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THE IMPACT OF DRAINAGE AND DEGRADATION ON TROPICAL PEATLAND HYDROLOGY, AND ITS IMPLICATIONS FOR EFFECTIVE REHABILITATION

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SUMMARY

Clearing and draining tropical Peat Swamp Forests lowers water tables and causes rapid subsidence of the peat surface through the processes of oxidation, compaction and consolidation. These processes have a profound effect on peatland topography and hydrology. Water levels are lowest, and therefore subsidence rates highest near canals, resulting in a distinctive ‘mini dome’ landscape. This is the situation in large parts of Central Kalimantan, Indonesia, where the Kalimantan Forests and Climate Partnership (KFCP) is undertaking a REDD+ demonstration initiative. Part of the activities of the KFCP involve peatland rehabilitation, focusing on ‘canal blocking’ rather than just dam construction, through a consultative process involving Village Agreements with local communities which aim to maximize community inputs and improving their livelihoods.

KEY WORDS: *rehabilitation, tropical peatland, REDD+, subsidence, oxidation*

INTRODUCTION

The tropical peatlands of Indonesia occupy around 22 million hectares and occur mainly in Sumatra (7.2 million ha), Kalimantan (5.8 million ha) and Papua (8.0 million ha) (Bappenas 2009). In 2006, a little over 55% of the peatland was still covered in Peat Swamp Forest, but this figure is decreasing rapidly, as more and more Peat Swamp Forests are cleared and drained for agriculture and forestry plantations. While one-quarter of Indonesia’s peatland is protected or conserved, about 3.3 million hectares of this is still forested, leaving large areas remaining in a very degraded condition and in need of rehabilitation. These degraded peatlands contribute to about 50% of Indonesia’s total greenhouse emissions (Bappenas 2009, Page *et. al* 2011). With the new developments in science and an improved understanding of the hydrological process in these degraded peatlands, there are now science based solutions to cost effective community based approaches to rehabilitating degraded peatlands and to minimize degradation of remaining Peat Swamp Forests. Some of the science and rehabilitation efforts are funded in the expectation that the methodologies and processes being developed will be useful on a large scale for reducing carbon emissions from peatlands under the REDD+ scheme now being considered by the international community under the UNFCCC (KFCP 2009a).

Before cost effective rehabilitation efforts can commence on a large scale, it is important to understand that the lowering of water tables in peatlands, which have been cleared of forests and subsequently drained by canals, leads to rapid subsidence of the peat surface through the separate processes of biological oxidation, compaction, consolidation and fire (Hooijer *et al.* 2011). This subsidence has a profound effect on the topography and hydrology of the peat. Subsidence rates are highest near canals, resulting in a distinctive 'mini dome' landscape with much higher surface gradients than are found in the original peat dome as shown in Fig 1.

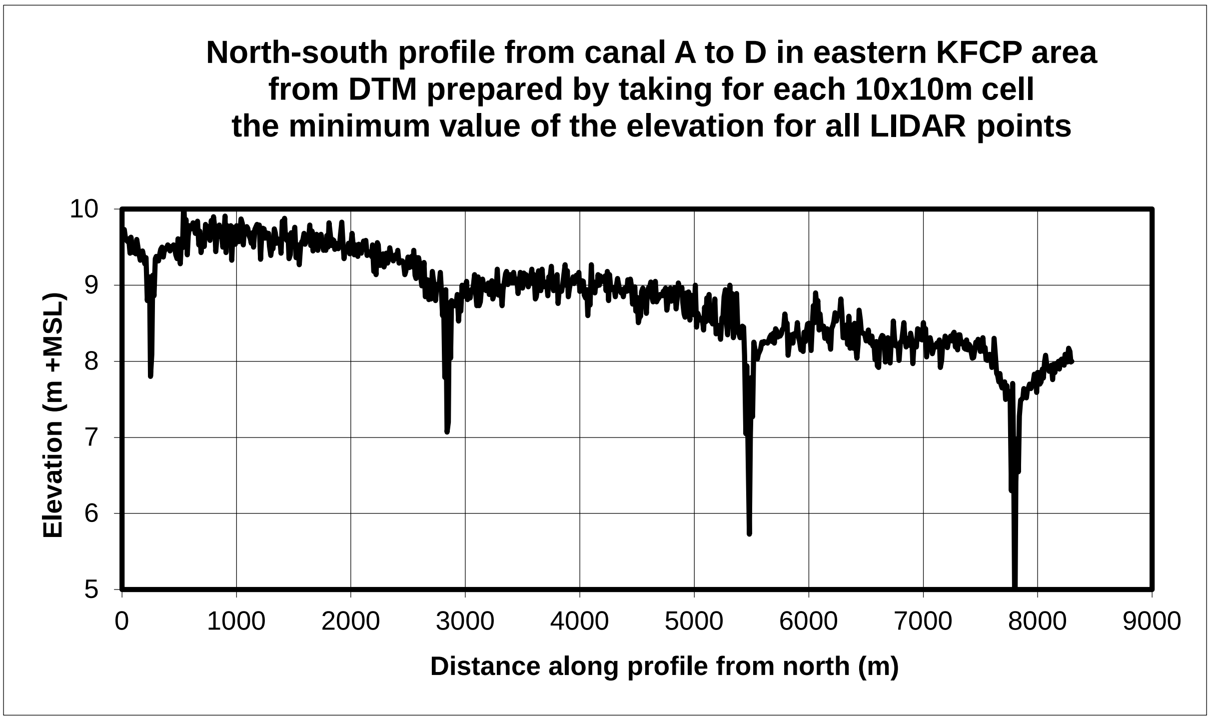

Figure 1: Lidar transect of the peat dome showing the 'mini domes' caused by oxidation and compaction.

The first step in the hydrological rehabilitation of drained peatlands, is to raise water tables to levels that resemble natural conditions. This understanding is now widely shared (Jaenicke *et al.* 2010) and a number of rehabilitation schemes have been undertaken on a pilot basis with this aim in mind. These schemes have been implemented mainly at a small scale, attempting to improve conditions in relatively small areas by building limited numbers of dams on narrow canals. Dam building efforts to date, have trialled somewhat different designs, but all have been box dams, constructed from either sawn boards, or wooden logs with inserts filled with bags of mineral soil, sand or peat and often placed with little regard to the peatland topography. A review of these dams indicated that most had dam crests which were below the water level, which negates the purpose of raising water levels and makes the dams extremely sensitive to erosion (KFCP 2009b). Nearly all dams were indeed damaged within one or two years, to a degree where the structure was having little impact on water levels. None of the designs trialled to date in the tropical peatlands in Central Kalimantan can have much effect on water levels in the longer term (EMRP 2009). These initial attempts at dam building have provided valuable lessons and have led to a more cost effective science based approach to canal blocking as opposed to dam building, which rely on community involvement and an understanding of the hydrology, topography, nature of the canal and their profiles.

KALIMANTAN FORESTS AND CARBON PARTNERSHIP

The Kalimantan Forests and Carbon Partnership (KFCP), is a REDD +demonstration initiative developed in 2008 funded by the Australian Government and implemented through the Indonesia- Australia Forest Climate Partnership (IAFCP). The KFCP was designed to demonstrate a credible, equitable, and effective approach to reducing greenhouse gas emissions from deforestation and forest degradation, including from the degradation of peatlands, that can inform a post-2012 global climate change agreement and enable Indonesia's meaningful participation in future international carbon markets (KFCP 2009a).

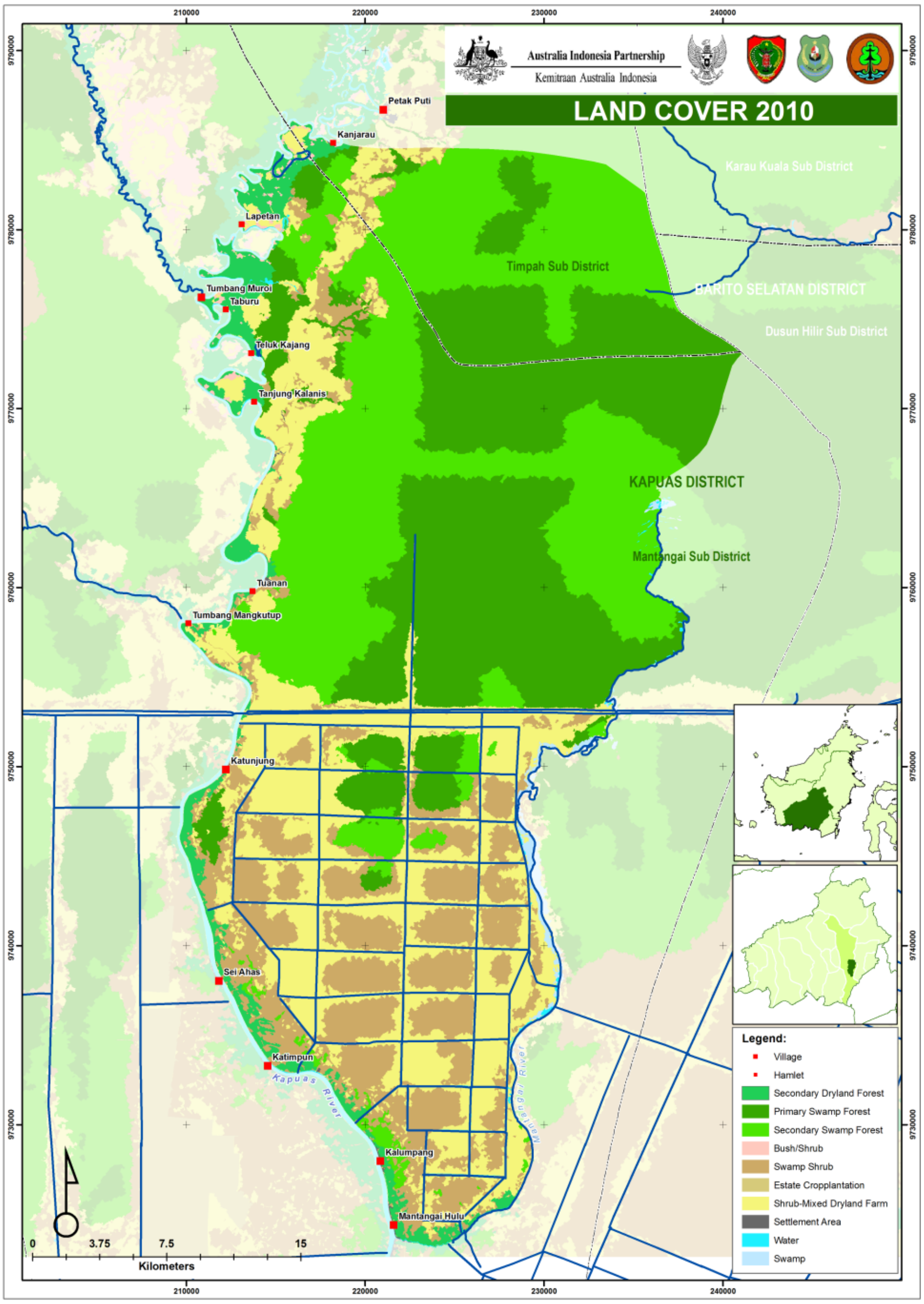

Figure 2: Location map of the Kalimantan Forests and Climate Partnership in Central Kalimantan, Indonesia

The KFCP is involved in an area covering 120,000 ha which is located within the 1.4 million ha of the ex Mega Rice Project Area (EMRP) in Central Kalimantan, Indonesia as shown in Fig 2. More than 1 million ha of this area, which consists mainly of peatlands, was cleared and drained for rice production between 1995 and '97. The forest clearing and draining of the peatlands caused drying out of the peat soils which has made them vulnerable to fire, the largest being in 1997 (Page *et al*. 2002). Much of the degraded peatlands is now an ecological and environmental disaster area emitting large amounts of greenhouse gas annually and contributing little to the livelihoods of the predominantly Ngaju dayak communities. (KFCP 2009a)

One of the REDD+ activities to be undertaken by KFCP is the testing of improved canal blocking systems to reduce greenhouse gas emissions from peatland. When the pilot is fully implemented, it will cover approx. 225 km^2 and will be the largest peatland hydrological rehabilitation demonstration activity of its kind to date in SE Asia, with hundreds of blocking structures being implemented along over 100 kilometres of wide canals (3-30 m in width).

Rehabilitation Strategy and Canal Blocking System in KFCP

Research and hydrological monitoring have been used to assess the environmental conditionsto which the canal blocking structures will be subjected, and what designs and materials will be most suitable and how communities will be able to participate in this valuable activity. A hydrological model has been used to predict water levels and discharges for different system design options as a consequence of the changes to the topography of the peat dome since it was disturbed. Extreme peak water flows of over 50 m^3/s are expected in the longer term, along with major and frequent fluctuations in water level from 1 m above to 1 m below the peat surface near the canals. As a consequence of this little understood fact, KFCP has built upon previous experience of "dam building" and developed a revised approach to peatland rehabilitation focusing on 'integrated canal blocking' and not just dam building. This customized system comprises a network of large numbers of different blocking structures with small water head differences, canal infilling and artificial and natural regeneration of Peat Swamp Forest species that can better withstand conditions in degraded peatlands which vary from extreme drought to inundation.

As a prelude to this activity, KFCP has developed a hydrological rehabilitation strategy for the deep peat areas to reduce GHG emissions as a demonstration appropriate for large scale rehabilitation efforts on degraded peatlands in Indonesia. The strategy also includes improving productivity of areas used by villages for their livelihoods (KFCP 2009b). KFCP will provide plans to improve the use of traditional lands on shallow peat, or mineral soils, on either side of the main peat dome, often used for agricultural purposes, by designing water control structures to reduce flooding in the wet season and improve food security. These interventions are undertaken and managed by communities through a consultative process culminating in Village Agreements which respect local values, land use rights, while maximizing community inputs and improving livelihoods.

Canal Blocking System

The canal blocking system will be implemented through Village Agreements negotiated with local communities and small contracts for the limited areas requiring machines for the construction of compacted peat dams. The KFCP canal blocking system as shown in Fig 3, is based on a principle of small head heights between structures and canal spillways and include a combination of the following four elements:

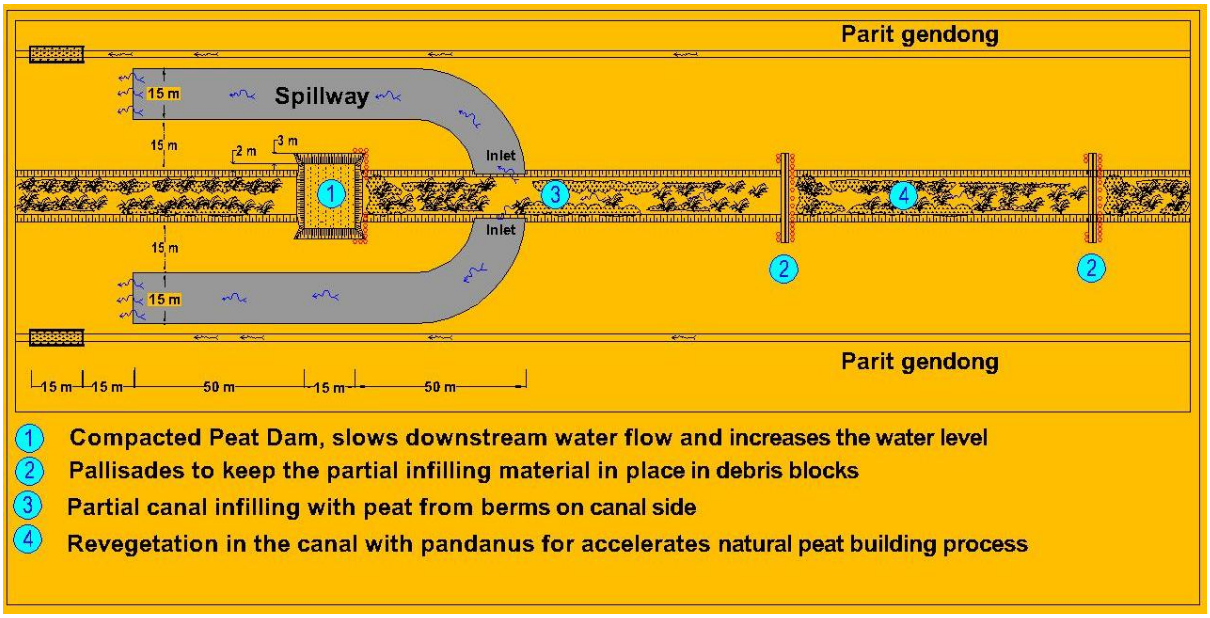

Figure 3: Canal blocking design

1. Mechanically built compacted peat dams with spillways (partial; only where required)
2. Palisades with a rattan debris block
3. Partial infilling of canals using excavators and manual labour
4. Planting of tree cuttings of natural flood tolerant species

1. **Mechanically-built compacted peat dams:** A compacted peat dam consists of peat soil excavated from the surrounding area and deposited into the canal as shown in Fig 3. Compacting the peat (with excavators) after depositing is essential to enhance strength and reduce permeability. To avoid damage and leakage the dam body should be sufficiently long (15 m or more, (8 m in small canals) with a crest level (after compaction) of at least 1.5 m above the surrounding peat surface. The head difference over the compacted peat dams should be kept small (0.2 m). It is crucial not to allow water to flow over these dams, which will be destructive when flow velocities are high in the wet season. It is therefore critical that a spillway system is also constructed to ensure excess water does not flow over the dam crest. The spillway should be very wide but shallow to i) provide sufficient discharge capacity, ii) reduce flow velocities in it, and iii) at the same time not reduce water levels.
2. **Palisade with debris block:** The ‘palisade and debris block’ dam which is constructed by local communities consists of a row of poles driven into the bottom of the canal and extended across the full width of the canal and supported by a second row. These structures are located upstream from the compacted peat dams at a head height of 0.2 m. The poles should be of tree resistant species such as *Melaleuca* sp. which are prevalent in the vicinity and driven into the mineral soils at approx 10 cm intervals across the canal. In order to trap as much sediment and vegetative material as possible, the communities will weave a rattan net with a mesh of 10 cm x 10 cm which is then pulled across the palisades and attached to the upstream side of the palisade.
3. **Partial infilling of canals using excavators and manual labor:** To reduce the flow in the canals during the sedimentation phase caused by the canal blocking structures, partial filling of the canals with peat and debris available on site is particularly effective. Many of the larger canals still have berms consisting of dug-out mineral soil, peat and dead

organic matter such as logs and branches. These large volumes of peat and debris from the canal sides are added to the upstream side of the structures, generating a block, the length of which depends on the amount of material available. The peat and debris which is often mixed with shrubs and small trees taken from the site, also provides some structural strength to the 'block'. Although the infilling can never result in full canal blocking, it will greatly increase canal roughness and reduce flow velocity in canals, and thereby increase water levels and flooding during heavy rainfall events if implemented over long stretches of canals. The increased extent of the flooding ensures that the total area carrying flood waters is much increased. This will reduce the chance of flood water flowing over the top of the palisades that are at or below the surrounding peat surface.

4. **Tree planting:** To further increase the hydrological roughness of the canal during the sedimentation process, planting highly flood-tolerant species along the edges of the flooded canals can achieve this aim. Planting vegetation will reduce the risk of the water carrying away the loose infill material and cutting a new channel through it. The species that has been quite effective for this purpose is the local *Pandanus* sp. This species readily grows from cuttings planted directly into the flooded peat at the sides of the canals and so is easy for the local communities to collect and plant in large numbers, funded as part of their Village Agreements.

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REFERENCES

Bappenas, (2009) Reducing carbon emissions from Indonesia's peatlands. Interim Report of a Multi-Disciplinary Study. National Development Planning Agency, Indonesia, December 2009.

EMRP (2009) Master Plan for the Rehabilitation and Revitalisation of the Ex-Mega Rice Project Area in Central Kalimantan. Guideline for Canal Blocking in the Ex Mega Rice Area of Central Kalimantan. Technical Report No. 4.

Hooijer, A., Page, S., Jauhiainen, J., Lee, W.A., Lu, X.X., Idris, A. and Anshari, G., (2011) Subsidence and carbon loss in drained tropical peatlands. Biogeosciences Discuss., 8, 8269–8302, doi:10.5194/bgd-8-8269-2011.

Jaenicke J, Rieley JO, Mott C, Kimman P, Siegert F, (2008) Determination of the amount of carbon stored in Indonesian peatlands. Geoderma, 147, 151–158.

KFCP (2009a) Kalimantan Forests and Climate Partnership. Design Document 2009.

KFCP (2009b) Strategic Peatland Rehabilitation Plan for Block A (North-West) in the Ex-Mega Rice Project Area, Central Kalimantan. Report prepared by Euroconsult MottMacDonald and Deltares|Delft Hydraulics team comprised of Nick Mawdsley, Wim Giesen, Arnoud Haag, Aljosja Hooijer, Marnix van der Vat, Nasrul Ichsan, Bismart Ferry Ibie and Taufik Hidayat. May 2009.

Page SE, Siegert F, Rieley JO, Boehm H-DV, Jaya A, Limin SH, (2002) The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature, 420, 61–65.

Page SE, Rieley, JO, and Banks, CJ, (2011) Global and regional importance of the tropical peatland carbon pool. Global Change Biology (17, 798-818.