Assessing the Success of Tropical Peatland Restoration: A Review

By Alue Dohong[a)], Paul Dargusch[a)] and John Herbohn[b)]

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a) School of Geography, Planning and Environmental Management (GPEM), the University of Queensland, Australia
b) School of Agriculture and Food Science (SAFS), the University of Queensland, Australia



BACKGROUND: WHY TROPICAL PEATLAND IS IMPORTANT?

- Tropical Peatland is only accounted for 441,025 KM^2 or is equivalent to 11% of the global peatland area, and 56% of the tropical peatland situated in Southeast Asia (SE Asia) with Indonesia shares the largest area that is about 47% of the SE Asia peatland area (*Page et al, 2011*)
- Tropical Peatland plays important roles in terms of ecological, economic & societal through its functions & services (*Rieley & Page, Safford & Maltby, 1998 1996; Joosten & Clark, 2002; Parish et al, 2007; Page et al, 2009*);
- Among other major functional & services that tropical peatland provided to human & non-human are **Provisioning/production services** (e.g. *timbers, NTFPs, wild plants/medicine*); **Regulation Services** (e.g. *climate change, flood control & prevention*); **Cultural/informational services** (e.g. *ecotourism, educational, religious practice*); and **Supporting Services** (e.g. *Biodiversity, nutrient cycling*) (*Joosten & Clark, 2002; Kimmel & Mander, 2010*)
- One example out of major regulation services that tropical peatland served is the climatic regulation, where tropical peatland is considered as the biggest & most efficient for storage and sink carbon through it above biomass & peat soil (*Parish et al, 2007*). *Page et al (201*1), for instance, revealed that tropical peatland is held about 88.6 Gt carbon or equal to 15-19% of the global carbon pool. Out of figure above, SA shared about 68.5 Gt (77%), where Indonesia is the largest contributor (65%)
- In addition, peatland in Indonesia, for example, is stored carbon between 15.93 Gt (minimum) up to 58.33 Gt (*Sorensen, 1993, Shimada et al 2001; Page et al, 2011*).

Peatlands Ecosystem Services & Beneficial Functions

Ecosystem Services of inland wetlands (MEA, 2005)	Beneficial Functions of Peatlands (Joosten & Clark, 2002)	Explanation/examples in context of Central Kalimantan Peatlands
Provisioning Services	**Production Functions**	
Fibre & fuel	*Peat extracted & used/wild plants (incl. forests &energy biomas)*	*Peat use in Agriculture/horticulture (ash fertilizer), timber, etc.*
Food	*Wild plants/wild & domestic animals*	*Used as food for people and domestic animals/wood, fur and medicine (e.g. Ornamental fish, orchied, traditional medicine)*
Fresh Water	*Water*	*Limited agriculture irrigation, drinking water & domestic use*
	Peat Substrate	*Agriculture/horticulture/forestry planting medium (e.g. vegetables, fruits, seedlings)*
	Carrier Functions	*Space in peatlands for is used for water transportation, irrigation infrastructures (e.g channel, logging transportation, etc.)*
Regulating Services	**Regulation Services**	
Climate regulation	*Regulation of global climate/regional and local climates*	*Regulation of GHGs, Regulation of Climatic Processes (Storage & Sink Carbon)*
Water Regulation	*Regulation of climate hydrology*	*Water storage, ground water recharge and discharge*
Water Purification and waste treatment	*Regulation of catchment hydrochemistry*	*Retention, recovery and removal of excess nutrient and pollutants*
Erosion protection	*Regulation of soil conditions*	*Peat blanket protecting the underlying soils from erosion*

Peatlands Ecosystem Services & Feneficial Functions ~Cont'd

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Cultural Services	**Informational Functions**	
Recreational & Aesthetic	*Recreation & Aesthetic functions*	*Opportunities for recreation & tourism (ecotourism & scientific tourism and appreciation of nature*
Spiritual & inspirational	*Spiritual & existential functions*	*Personal feeling & well-being, religious significance (traditional religious ceremony, traditional sacred sites)*
Educational	*Signalization & recognition functions*	*Opportunities for education, training & research (Natural laboratory, research sites, arboretum)*
Supporting Services		
Biodiversity		*Habitat for species*
Soil formation		*Accumulation of organic matters (peat)*
Nutrient cycling		*Storage, recycling, processing & acquisition of nutrients*
Source: Adopted & modified from Kimmel & Mander, 2010		

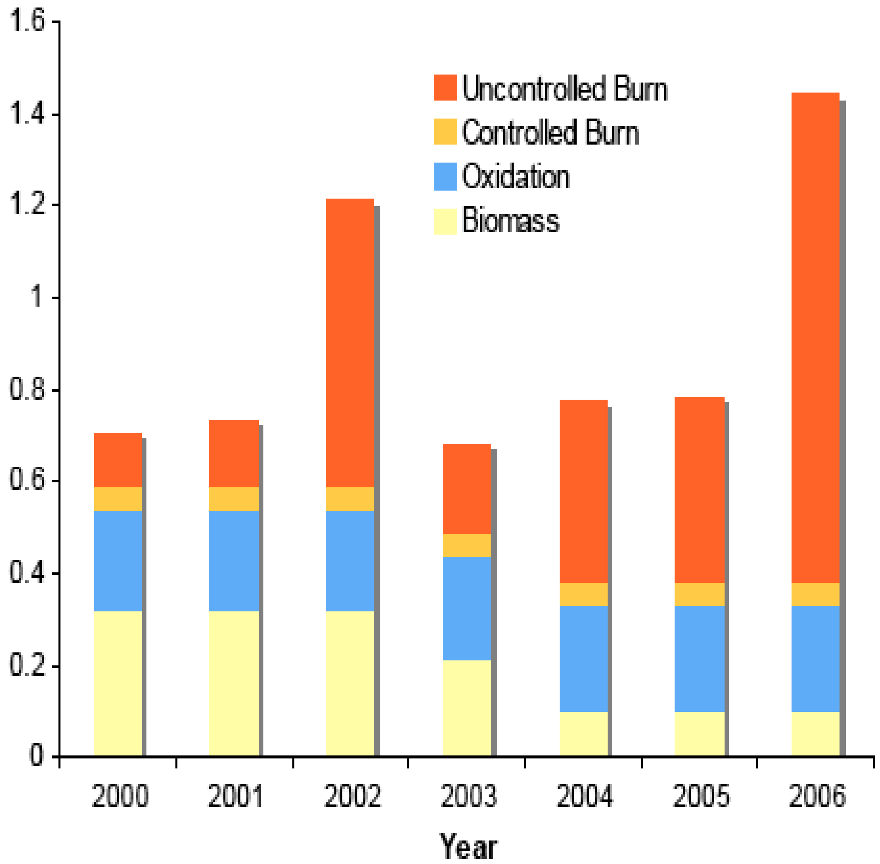
Importance of Tropical Peatland in terms of Climatic Regulation & Control: Indonesia's Peatland Case

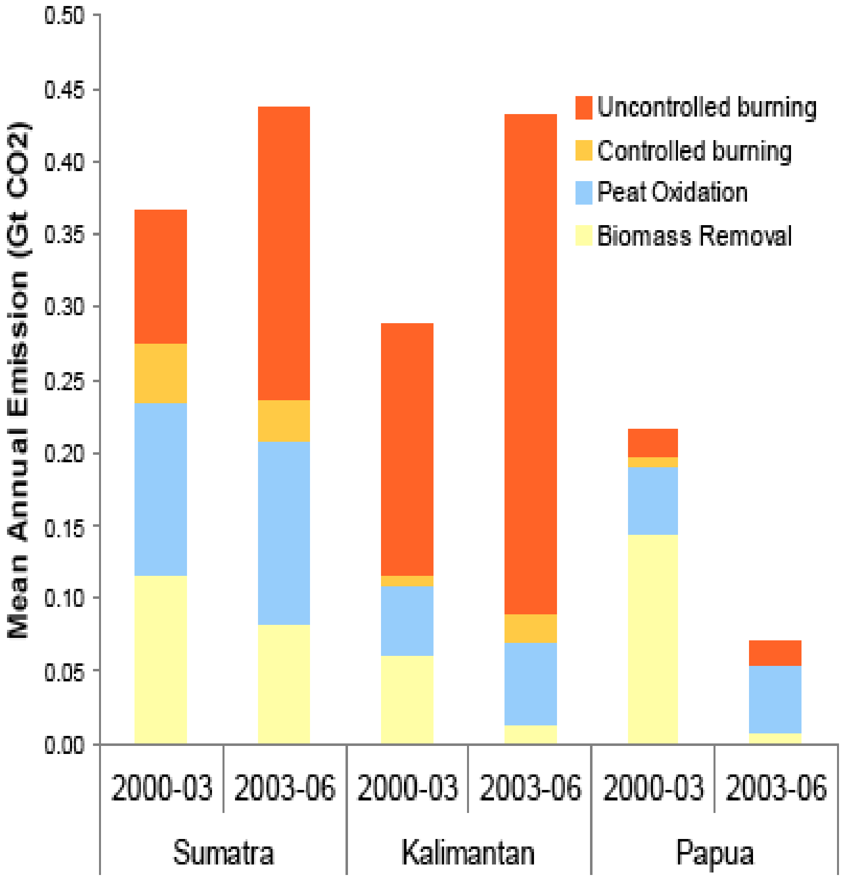
No	Description	Amount/Unit	Reference/Year
1.	Total Area	22 Mha (12% of the country land area)	Bappenas (2009)
		20.6 MHa (10.8% of the country land area)	WIIP (2005)
		22.5 Hactares (83% of SE Asia Peatlands	Hooijer et al (2006)
2.	Carbon Content in Peatland	15.93-19.29 Gt	Sorensen (1993), Shimada at al (2001)
	Carbon store in tropical peatland	Minimum =57.34Gt Best estimate = 57.36 Gt Max = 58.33	Page et al (2011)
3.	Emissions from Peatland	903 MtCo2 (2000-2006)	Bappenas (2009)
	BAU Emission	1,387 MtCO2 by 2025	Bappenas (2009)
4.	Potential Emission Reduction from Peatland		
	• legal compliance and BMP under existing Peatland Production	• 338 MtCO2 by 2025 (24% of potential reduction)	Bappenas (2009)
	• Peatland Rehabilitation and prevention of uncontrolled fires	• 430 MtCo2 by 2025 (31% of the potential reduction)	idem
	• Revision of land allocation, forest conservation and landswamps	• 513 MtCO2 (37% of the potential reduction)	idem

BACKGROUND: Tropical Peatland is Under Threat of Degradation

- Although tropical peatland is considered important ecosystem, however, this fragile ecosystem, particularly in the SE Asia (e.g Indonesia), is under significant threats of degradation result from mostly anthropogenic activities and misguided policies (*Rieley & Page, 1996; Safford & Maltby, 1998; Aldhous, 2004; Parish et al, 2007, Anshary, 2010*);
- Conversion to other land uses, logging, drainage and repeated fires are considered as major drivers of peatlands destruction and degradation in Southeast Asia notably in Indonesia (*Page, 2002, 2009; Jeanicke et al, 2008; Meittinen, 2010; Hergoualch'h & Verchot, 2011, Hooijer et al, 2010, 2012; and Hoscilo, 2011*);
- Conversion of peatland to industrial plantation and agriculture are major responsible for driving peatland destruction and degradation in the SE ASIA (*Hooijer et al, 2006; Koh et al,2009, 2011; Page et al, 2002, 2011;Fargione et al, 2008; Koh, 2009, 2011; and Meittinen, 2010, 2011, 2012*). For instance, *Koh et al (2011)* found that there were about 880,000 hectares of tropical peatlands in Peninsular Malaysia, Sumatera and Borneo were converted into Oil Palm Plantation in 2005.

CO2 Emission from Peatlands in Indonesia (2006)





Estimated CO2 Emission from Peatlands result from below-above biomass lost, peat oxidation & fires (Source: BAPPENAS, 2006)

BACKGROUND:
Tropical Peatland Is Under Threat of Degradation ~ Cont'd

- Construction of massive drainage canals and repeated fires following the peat swamp forests conversion have major impacts to the peat oxidation and subsidence leading to the release of huge CO2 emission to the Atmosphere (*Page et al, 2002, 2011; Hooijer et al, 2006,2010, 2012, Hoscilo et al, 2011;Meittinen, 2012; Koh et al, 2011; Jauhiainen, 2012*);
- For instance, *Parish et al (2007)* estimated that there were about 2.00 Gt CO_{2e} have been released into the atmosphere resulted from fires and drainage of peatlands in the SE Asia in 2006. In addition, *Page et al (2002)* predicted that the single 1997/98 Elnino has released between 0.12-0.15 Gt CO_{2e} to the atmosphere from peatland fires in Central Kalimantan.
- Apart from created severe impact to the local, regional & global climate changes, peatland conversion has a significant negative impacts to the reduction of peat forest cover, extensive derelict/degraded bareland, loss of biodiversity, and socio-economic and socio-culture of the local people (*Aldhous, 2004; Miettinen & Liew, 2010; Koh et al,2011*).
- To reduce the scale of peatland degradation, hence, tropical peatland scientists urge the necessary to undertake tropical restoration measures, by means of stop drainage, tree planting and prevent fires so as to save tropical peatland, notably in Indonesia (Hooijer et al, 2006, 2010, 2012; Page et al 2009; Parish et al, 2007; Jeanicke, 2011)

Relationship Between Peatland Drainage, Fire & Peat Decomposition with CO2 Emission

Source of CO_2 Emission/Year	Geographic Scale	CO_{2e} Emission Released	Reference
Fires and Drainage (2006)	SE Asia	2,00 G_t	Parish et al, 2007
Fires (1997/98)	Central Kalimantan	0.12 – 0.15 G_t	Page et al, 2002
Peat Decomposition (2006)*)	SE Asia	355 M_tYr^{-1} – 855 $MtYr^{-1}$	Hooijer et al, 2010
Peat Decomposition (2010)**)	Peninsular Malaysia, Sumatera & Borneo	233 $MtYr^{-1}$ CO_{2e}+)	Meittinen, 2012
Peat & Forest Fires (2000-2006)	Borneo	74 ± 33 Tg CYr^{-1}	Van der Werf, 2008
	Indonesia	470 Mt CO_2 Yr^{-1}	

Notes: Gt = Giga Tones; Mt = Million Tones; Tg = Terra gram ($T = 10^{12}$)
*) 82% from Indonesia's Peatland
**) Industrial plantation (Oil Palm, Tree Plantation)
+) Oil Palm industrial plantation contributed 161 $MtY^{-1}CO_{2e}$

Effect of Drainage Depth on CO_2 Emission

Drainage Depth	CO_{2e} Emission Released	Reference
10 Cm	9 $tCO_{2e}ha^{-1}yr^{-1}$	Couwenberg et al, 2010
75 Cm (first 5 year of oil palm)	178 $tCO_2eha^{-1}yr^{-1}$	Hooijer et al, 2012
70 Cm (after 5 years of oil palm)	73 $tCO_2eha^{-1}yr^{-1}$	Hooijer et al, 2012
63 Cm	63 $tCO_2eha^{-1}yr^{-1}$	Meittinen, 2012
75 Cm (in oil palm plantation)	100 $tCO_2eha^{-1}yr^{-1}$	Meittinen, 2012
Notes: t = ton; CO_2e = CO_2 equivalent		

BACKGROUND:
The Importance Of Tropical Peatland Restoration Measures

- Restoration is generally aimed at to revive the degraded ecosystem so that its major functions and services are returned & recovered at least close to its original state (*Hobbs, 2007; Hobbs & Walker, 2007; SER, 2012; Page, 2009*).
- Put in context to the tropical peatlands, the restoration efforts are targeted to stop/or reduce drainage, enhancement peat vegetation, maintenance of carbon storage & sink, and fires prevention & control (*Joosten & Clarke, 2002; Hooijer et al 2006; Parish et at 2007; Page, 2009, Couwenberg, 2010; Jeanicke, 2011*).
- In addition, rewetting of degraded peatland is seen by many tropical peatland scientists as the most effective & efficient ways to reduce peatland degradation caused by drainage. In addition, rewetting of degraded peatland is also believed as one of the most effective methods to settle down peatland fires *(Parish et at 2007; Page, 2009, Couwenberg, 2010; Jeanicke, 2011).*
- Although, just recently introduced, the tropical peatland restoration initiatives receive greater attention and many practical activities have taken place on the ground notably in the SE Asia since the last decade.
- However, little is known to what extent these restoration initiatives succeeded in reducing peatland degradation in the region. Hence, there is a need to develop an assessment framework to evaluate the success of tropical peatland restoration initiative.

DRIVERS OF TROPICAL PEATLAND DEGRADATION (With reference to SE Asia)

- ☞ Policy & Institutional (Agriculture Policy, absent of responsible agency)
- ☞ Socio-economic & Market (Bio-fuel Market);
- ☞ Technology (land clearing technology, e.g. *fires*)
- ☞ Biophysical (decomposition, drainage, shrinkage, peat properties changed)

DEFINING RESTORATION:
From Ecological Perspective to Tropical Peatland

The followings are ecosystem (ecological) restoration (ER) definitions defined by various organization and /or authors:

- **'an intentional activities that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability (Global Restoration Network, www.globalrestorationnetwork.org/restoration)**
- 'an activity or series of activities undertaken to return a degraded ecosystem to a healthy state' (Palmer & Filoso, 2009);
- 'an attempts to revive the natural resource functions of degraded ecosystems, thus reinstating the environmental and economic services that these provided (Page et al, 2009)
- 'an elective initiative that fosters the sustainable recovery of ecosystems that have been degraded, damaged, or destroyed' (Clewell, 2006)
- 'a process that aims to regain ecological integrity and enhance human well-being in deforested and degraded forest landscapes' (Rietbergen-McCracken et al, 2007)
- ….'Ecological restoration among other things is clearly required to repair the damage and to halt or reduce economic losses and socio-economic disruptions caused by this abuse of rangelands…' (Aronson et al, 2010)
- **Contextualize those definitions to tropical peatland restoration is an effort or series of efforts to stop or cure peatland degradation scale and state by putting in place series of physical and non-physical measures to reinstate both ecological and socio-economically services of restored peatland ecosystem.**

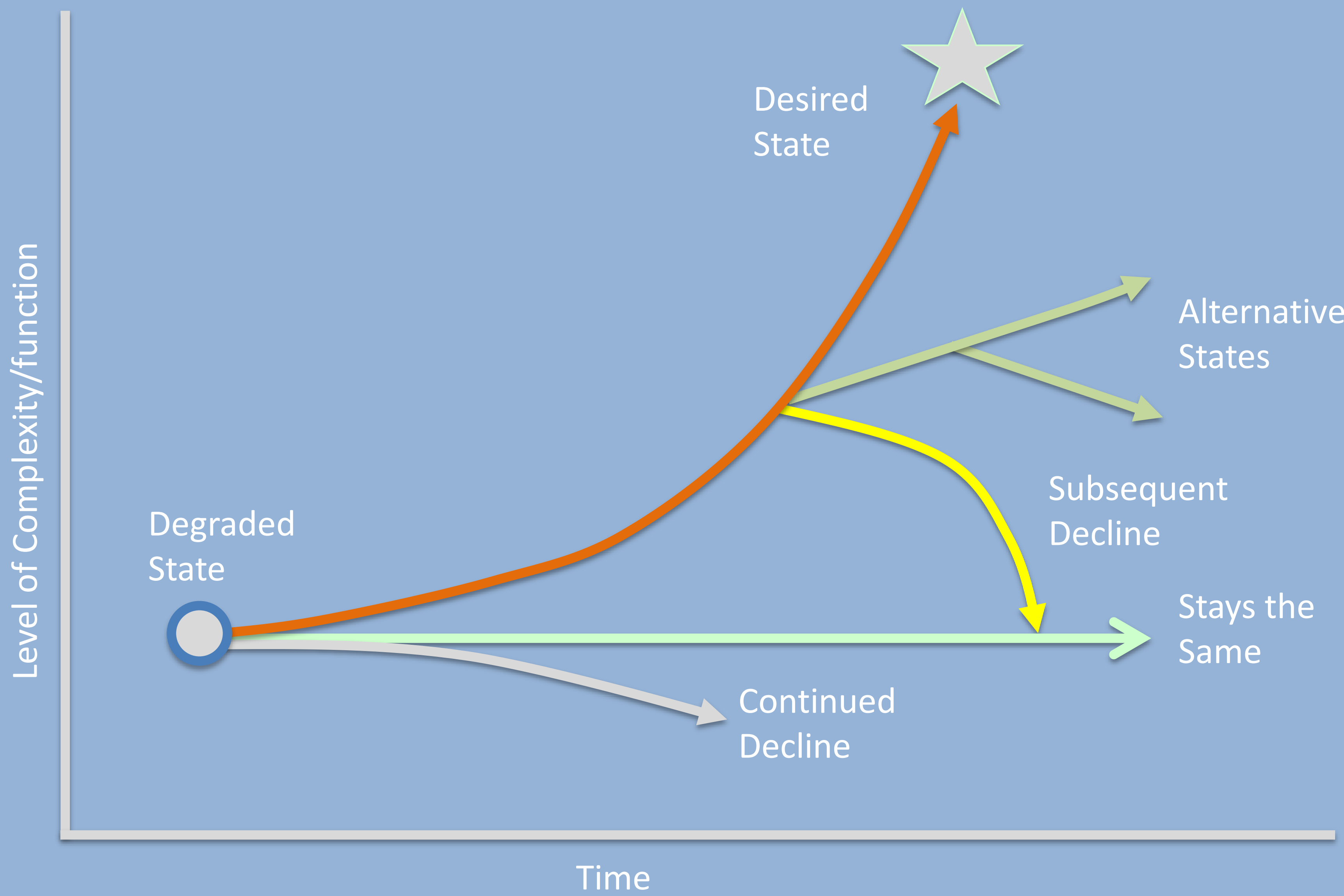
SETTING THE GOAL OF PEATLAND RESTORATION: Choice Between Trajectories

Where to go?

Back to Original Condition?

New State (Alternative States & Future Use options)

Traditional View of Restoration Options for a Degraded System: Possible Trajectory Alternatives



Adopted from Hobbs & Norton, 1996

KEY QUESTIONS NEED TO BE ADDRESSED IN RESTORING DEGRADED TROPICAL PEATLAND

- What is the realistic goal?
- What are the Major ecological & socio-economic constraints?
- What are the key ecosystem elements & functions to be restored?
- Will the restored peatland be sustainable in the long term?
- Will the technology and lesson learnt be available and applicable;
- What are the potential institutional, policy & Management Constraints?

Adopted & modified from Rieley (www.geog.le.ac.uk/carbopeat/media/pdf/tullamarepapers/rieley2.pdf)

Current Knowledge & Practices in the Tropical Peatland Restoration

- Intervention approach:
  - Hydrological restoration (Rewetting/canal blocking);
  - Revegetation (tree planting, natural succession);
  - Protection of Carbon Storage and Sink
  - Fire prevention and control
  - Livelihood Development
- Scale Approach:
  - Site specific and project-based
  - Partially intervention (not integrated)
  - NOT on landscape/ecosystem basis
- Achievement/Success & Sustainability:
  - Mixed
  - Lack comprehensive assessment and monitoring done;
  - Absence of an integrated framework for assessing the success.

Identifying the Major Drivers of Tropical Peatland Restoration

Technical/Biophysical Drivers

- ☞ Rewetting technology (Dam designs, Dam construction SOPs);
- ☞ Silviculture &Nursery technologies (SOPs, planting techniques);
- ☞ Traditional Knowledge;
- ☞ Total degraded peatland areas

Institutional, Policy and Management Drivers

- Peatland Conservation & Protection Policy (Local, National & International) → Moratorium (Inpres 10/2011), UULH (32/2009), Kepres 32/1990 (Deep peat), MoF Reg No. 14/2009)
- Ecosystem Restoration programme (e.g. MOF regulation No. 20/2012)
- Tenure Security & Customary rights protection (Perda No. 16/2009 in Central Kalimantan)
- Institutional arrangement
- Spatial Plan and land use policy
- Long term planning arrangement
- Forest rehabilitation Programs (e.g. in Indonesia – OBIT, RF)
- Decentralization Policy (Act No. 32/2004 in Indonesia)

Socio-economic & Market Drivers

- Livelihood Development;
- Carbon Market (CDM, REDD+ & PES);
- Local Participation & Involvement;
- Economic & Financial Incentives;
- Green products & Low Emission Policy
- Green & Climate Investments;
- FPIC & other social safeguard.

Lesson Learnt from Previous & Current Peatland Restoration Initiatives

- Peatland Hydrological Restoration Guidance & SOPs;
- Peatland rehabilitation Guidance & SOPs;
- Fire Prevention & Control Guidance & SOPs;
- Technical capacity & expertise.

Measuring the Success of Tropical Peatland Restoration

- What is the major element to be measured?
- What are the success indicators to be used?
- How is the major step in measuring success?
- What is the procedure to be used?

What is the major element to be measured?

- Ecological Attributes:
  - Vegetation characteristics (vegetation structure, forest dynamics)
  - Species Diversity (plant & fauna)
  - Ecosystem Processes (water/hydrological cycle, mineral cycle, energy flow, community dynamic)
  - Peat properties changing
- Socio-economic Attributes:
  - Income and employment impacts;
  - Business opportunity
  - Tenure system
  - Social cohesion
  - Community participation and involvement
  - Etc.

What are the Success Indicators to be used?

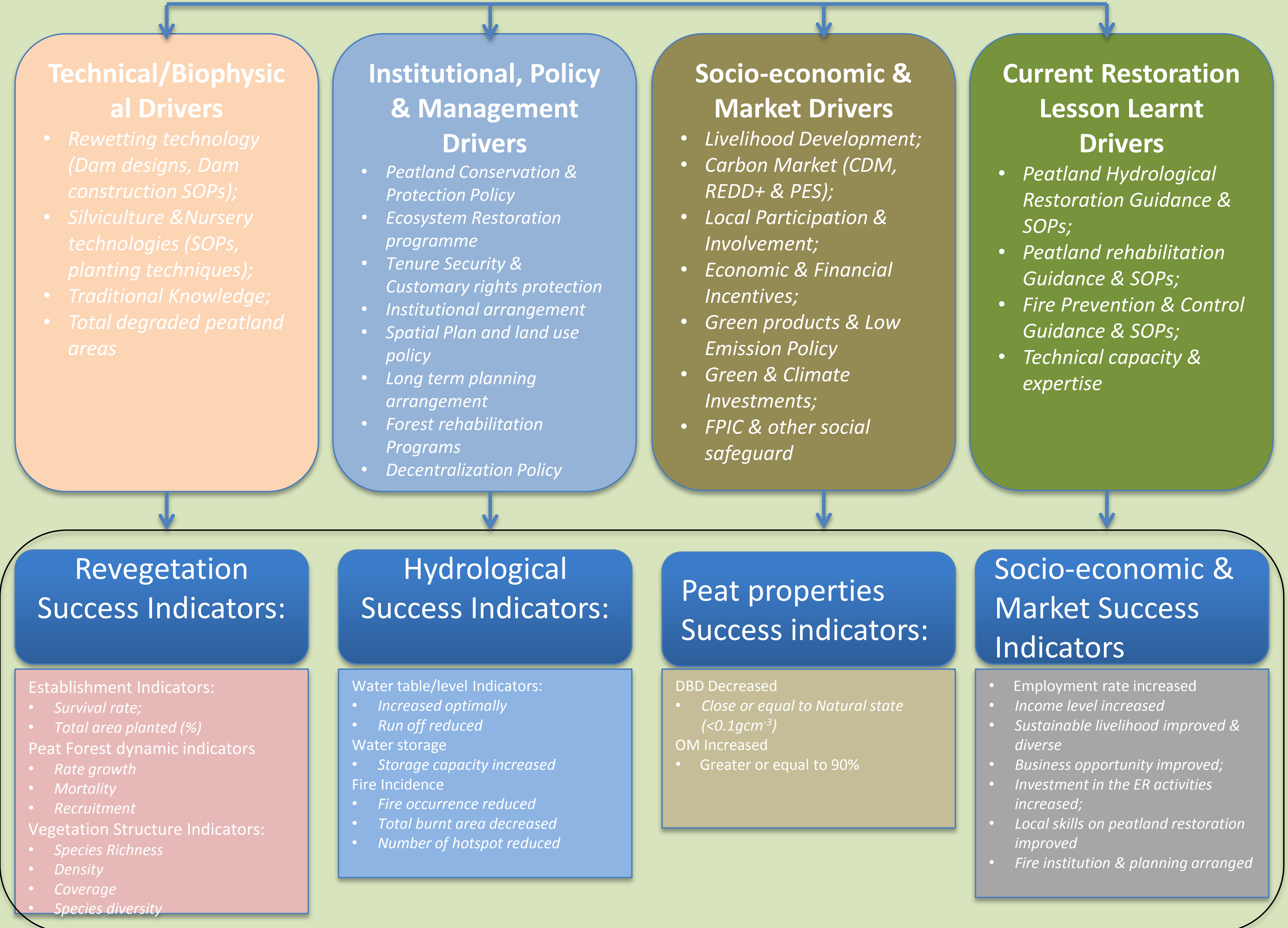
Revegetation Success Indicators:	Hydrological Success Indicators:
• *Establishment indicators* • *Peat Forest Dynamics Indicators* • *Vegetation structure indicators*	• *Water table/level* • *Storage,* • *Fire Incidence;*
Peat properties Success indicators:	**Socio-economic & Market Success Indicators**
• *Concentration of OM (Organic Matters)* • *TOC (Total Organic Carbon)* • *pH, Water content, DBD, TN, TS, etc.*	• *Employment Rate* • *Income level* • *Livelihood sustainability & diversity* • *Business Opportunity* • *Investment opportunities in ER increased* • *Local capacity & skill increased* • *Fire institution & Planning*

How is the Major Steps in Measuring Success?

- Developing Monitoring Design & Protocol
- Conducting baseline study
- Establishing Reference Site
- Implementing monitoring both within reference and restored sites
- Evaluating the Success (direct comparison & trajectory analysis);
- Improving restoration strategy & measures.

What is the Procedure to be Used?

- Developing the General Framework for Measuring Success.
- Developing Measurement SOPs



A Conceptual Framework for Assessing Tropical Peatland Restoration Success

Thanks for kind attention