas to its original state.

The following are examples of areas that are recommended to be identified, managed and enhanced as conservation areas within plantations on peatlands due to their high conservation value and/or unsuitability for planting oil palms:

- Peat dome (Padang Raya) areas (low moisture and fertility)
- Shoulder of dome (Alan Forest) areas (large roots contained in peat)
- Undrainable areas
- Vital wildlife corridors (to avoid human-wildlife conflict)
- Remaining natural peat swamp forest areas and streams with endemic or endangered species or other HCV characteristics

Guidance in terms of regulatory requirements for maintenance of conservation areas and river reserves is provided by the Drainage and Irrigation Department (DID) Guidelines, Indonesian Law No. 41/1999 and Indonesian Sustainable Palm Oil (ISPO) Principles and Criteria. These should be adhered to.

ENVIRONMENTAL MANAGEMENT

It is critical to incorporate a sensible environmental management plan to ensure that good environmental and waste management practices are adopted to conserve resources in the long term rather than allowing it to be exploited for short term gains. Environmental legislation and audit systems in place in both Indonesia and Malaysia must be followed.

FIRE PREVENTION AND CONTROL

Peatland fires are a serious problem in Indonesia and Malaysia. The 'Manual for the Control of Fire in Peatland and Peatland Forest' published by Wetlands International – Indonesia Programme in December 2005 elaborates on a variety of concepts and practical measures for the prevention and suppression of fire and also draws from field experience in handling of land and forest fires in the peatland areas of Kalimantan and Sumatera, Indonesia. The following are important elements quoted from this Manual (Wetlands International – Indonesia Programme, 2005).

Fires occur not only on dry land but also on wetland areas such as peatland, particularly during the dry season when these areas dry out (especially when deforested and drained). Overcoming fire on drained and deforested 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. On 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 fires are difficulties in obtaining large quantities of water nearby and gaining access to the site of the blaze. For these reasons, severe/extensive peatland fires can only be extinguished by natural means i.e. long consistent periods of heavy rain.

PLANTATION-SPECIFIC GUIDELINES

Plantation companies can help prevent peat fires by ensuring the following recommendations are in place and implemented:

- ***Zero Burning methods for land clearing/replanting:*** Implementation of Zero Burning concepts greatly reduce the risk of fires occurring.
- ***Effective surveillance and monitoring:*** In order for surveillance and monitoring of plantation activities to be effective, overall work needs to be broken down into smaller management units i.e. unit, block, sub block. The leader of each unit, block and sub block is responsible for the surveillance and monitoring of their area with regards to fire prevention. There should also be an intensive network of paths around estate blocks to facilitate surveillance and enable fire-fighting personnel and equipment to access areas of concern quickly. These paths can also function as fire breaks to prevent surface fires from spreading.
- ***Formation of land and peat forest fire suppression units:*** It is important to develop an organizational structure to handle fire control in a plantation company. Overall leadership should be provided by the Head of the Fire Protection Division 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 Head of Fire Protection Division:
  - o *Information Unit:* develops and manages information related to fire danger
  - o *Special Fire-Fighting Unit:* backs up the core fire-fighting units
  - o *Guard/Logistics Unit:* mobilizes equipment and handles logistics
  - o *Sentry units:* posted in places that are especially prone to fire
  - o *Core fire-fighting units (for each block):* patrol units who have the task of surveillance over the whole block

MINIMIZATION OF GREEN HOUSE GAS (GHG) EMISSIONS FROM OIL PALM PLANTATIONS

The transformation of an intact peat swamp area to oil palm plantations leads to a release of carbon and greenhouse gasses to the atmosphere (De Vries *et al*., 2010; Henson, 2009; Jeanicke *et al*., 2008; Danielson *et al*., 2008; Fragioni *et al*., 2008; Rieley *et al*., 2008; Gibbs *et al*., 2008; Wosten and Ritzema, 2001; Hooijer *et al*., 2010). When oil palm plantations are developed on peat, oxidation due to drainage, the possible increased fire frequency and carbon losses in the case that forest is cleared are the major sources of significant increases in greenhouse gas emissions. Page *et al*. (2011) reviewed a large number of assessments of GHG emissions from peatlands in SE Asia and concluded that the best available estimate of GHG emissions from oil palm plantations on peat was 86 tonnes of CO_2 per hectare per year (annualized over 50 years) based on combined subsidence measurements and closed chamber measurements in the same plantation landscape.

Methane emissions from open water bodies such as drainage canals and ponds are likely to impact the methane balance. This may be significant since the water surface from drainage canals may account for up to 5% of the total area of a plantation on peatland. Nitrous oxide is primarily emitted from agricultural landscapes as a byproduct of nitrification and denitrification. In oil palm plantations, the application of fertilizers in particular accelerates the release of nitrous oxide and also of CO_2 (by catalyzing biological processes that result in oxidation). It is important to note that current sustainability measures in oil palm plantations on peatlands will only decrease emission source strengths, but will not stop peat carbon emissions, which with a drainage level of 40-60cm will still be around 35-55 tonnes of CO_2 per hectare per year.

Once a plantation is developed, maintaining the water table as high as practically possible (40-60cm) and preventing fires will considerably reduce CO_2 emissions since oxidation and fires are the largest emission sources. In addition, the following are areas where the oil palm sector can minimize GHG emissions on peat plantations: water management, fire prevention, soil compaction, fertilizer practices, carbon stock, mill practices and fuel utilization.

SOCIAL AND CULTURAL ISSUES

Satisfactory amenities lead to healthy and more productive workers. Proper housing, water and electricity supplies are basic needs. Clinics, shops, playgrounds and other supporting amenities will make a big difference in labour productivity and retention.

In areas where plantations operate, it is not uncommon in some cases for there to be prior users or owners of the land. Often those in the area include communities with either claims to tenure, use, territory or environmental services. In peatland areas, traditional communities and indigenous groups there are intrinsically tied to the land for a wide range and often essential uses. These can include ancestral lands, community forests, subsistence or low impact agriculture and relying on the area itself for natural resources. These resources include timber, sustenance and other Non-Timber Forest Products (NTFP). In addition peatland are also often maintained as natural water regulators preventing flooding and ensuring soil fertility.

There are often issues relating to Native Customary Rights (NCR) and land claims by natives both in Malaysia and Indonesia. These should be resolved peacefully by negotiation and sometimes, inevitably via conflict resolution methods and tools available. For oil palm plantations on peatlands, one risk from poor relations with local communities and not resolving conflicts at early stages may be higher chances of fire due to arson.

COOPERATION WITH LOCAL COMMUNITIES

It is often heard that many plantations find it extremely challenging in trying to recruit workers from their community area. The reasons often cited by plantations include the differences in expectations between many communities and the estate. Often individuals in the community may be involved in part-time or casual work, such as seasonal labour. Such an arrangement is suited to many as it allows time for tending to their own land; often cultivated with cash crops like rubber or oil palm and fruit orchards.

Plantations may find benefit in extending community relations both in sophistication and cooperation. Thus far, examples of synergies between local communities and plantations are rare. The closest relations known are the sale of cash crops to plantation mills. However plantations may find cost-benefits from increasing its sourcing of food with local content. Many communities often lack resources and capacity in entrepreneurial ventures. Plantations may be pivotal in raising capacity of communities in trade, tourism, marketing and agronomic practices.

OCCUPATIONAL HEALTH AND SAFETY ISSUES

Plantation activities are labor intensive and in some situations, regarded as being more difficult on peat than on mineral soil plantations. During rainy seasons, due to the presence of localized flooded patches, there could be more incidences of mosquito-related infectious diseases. Soggy fields and road conditions during wet seasons may also result in higher cases of accidents in the field. During dry seasons, good drinking and bathing water may be limiting in some peat estates, giving rise to related health problems. It is therefore important to consult with estate employees/workers for promoting and creating safe work systems and environments in peat estates rather than just basing on prescriptive regulations.

6.0: BEST MANAGEMENT PRACTICES (BMPS): RESEARCH & DEVELOPMENT, MONITORING AND DOCUMENTATION

RESEARCH AND DEVELOPMENT

Research and development is vital for continual improvement of BMPs for oil palm cultivation on peatland, especially since this is a relatively new area of development for the oil palm sector.

The task of increasing productivity, efficiency and decreasing adverse impacts or slowing down adverse processes of oil palm plantations on tropical peat poses a great challenge to researchers and planters. Most large companies with substantial peat plantings e.g. United Plantations, Tradewinds Plantations and PT TH Indo Plantations have established in-house Research and Advisory Departments dedicated to meet these needs. When engaging third-party agronomists for advisory services, it is important to select those with proven field experience and a track-record on tropical peat.

More applied research is vital to enhance the potential of decreasing environmental impacts of oil palm cultivation on peat. Cost-effective innovations are continuously needed to meet the many challenges of oil palm cultivation on peatland. Planters with practical experience can also play a role in developing new peat technologies rather than just leaving it to agronomists and researchers.

MONITORING AND REPORTING

By law, oil palm plantation companies are required to monitor and report on environmental and social impacts of their developments in the form of environmental and/or social management plans. This is especially important for cultivation on peatland, an environmentally sensitive ecosystem with complex hydrological regimes.

DOCUMENTATION OF OPERATING PROCEDURES

Documentation of BMPs and including this information in oil palm plantation companies' standard operating procedures is the key to effective implementation of these BMPs. This is in line with RSPO's Principles & Criteria for Sustainable Palm Oil (RSPO P&C).

7.0: OIL PALM CULTIVATION BY SMALLHOLDERS ON PEATLAND

Smallholder production has much to offer the future of the palm oil industry in terms of sustainability and credibility especially in Indonesia where smallholders account for about 40% of palm oil production (holdings < 25 hectares).

Oil palm yields of smallholders on peat both in Indonesia and Malaysia are generally much lower than large plantations due mainly to poor land preparation and inadequate agronomic inputs, especially poor water management, inadequate/imbalanced fertilizer applications, improper pest and disease management and poor harvesting practices. Many smallholders also use illegitimate planting materials with high dura contamination giving rise to lower FFB yields and oil extraction.

Coordination and cooperation is the key to effective implementation of BMPs for cultivation on oil palm on peatland for smallholders. For smallholders, implementation of vital components for cultivating oil palm on peat like water management, fertilizer management, pest and disease control and fire prevention, usually require a network for cooperation either with companies or amongst smallholders. Local governments also have a role to play as coordinators. Implementation challenges may be less inherent for scheme smallholders but independent smallholders usually require technical and financial support.

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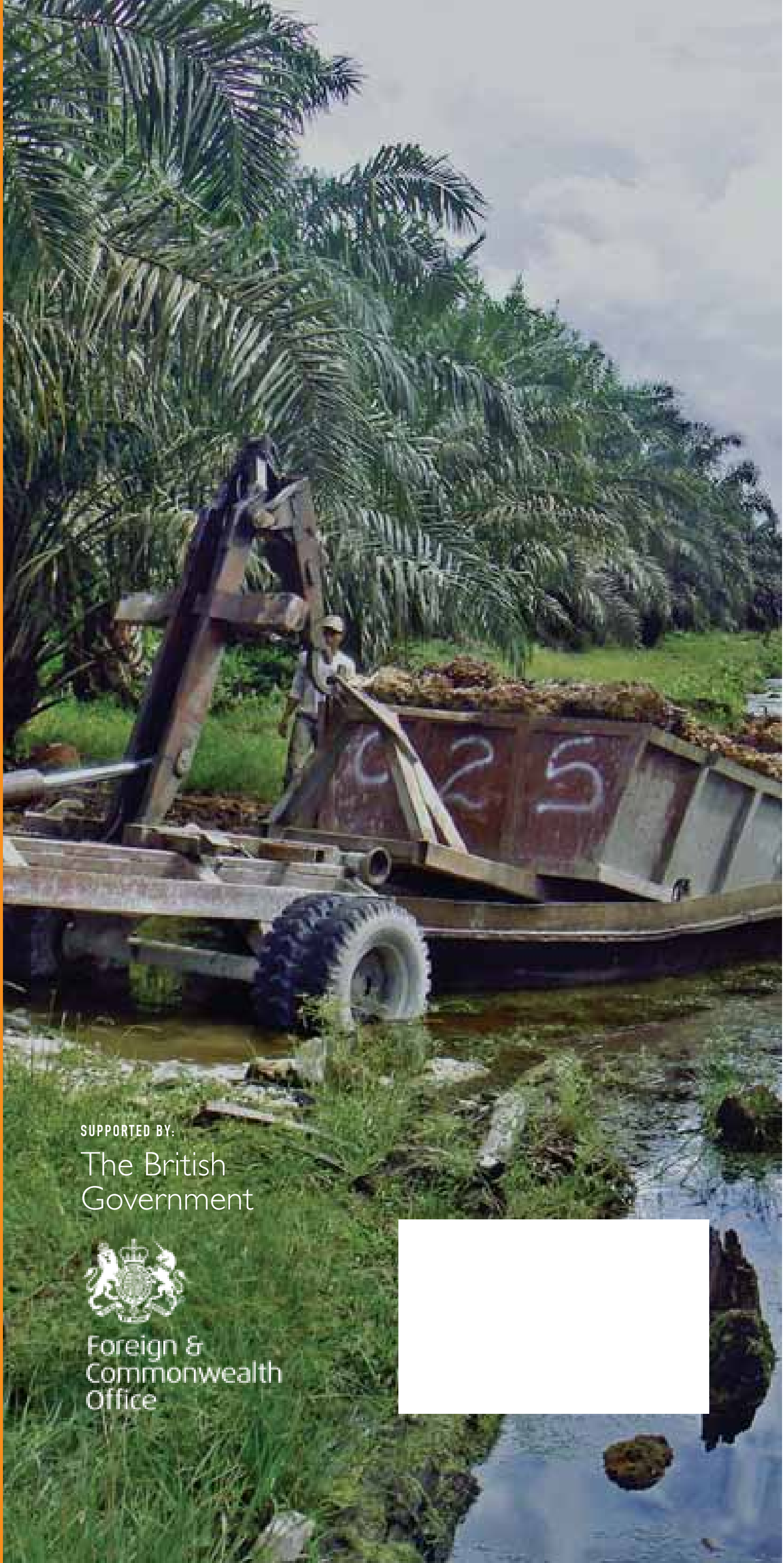
COVER IMAGE:
Workers loading barges with oil palm fruits, which have been transported by water to save energy and enhance access.



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