Greenhouse gas emissions related to deep and shallow peat

The greenhouse gas (GHG) emissions related to converting peat into plantations remains an crucial topic of discussion in the ILUC (indirect land use change) debate. Peat is considered a high carbon stock area and conversion of this results in high land use change emissions. This paper aims to shed light on the process of converting peat land into suitable plantations through drainage and the resulting subsidence of peat. It is important to note that the accurate and detailed mapping of peat (both extent and depth) is vital to calculate factual GHG emissions in relation to land use change. The last part of this paper will look at the peat maps currently available and draw conclusions based on their accuracy levels.

1.1 Subsidence rate, deep and shallow drainage and its effect on emissions

Tropical peatlands are naturally shaped as domes, where the shallow parts on the outskirts of the dome are near a river. The curve of the dome is dependent on its stable shape: if the shape is flatter than the water tables allow for, it will sequester carbon and grow at its core. If the dome is above the water table, the excess peat will decompose (Cobb et al., 2017). The average peat thickness for tropical peat in Indonesia is 5.5 meters deep and 86% is at least 3 meters deep (Hooijer and Vernimmen, 2013). In order to convert this peat area into a plantation, the water table needs to be lowered. Figure 1 has a simplified overview of how this process is done and its effect on the peat layer.

The initial stage of expansion into tropical peatlands, is deforestation. 50-75% of the Malaysia and Indonesian forested peatlands have been deforested since 1990, mainly for palm oil and pulpwood cultivation (Evans et al., 2021). The loss of aboveground carbon stock leads to GHG emissions as well as the debris that comes from it. After removing the aboveground biomass, ditches are constructed to lower the water table. This exposes the top layer of peat to anaerobic conditions and oxidation. Once the exposed peat has dried, it will either decompose or burn, causing the carbon to be released into the atmosphere. Most of the emissions related to the conversion of peat occurs in this stage. The exposed peat will continue decomposing and shrink, a phenomenon known as soil subsidence, until the water level is once again reached.

In the last stage there will still be annual emissions, however the emission rate decreases as there is less peat exposed. The main emissions in this stage are related to continued drainage, thus thereby slowly further lowering the water table to maintain the plantations. Alternatively, rewetting the peat surface and increasing the water table would reduce the emissions and restore the peat layer. Studies of acacia and oil palm plantations in South-East Asia have shown that peat surface subsidence after 5 years was 142 cm, half of which occurs in the first year. After those five years the subsidence rate remained constant with a 3 to 5 cm per year decrease (University of Leicester n.d.). Evans et al. (2019), report a subsidence rate of 4.2-4.3 cm yr^{-1} for acacia on tropical peatland. After 20 years the subsidence rate will decrease with 0.5 cm a year.

Most studies that look at cropland conversion of peat and the related GHG emissions, focus on the water levels and the share that is drained (deep drainage or shallow drainage), not so much on the thickness and depth of the peat dome. They found that deeper drainage and lowering water tables leads to increased GHG emissions through the oxidation of the exposed peat layer.

Hooijer et al (2010) found a positive linear relationship between peat drainage and GHG emissions, in their study set in Southeast Asia (Indonesia, Malaysia, Brunei and Papua N. Guinea). This is in line with studies done in other parts of the world, such as in Florida (Hu et al. 2017), Zoige peatland in China (Cao et al., 2018), a multi-site analysis of tropical peatlands (Prenato et al., 2020), and 16 sites in the UK (Evans et al., 2021). It is therefore well documented that continuously lowering water tables would lead to higher GHG emissions.

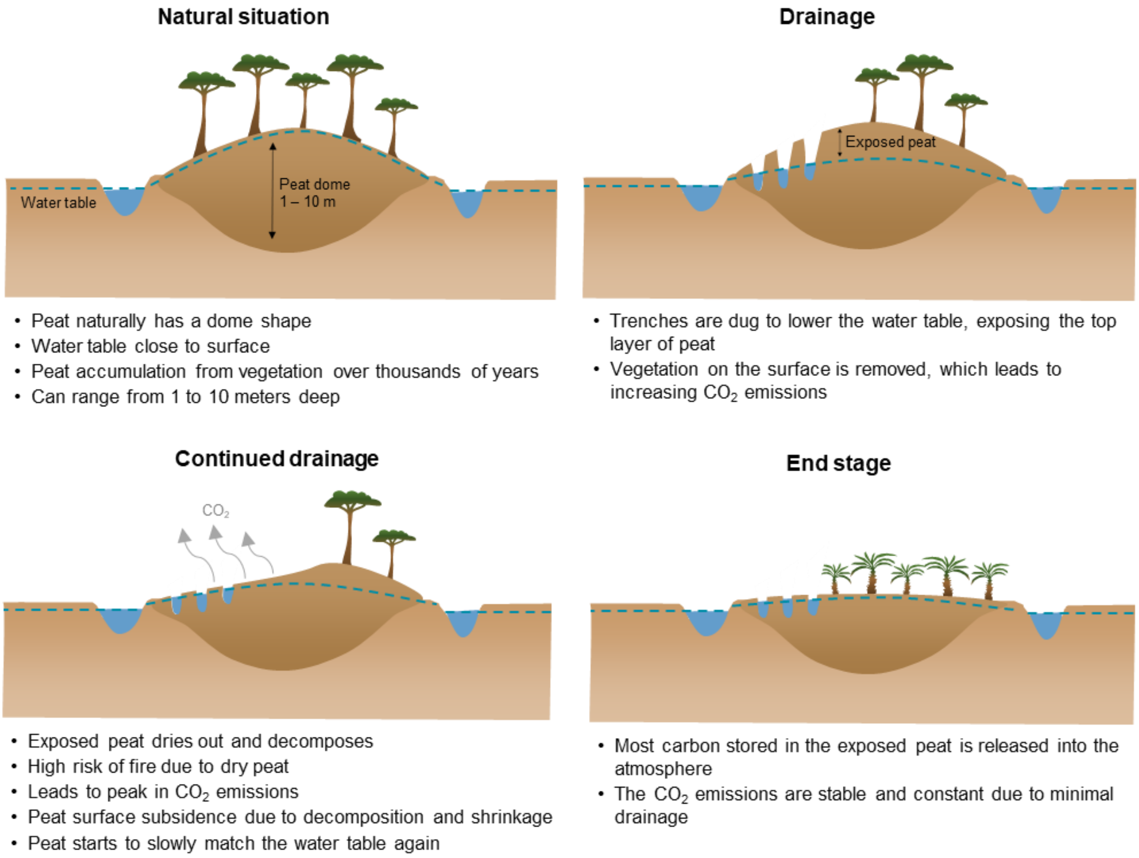

Figure 1 Peat to plantation conversion process

Yli-Halla (2022) is one of the few studies that looks at peat thickness and emissions, namely leaching substances and GHG emissions. They found that the thickness of peat did not have a statistically significant impact on the GHG emission in their eight-week study, which is not including a whole growing season. There is no scientific evidence supporting that shallow (<0.5m) peat would have lesser emissions than deep peat. So it is not so much the underlying thickness of the peat layer which is of importance for the height of GHG emissions, but moreover the amount of peat that gets exposed to air due to lowering water levels.

Anshari et al. (2021) estimated the average annual emissions related to peat subsidence to be 30 and 90 t CO_{2e} ha-1 yr^{-1}, which is similar to the IPCC default values of 40 t CO_{2e} ha^{-1} yr^{-1} and 73 t CO_{2e} ha^{-1} yr^{-1} for oil palm and acacia plantations on peat respectively. A large part of the emissions is concentrated in the first stages: deforestation and drainage. McCalmont et al. (2021) measured 110 t CO_2 ha^{-1} yr^{-1} for the first six years after conversion, of which one quarter comes from decay of aboveground biomass. At the latest stage of maturing McCalmont et al. (2021) reported a conservative estimate of 17.5 t CO_2 ha^{-1} yr^{-1}.

Figure 2 below gives a schematic overview of the annual emissions. The main emissions are during the initial drainage due to deforestation and continue as the exposed peat layer decomposes. Once the exposed peat layer is thinner and reaching the water levels, the emission rate slows down. However, small levels of draining to maintain the plantation may cause for an increase in annual emissions. The bulk of the emissions remain in the initial drainage and continued drainage stage.

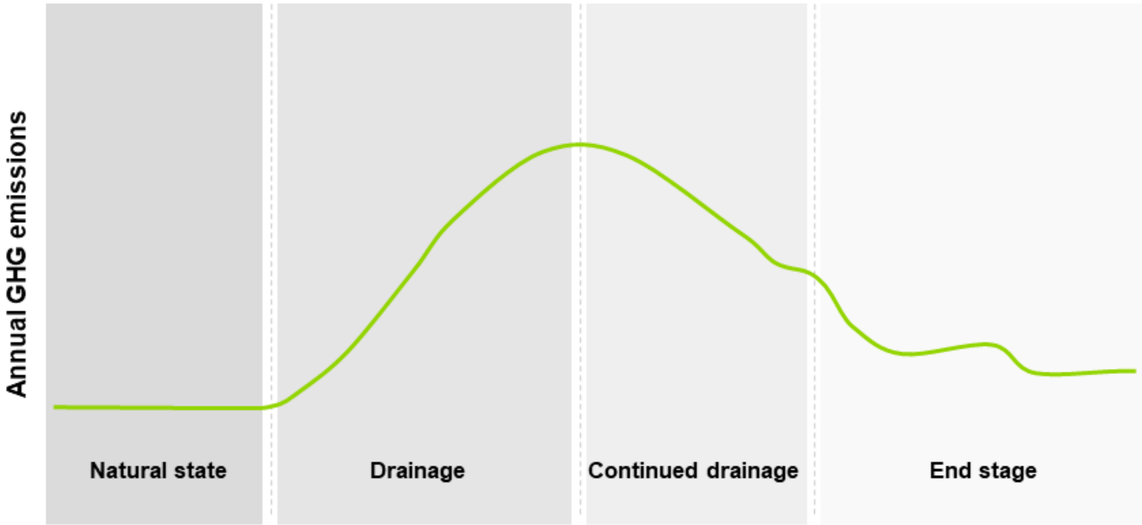

Figure 2 Schematic overview of annual GHG emissions related to the conversion of peatlands

1.2 Map differences in deep and shallow peat

Deep peat is often underestimated due to shortcomings in maps, where deep peat is incorrectly labelled as shallow peat. A study by Hooijer and Vernimmen (2013) compared the widely used maps by Wetlands International (WI) and Indonesian Center for Agricultural Land Resources Research and Development (BBSDLP) with field measurements and found that both maps underestimate peat thickness. Measurements showed a 1.5 meters peat thickness underestimate on average (+-27%) for WI and 2.0 meters (+-36%) for BBSDLP. Peat extend is also underestimated, 1.7 Mha for WI and 3.6 Mha for BBSDLP. The BBSDLP map is based on the WI map, but with lower class values, which explains their higher underestimations of deep peat.

The data in this project is derived from Miettinen et al. (2017), which shows the average yearly emissions per hectare from drainage of various peat land-covers. Their study uses a combination of WI, BBSDLP and Regional Physical Planning Programme for Transmigration (RePPProT) peat atlas data to map the Indonesian peatlands. The combination of the three datasets the data by Miettinen et al. (2017) results in the most complete and detailed map using remote sensing. Austin et al. (2017) only uses the BBSDLP map, which explains why more weight was put on the Miettinen et al. (2017) data.

1.3 Conclusions

The majority of the GHG emissions take place in the first stage of conversion due to deforestation and the first drainage. In the first years after lowering the water tables, the emissions are high due to oxidation of the exposed peat layer. Once the peat is decomposed, the emissions decrease to stabilize at a lower continuous rate of emissions.

Most studies focus on the effects of lowering water tables in peatlands on the GHG emissions, rather than focussing on the depth and thickness of the peat layers. One study by Yli-Halla (2022) included peat depth in their emissions study and found no statistically significant evidence. The drainage levels, and resulting exposed peat layer, have a larger effect on the annual GHG emissions than the peat depth.

1.4 Works cited

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