Sustainable Management of Peatland Ecosystems in Mekong Countries

Training Module 1A
PEATLAND IDENTIFICATION: DEFINITION, CHARACTERISTICS AND IDENTIFICATION OF PEATLANDS

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1.0 Overview

Peatlands are the most extensive wetland ecosystem globally. They provide important ecosystem services related to climate and water regulation and biodiversity conservation. While covering only 3 % of the Earth's land surface, peatlands store 25% of the world's soil carbon. Degrading peatlands, covering only 0.4% of the land surface are responsible for nearly a quarter of global carbon emissions from the land-use sector.

Tropical peatlands in Southeast Asia are mainly naturally covered with peat swamp forests, but some systems in northern ASEAN or in uplands are vegetated with sedges, reeds or mosses. Peatlands cover approximately 25 million hectare (ha) in the Southeast Asia with the majority in Indonesia, Malaysia, Brunei Darussalam, Thailand and Viet Nam, and smaller areas in Myanmar, Lao PDR and the Philippines. Peatlands play a critical role in the economy and ecology of the region – providing timber and non-timber forest products, water supply, flood control and many other benefits. They also play a very significant role of global significance in storing an estimated 70 billion tonnes of carbon or approximately 5% of all global terrestrial carbon as well as being repositories for unique and important biodiversity.

2.0 What are peat and peatlands? (from Joosten in Parish *et al*, 2008)

Peat is a soil layer that forms when inputs of dead plant organic matter to the soil exceed the mineralization and export of soil organic matter over a long period of time. These conditions generally require that water levels be near the soil surface. Under these conditions, soil water saturation and oxygen deficiency limit the decomposition of soil organic matter but still allow biomass production by locally adapted vegetation. Water saturated peat consists of more than 95 percent of water. The water content largely determines the peat's physical characteristics, such as bulk density, compressibility and hydraulic conductivity. A peatland is "an area with a naturally accumulated peat layer at its surface".

Peatland types

There are two major types of peatlands (see Figure 1): bogs (which are mainly rain-fed and nutrient-poor) and fens (which are mainly fed by surface or ground water and tend to be more nutrient-rich). However, there are many different variations of peatland type, depending on geographic region, altitude, terrain and vegetation. Peatlands may be naturally forested or naturally open and vegetated with mosses or sedges. Another distinction that can be made is between peatlands where peat is currently being formed – these are known as mires – and areas which formerly had peat formation, but due to human interventions or climate change, peat is no longer developing.

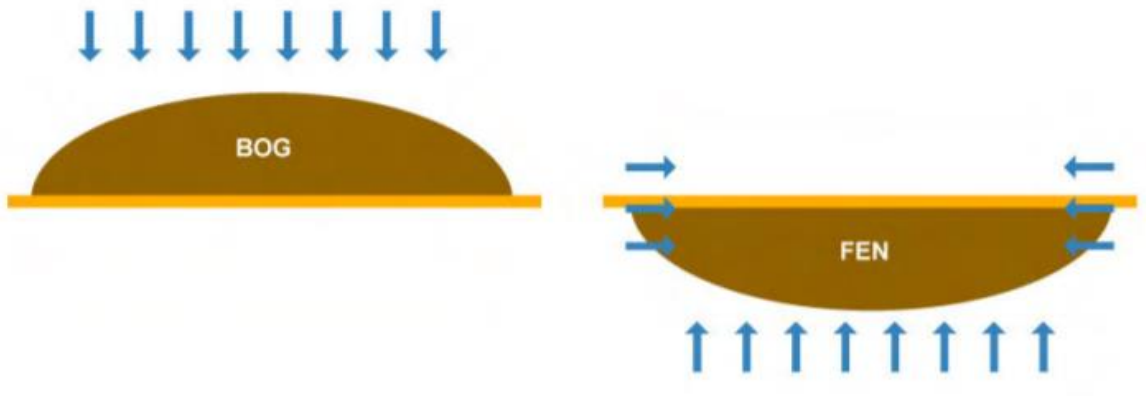

Figure 1: The classical difference between "bog" and "fen" peatlands.
Shaded = peat; Arrow = water flow (Source: Joosten, 2008)

Definition of peat for Northern ASEAN region

There is a variety of definitions of peat internationally, but most relate to the depth and content of organic matter. In southern ASEAN, the most extensive peatlands are ombrotrophic bog peatlands which have formed in lowland swamps following sea level rise. Most of their water input is from rainfall and as a result, they have little mineral content and are mainly formed of organic matter. In Northern ASEAN region, peat tends to be found mainly in lake and river basins where there is a higher input of mineral soil and therefore lower portion of organic matter. Given the much higher density of mineral content than organic matter[1] – a small increase in the volume of mineral content – can lead to a high percentage reduction in the relative weight of organic matter.

For the Mekong countries, it is recommended to derive the definition based on the FAO World Reference Base for Soil Resources[2] definition of organic soil (Histosols) to identify peat.

> *Histosols (organic soils) are soils with cumulative organic layer(s) greater or equal to 40cm thick in the top 80cm of soil,* saturated with water for at least one month in most years (unless artificially drained) and *containing 12*-18 % (by dry weight) organic carbon (20-30 % organic matter/*Loss on Ignition*)[3] or more, depending on clay content *(World Soil Reference Base, FAO 2015).*

3.0 Characteristics of peatlands

3.1 Introduction

The major characteristics of natural peatlands are permanent water logging, the formation and storage of peat, and the continuous upward growth of the surface. These characteristics determine the specific goods, services, and functions associated with peatlands. The long-term storage of carbon and water within peatlands as well as the high biodiversity of peatland especially in the tropics is of global significance. Worldwide, peatlands contain 550 billion tonnes of carbon) and 10% of the global fresh water in their peat (Parish *et al*, 2008) Carbon storage is made possible by the permanent water-logging of the peat body. Water-logging and the continuous upward growth of the surface further determine the special and extreme site conditions to which peatland organisms are exposed.

These conditions typically include (Joosten, 2008):

- A scarcity of oxygen and the presence of toxic ions such as $Fe2+$, $Mn2+$, $S2-$ in the root layer
- Continuously rising water levels that can suffocate perennial plants
- A scarcity of nutrients
- A generally cooler temperature than the surrounding mineral soils, with stronger temperature fluctuations
- Acidity caused by organic acids and cation exchange
- The presence of toxic organic substances produced during decomposition

As a result of these extreme conditions, natural peatlands are generally species-poor compared with mineral soils in the same biographic region. However, many peatland species are strongly specialised and not found in other habitats.

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[1] The bulk density of mineral soil is about 2-2.5gm/cm^3 whereas organic matter may be 0.05gm/cm^3

[2] IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015 International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

[3] 18 % (by dry weight) organic carbon (30 % organic matter/ *Loss on Ignition*) or more if the mineral fraction has 60 % or more clay; or have 12% (by weight) organic carbon (20 %organic matter) or more if the mineral fraction has no clay; or have a proportional lower limit of organic carbon content, between 12 and 18 %

3.2 Physical Properties

The physical and chemical properties of peat can be determined by using a variety of field, laboratory and modelling techniques[4]. Due to the inherently unstable properties of peat, the use of each of these methods presents some difficulties. Consequently, different methods are often combined to deliver multiple estimates for the same parameters.

Key Physical properties (adapted from Andriesse, 1988) include:

a) Bulk density

The bulk density of an organic soil is the weight of a given volume of soil usually expressed on a dry weight basis in grams per cubic centimetre (g/cm^3). Bulk density is perhaps the most important intrinsic characteristic of peat because many other properties are closely related to it. Bulk density depends on the amount of compaction, the botanical composition of the materials, their degree of decomposition, and the mineral and moisture contents at the time of sampling. Bulk density can be measured by taking a peat sample of known volume and measuring its dry weight. Values range from 0.05 g/cm^3 in very fibric, undecomposed materials to 0.5 g/cm^3 in well decomposed materials.

b) Determination of organic matter content through loss on ignition method

The main method to establish the amount of organic versus mineral matter in an organic soil is by loss on ignition (LoI). In this method, the sample is first dried in an oven at 105 degrees to remove most of the water. It is then incinerated, at a temperature of ±800°C. The organic material is lost leaving behind the mineral matter or ash. The relative percentage of organic matter (the amount lost on ignition/incineration) and the mineral content remaining. This information is key in the differentiation between peat and mineral soils.

c) Irreversible drying

Irreversible drying occurs after periods of intensive drying and is typical of badly degraded peat soils. Surface layers of organic materials in many reclaimed and drained peat swamps exhibit this behaviour. After exposure to the sun, the materials become rather like coffee grounds, and are very difficult to re-wet as the molecular structure changes such that the peat is hydrophobic (or repelling water) compared to it being hydrophilic (or attracting water) in its natural state. This may be a barrier to restoration of a degraded peatland.

d) Swelling and shrinking

Most organic soils shrink when dried but swell when re-wetted, unless they are dried to a threshold value beyond which irreversible drying occurs. Shrinkage calculated as a percentage of the original volume ranges from 90 percent for peats with a very high water content to 40 percent for fibric peats. Organic soils appear to become less affected by drying after they have been cultivated for some time. This is partly related to the increased decomposition and gradual change from a fibric to a more sapric nature. The wood content of the peat influences shrinkage as the wood acts as a stable skeleton reducing shrinkage of the whole.

e) Humification

Humification is a measure of the degree of decomposition of the organic matter in peat. This is important to know as the degree of decomposition affects many of the physical properties (eg Bulk density, water holding capacity, carbon storage etc)

Peat (Histosols) can be sub-divided into three different types based on the degree of decomposition/humification of the peat:

a) **Sapric peat**, which consists of less than one-sixth recognizable plant matter after the soil is gently rubbed;
b) **Fibric peat**, which consists of more than two-thirds recognizable plant tissue after rubbing; and

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[4] Riccardo Biancalani and Armine Avagyan (eds). 2014. Towards climate –responsible peatlands management. Mitigation of Climate Change in Agriculture Series 9. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/3/a-i4029e.pdf

c) **Hemic peat**, which falls between these categories.

These terms are described further below (from Andriesse, 1988)

Fibric

These soil materials commonly have a bulk density of less than 0.1g/cm^3, an unrubbed fibre content exceeding two-thirds of the volume, and a water content, when saturated, ranging from about 850 percent to over 3,000 percent of weight of oven-dry material. Their colours are commonly light yellowish brown, dark brown or reddish brown.

Hemic

These soil materials are intermediate in degree of decomposition. Bulk density is commonly between 0.07 and 0.18 and the fibre content is normally between one-third and two-thirds of the volume before rubbing. Maximum water content when saturated ranges from about 450 to 850 percent.

Sapric

These soil materials are the most highly decomposed. Bulk density is commonly 0.2g/cm^3 or more, and the fibre content averages less than one-third of the volume before rubbing. Maximum water content when saturated normally is less than 450 percent on the oven-dry basis.

This information is summarised in **Table 1**.

Table 1: Characteristics of organic materials according to their degree of decomposition (source: Soil Taxonomy in FAO[5])

	Fibric	**Hemic**	**Sapric**
Wet bulk density(gcm^{-3})	< 0.1	0.07 – 0.18	> 0.2
Fibre content	2/3 volume before rubbing; ¾ % volume after rubbing	1/3 – 2/3 % volume before rubbing	< 1/3 volume before rubbing
Saturated water content as percent of oven-dry material	850 – > 3,000	450 – > 850	< 450
Colour	Light yellowish brown or reddish brown	Dark greyish brown to dark reddish brown	Very dark grey to black

One common semi-quantitative technique to assess in more detail the degree of peat humification is the Von Post scale

The Von Post scale considers:

- the colour and turbidity of the water squeezed from a peat sample;
- the proportion of peat extruded between fingers; and
- the type of plant residues visible in the sample.

The Von Post value is a fair proxy to estimate both the state of decomposition and physical (hydraulic) parameters of the peat layer.

How to complete field examination

- Gather egg shaped sample fitting your hand
- Squeeze sample as hard as you can
- Catch amorphous material and water with other hand
- Observe extruded (amorphous) material
- Estimate relative volume of fibers remaining in hand
- Compare to **Table 2 and Table 3**.

[5] FAO. Chapter 5 – Classification. http://www.fao.org/3/x5872e/x5872e07.htm

Application of the Von Post technique is elaborated in a training video by US Department of Agriculture[6].

Table 2: Von Post Humification Scale (source: FAO, 2011)
The von Post scale is a field test to rank organic soils by degree of humification (decomposition). The 10 steps correspond to percentage of decomposition i.e. 1 = 10% or undecomposed plant material, and 10 = 100% decomposed or colloidal, such as the highest caloric value burnable black peat.

SYMBOL	DESCRIPTION
H1	Completely undecomposed peat which, when squeezed, releases almost clear water. Plant remains easily identifiable. No amorphous material present.
H2	Almost entirely undecomposed peat which, when squeezed, releases clear or yellowish water. Plant remains still easily identifiable. No amorphous material present.
H3	Very slightly decomposed peat which, when squeezed, releases muddy brown water, but from which no peat passes between the fingers. Plant remains still identifiable, and no amorphous material present.
H4	Slightly decomposed peat which, when squeezed, releases very muddy brown water. No peat is passed between the fingers but plant remains are slightly pasty and have lost some of their identifiable features.
H5	Moderately decomposed peat which, when squeezed, releases very muddy water with a very small amount of amorphous granular peat escaping between the fingers. The structure of the plant remains is quite indistinct although it is still possible to recognize certain features. The residue is very pasty.
H6	Moderately highly decomposed peat with a very indistinct plant structure. When squeezed, about one-third of the peat escapes between the fingers. The residue is very pasty but shows the plant structure more distinctly than before squeezing.
H7	Highly decomposed peat. Contains a lot of amorphous material with very faintly recognizable plant structure. When squeezed, about one-half of the peat escapes between the fingers. The water, if any is released, is very dark and almost pasty.
H8	Very highly decomposed peat with a large quantity of amorphous material and very indistinct plant structure. When squeezed, about two-thirds of the peat escapes between the fingers. A small quantity of pasty water may be released. The plant material remaining in the hand consists of residues such as roots and fibres that resist decomposition.
H9	Practically fully decomposed peat in which there is hardly any recognizable plant structure. When squeezed, it is a fairly uniform paste.
H10	Completely decomposed peat which no discernible plant structure. When squeezed, all the wet peat escapes between the fingers.

[6] https://www.youtube.com/watch?v=3kNosFsk--s

Table 3: Details of characteristics of peat to be used with Von Post Scale (Adapted from Rokus, 2020)

Type		Condition of Peat Before Squeezing				Condition of Peat on Squeezing		
Degree of Humification	**Class**	**Soil Color**	**State of Decomposition**	**Plant Structure**	**Content of Amorphous Material**	**Squeezed Solution**	**Material Extruded (Passing Between Fingers)**	**Nature of Residue**
H1	**Fibric**	White or yellow	None	Easily identified	None	Clear, colourless water	Nothing	Unaltered, fibrous
H2	**Fibric**	Very pale brown	Insignificant	Easily identified	None	Yellowish water/ pale brown-yellow	Nothing	Almost unaltered
H3	**Fibric**	Pale brown	Very slight	Still identifiable	Slight	Brown, muddy water not peat	Nothing	Most remains easily identifiable
H4	**Hemic**	Pale brown	Slight	Not easily identified	Some	Dark brown muddy water, no peat	Some peat	Most remains identifiable
H5	**Hemic**	Brown	Moderate	Recognizable but vague	Considerable	Very dark brown muddy water little peat	Some peat	Most of remains hard to identify
H6	**Hemic**	Brown	Moderately strong	Indistinct (more distinct after squeezing)	Considerable	Very dark brown muddy water with peat in suspension	About one third of peat squeezed out	Very strongly pasty
H7	**Sapric**	Dark brown	Strong	Faintly recognizable	High	Very dark brown muddy water	About one half of peat squeezed out	Very strongly pasty
H8	**Sapric**	Dark brown	Very strong	Very indistinct	High	Very dark brown pasty water	About two thirds of peat squeezed out; also some pasty water	Very strongly pasty
H9	**Sapric**	Very dark brown	Nearly complete	Almost unrecognizable	Very high	Very dark brown paste	Nearly all the peat squeezed out as a fairly uniform paste	Very strongly pasty
H10	**Sapric**	Black	Complete	Not discernible	All	Very dark brown paste	All the peat passes between the fingers; no free water visible	Very strongly pasty

3.3 Peatland hydrology (Adapted from Labadz, J. *et al* 2010)

Hydrology is the science of the occurrence, distribution, and movement of water, including both its quantity (flows and resting water levels whether over the surface, within the soil and deeper in the ground) and its quality (including acid/base status and concentrations of nutrients and toxins). Whilst the high organic content of the peat soil is its primary defining characteristic, it is the water-retention and thus the hydrological properties of peat which allow its continued existence and produce its distinctive suite of habitats. Understanding the hydrology of peatlands is fundamental to such habitats, as "it is probably the single most important condition influencing peatland ecology, development, functions and processes". Bragg and Tallis (2001) stressed the sensitivity of peatlands, especially the ombrogenous (rain-fed) peatlands, to any change in their hydrology. **Figure 2** illustrates how both the peat itself and the plant assemblages it supports are intimately connected with the water (hydrological conditions) in a mire.

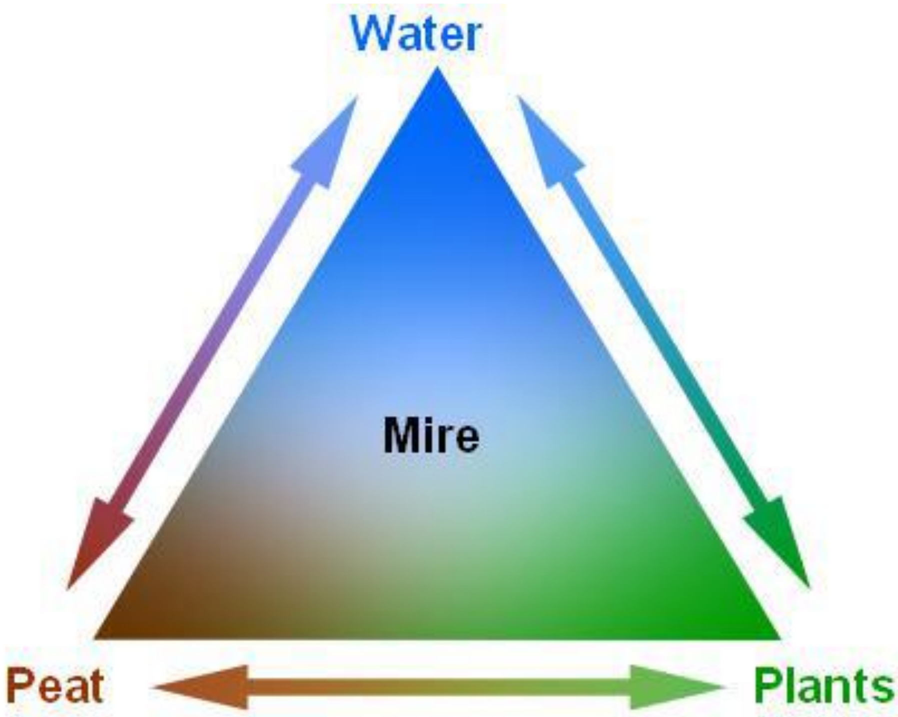

Figure 2: Living peatland (mire) formation and function depends on the inter-relationships between three key factors - Water, Plants and Peat (Source: Joosten, 2008)

Controls on Peatland Hydrology

The nature of a peatland is controlled by hydrological processes. Its existence depends upon retaining water and its characteristics depend upon the origin, volume, chemical quality and variability of water supply. Living peatlands (known as Mires) are often subdivided into three main types (Labadz, J. et al, 2010):

- ombrogenous mires are those under the exclusive influence of water from rainfall;
- topogenous mires are controlled by horizontal flows of "mineral soil water" confined by topography;
- soligenous mires are developed on sloping sites where laterally mobile "mineral soil water" maintain wet conditions.

Hydrological functioning and drainage (from Andriesse, 1988)

The hydrological functioning of peatlands varies depending on the season, the position in the watershed and the state of drainage or degradation. The large surface, flat topography and water-holding capacity generally allows low-lying peatlands to play a buffering role in regional hydrology. Peatlands and other wetland types, including marshes and floodplain wetlands, are often seen as ‘sponges’, delaying flood peaks and reducing their amplitude. During dry periods, these wetlands may provide a source of water to the regional stream network.

Peatland hydrology, as well as much of its ecology, has been described according to a system with two distinct layers: the ‘acrotelm’ and the ‘catotelm’. In this system, the catotelm is the permanently saturated lower portion of the peat profile that underlies the acrotelm, a high-hydraulic conductivity ‘active’ layer. The catotelm is nearly always anoxic with slow biogeochemical kinetics, while the acrotelm is aerobic (i.e. oxygen containing) during periods when the water table is low (and possibly year-round depending on site conditions).

Drainage also has critical, nearly irreversible, effects on peat structure and on the ecological services provided by peatlands. The substantial drop in the water table that is required for agricultural production (ranging from 0.2 metres for grasslands to 1.2 metres for production of certain crops) leads to a decline in soil moisture content and the contraction of peat volume, which is further compounded by oxidation. This consolidation increases the specific density of the upper peat layers and causes the soil surface to subside. These shifts in peat properties decrease its structural porosity and hydraulic conductivity, which makes it difficult to carry out continued drainage in peatland landscape.

3.4 Peatland Formation (from Joosten in Parish *et al,* 2008)

Water is the single most important factor enabling peat accumulation. Water-logging is a pre-requisite for the creation and preservation of peat. Peat accumulation only takes place when the water level is just under, at, or just over the surface over the long-term. When water levels are too low, plant remains decay too rapidly to allow accumulation. Water levels that are too high, obstruct the production of plant material because the submersed plant parts are suffocated through lack of oxygen and carbon dioxide

Peat accumulation therefore only takes place in the range of water “availability” (both in space, with regard to water levels, and time, with regard to seasons), in which the decay of organic material is inhibited more than its production. In areas with deeper and fluctuating water levels a larger part of the organic material decays. This leads to less peat accumulation and more strongly humified peat. Activities that substantially lower or raise the water level in peatlands negatively affect their peat accumulation capacity and their associated functions.

In different parts of the world, different plant groups and plant parts are the main peat formers. Mosses (Bryophytes) determine peat growth in cold (e.g. boreal and subarctic) and wet-and-cool (e.g. montane, oceanic) places. In more temperate and continental parts of the world, the drier climate forces peat formation to “go underground”. There, peat is formed from the downward growing rhizomes and rootlets of grasses (Poaceae) and sedges (Cyperaceae). Peat accumulates in the first 10–20 cm below the surface, as new root material is injected into the older peat soil matrix. In tropical lowlands peat is forms even further under the surface by the roots of tall forest trees (Prager et al. 2006).

In natural peatlands, peat typically accumulates with a long-term rate of 0.5-1 mm and 10 – 40 tonnes C per km2 per year, with locally strong variation. These general rates may be slower under less favourable climatic or hydrological conditions such as in the Arctic tundra, or faster, particularly in the tropics The peatlands existing today largely originated from the end of the Late-Glacial and in the first part of the Holocene.

Acidity and nutrient availability particularly determine plant diversity in natural peatlands. Precipitation water is poor in nutrients and somewhat acidic. Through contact with the mineral soil/bedrock, the chemical properties of the water may change. As a result, peatlands in different hydro-geological settings receive water inputs of different quality (Joosten and Clarke 2002). On the basis of acidity (base saturation) and nutrient availability (trophic conditions) different “ecological peatland types” are distinguished (see Table 4). The dependence of local peatland conditions on the quality of the incoming groundwater necessitates a thorough assessment of the relationship between the hydrology and the surroundings.

Table 4: Peatland types and their pH characterization (source: Joosten, 2008)

Peatland type	**pH range**
Bog	3.7 – 4.2
Extremely poor fen	3.8 – 5.0
Transitional poor fen	4.8 – 5.7
Intermediate fen	5.2 – 6.4
Transitional rich fen	5.8 – 7.0
Extremely rich fen	7.0 – 8.4

The functions of peatlands are strongly dependent on their hydrology and features (including their position in the landscape and the conditions of peat formation).

A distinction is made between terrestrialization, when peat develops in open water, and paludification, when peat accumulates directly over a formerly dry mineral soil (Figure 3). In terrestrialization, peat formation takes place in floating mats (e.g. *Papyrus* islands) or under water on the bottom of the lake (e.g. many *Phragmites* stands). Peatlands may also form on formerly dry soils when the water level in the catchment rises slowly due to external reasons (water rise peatlands). Flood peatlands are periodically flooded by rivers, lakes or seas. Without externally induced water level rise (due to climate change, changes in land use, rising sea levels, rising river beds, beaver dams, the origin of stagnating layers in the soil and so on) all these horizontal peatlands only accumulate peat for a limited time.

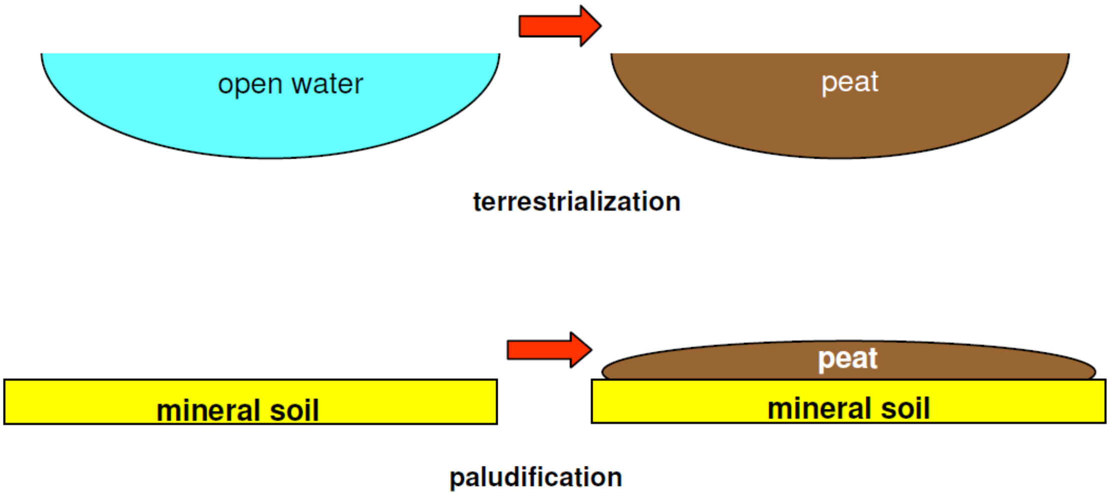

Figure 3: The difference between terrestrialization and paludification (Source Joosten, in Parish *et al* 2008)

3.5 Carbon storage and GHG emissions (from Parish *et al* 2008)

Peatlands and carbon

Peatlands are some of the most important carbon stores in the world. They contain nearly 30 percent of all carbon on the land, while only covering 3 percent of the land area. Peatland ecosystems contain disproportionately more organic carbon than other terrestrial ecosystems. Peatlands have accumulated and stored this carbon over thousands of years, and since the last ice age peatlands have played an important role in global greenhouse gas balances by sequestering an enormous amount of atmospheric CO_2. Peatlands in many regions are still actively sequestering carbon. However the delicate balance between production and decay easily causes peatlands to become carbon sources following human interventions. Anthropogenic disturbances (especially drainage and fires) have led to massive carbon losses from peatland stores and generated a significant contribution to global anthropogenic CO_2 emissions. Peatland restoration is an effective way to maintain the carbon storage of peatlands and to re-initiate carbon sequestration.

- While covering only 3% of the World's land area, peatlands contain at least 550 billion tonnes of carbon in their peat. This is equivalent to 30% of all global soil carbon, 75% of all atmospheric C, equal to all terrestrial biomass, and twice the carbon stock in the forest biomass of the world. This makes peatlands the top long-term carbon store in the terrestrial biosphere.

- Peatlands are the most efficient carbon (C) store of all terrestrial ecosystems. Peatlands in the tropical zone store 10 times as much carbon per ha than other ecosystems on mineral soil.
- The peat layer is a long-term store of carbon. Peatlands have accumulated and stored this carbon over thousands of years. Permanent waterlogging and consequent restricted aerobic decay is the main prerequisite for continued long-term storage of carbon in peatlands.
- Most coal and lignite and part of the 'mineral' oil and natural gas originated from peat deposits in previous geological periods.
- Peat growth depends on a delicate balance between production and decay. Natural peatlands may shift between carbon sink and source on a seasonal and between-year time scale, but the accumulation of peat demonstrates that their long-term natural balance is positive.
- Human interventions can easily disturb the natural balance of production and decay turning peatlands into carbon emitters. Drainage for agriculture, forestry and other purposes increases aerobic decay and changes peatlands from a sink of carbon to a source. Peat extraction (for fuel, horticulture, fertilizers, etc.) transfers carbon to the atmosphere even more quickly.
- Peatland drainage also facilitates peat fires, which are one of the largest sources of carbon released to the atmosphere associated with land management.
- Carbon dioxide emissions from peatland drainage, fires and exploitation are estimated to currently be at least 3000 million tonnes a year equivalent to more than 10% of the global fossil fuel emissions.
- Peatland degradation and fires in Southeast Asia (primarily Indonesia) are responsible for half of the global peatland emissions.
- Peatland conservation and restoration are effective ways to maintain the peatland carbon store and to maximise carbon sequestration with additional benefits for biodiversity, environment and people.

Peatlands and greenhouse gases

The world's peatlands influence the global balance of three main greenhouse gases (GHG) – carbon dioxide (CO_2) methane (CH_4) and nitrous oxide, (N_2O). In their natural state, peatlands remove CO_2 from the atmosphere via peat accumulation and they emit methane. The long-term negative effect of methane emissions is lower than the positive effect of CO_2 sequestration. By sequestering and storing an enormous amount of atmospheric CO_2 peatlands have had an increasing cooling effect, in the same way as in former geological eras, when they formed coal, lignite and other fossil fuels.

When peatlands are disturbed, they can become significant sources of carbon dioxide and at the same time do not totally stop emitting methane which is still intensively released from drainage ditches and under warm wet conditions even from milled peat surfaces and peat stockpiles. Drained peatlands, especially after fertilization, can become an important source of nitrous oxide. Peatland restoration reduces net GHG emissions to the atmosphere, certainly in the long-term.

- Since the last ice age, peatlands have sequestered enormous amounts of atmospheric CO_2.
- Small changes in the ecology and hydrology of peatlands can lead to big changes in GHG fluxes through influence on peatland biogeochemistry.
- Anthropogenic disturbances (especially drainage and fires) have led to massive increases in net emissions of GHG from peatlands, which are now a significant contribution to global anthropogenic emissions.
- Peatland drainage leads to increased CO_2 emissions in general and a rise of N_2O release in nutrient rich peatlands. It may not always significantly reduce CH_4 emissions.
- Because of the large emissions from degraded peatlands, rewetting and restoring them is one of the most cost-effective ways of avoiding anthropogenic greenhouse gas emissions.

Impacts of future climate change on peatlands

The strong relationship between climate and peatland distribution suggests that future climate change will exert a strong influence on peatlands. Predicted future changes in climate of particular relevance to peatlands include rising temperatures, changes in the amount, intensity and seasonal distribution of rainfall, and reduced snow extent in high latitudes and in mountain areas. These changes will have significant impacts on the peatland carbon store, greenhouse gas fluxes and biodiversity.

3.6 Other Functions and values of peatlands

Peatlands are of considerable value to human societies due to the wide range of goods and services they provide. Peatlands help to maintain food and other resources and have functional significance far beyond their actual geographical extent.

Peatlands provide a number of important ecological services including:

- Storing and providing water supply
- Habitat for biodiversity

Water resource management (from Joosten, 2008)
Peatlands play an important role in catchment hydrology with respect to water storage, water quality, the support of groundwater levels and flood and drought mitigation. Peatlands often form major components of local and regional hydrological systems and have the ability to purify water by removing pollutants (Joosten and Clarke 2002). Large peatland bodies may regulate the surface- and groundwater regime and mitigate droughts and floods. Riparian peatlands store floodwaters, resulting in a downstream reduction of velocity and volume of peak discharges. Coastal peat swamps act as a buffer between salt- and freshwater systems, preventing saline intrusion into coastal lands. The water storage and retention function of peatlands is locally important for the supply of drinking water and for the irrigation of agricultural lands. In regions where catchment areas are largely covered by peatlands, as well as in drier regions where peatlands indicate a rare but steady availability of water, they can play an important role in maintaining water supplies for drinking and irrigation water.

Biodiversity
Peatlands play an important role as habitat for a broad range of species. Peatlands also have high ecosystem diversity with many different types of peatlands found throughout the world. Although their total species richness is low, peatlands host many characteristic species. Peatland species have evolved to live in the characteristic features of high water tables and acidity, and low oxygen levels. For many species, peatlands are the only available habitat, within a biogeographic region and even globally. Many peatland species have restricted distributions and are not found in other habitats. These highly adapted species can only survive if their habitat is conserved.

References
This training note is prepared with extracts from multiple sources as listed below:

1. Andriesse, J. P. 1988. Nature and Management of Tropical Peat Soils FAO Soils Bulletin 59, FAO, Rome.
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