**Summary**

This paper examines the issue of continued and increased pressure on carbon conservation in the peat- lands of Indonesia – with a specific focus on the coastal peatlands of Riau Province, Sumatra and the current development on those lands. What can be realistically expected to be conserved is considered alongside the mechanisms available to do so. Land use development and, therefore, deforestation in Riau started in the early 1980s when major clearing began for the establishment of large palm oil plan- tations. This was quickly followed by the widespread establishment of smaller oil palm holdings by small holders. The 1990s saw the emergence of the pulp and paper industry in the Province and public sector lands were converted to industrial tree plantations for fibre. Initially most of the forest conversion took place on the more accessible mineral soil lands. Development of the peat swamp environment fol- lowed later; requiring more intensive investment in capital and technology to expand at a large scale. At the small scale of the individual householder, peat is difficult to develop as the surrounding hydrolo- gy cannot be controlled.

Practical options for carbon conservation and development alternatives in this setting are limited. Large areas of peatland are already degraded and the forest removed. Rehabilitation of peatlands for carbon and biodiversity conservation is one option but in practice it is entirely unproven and would require enormous long-term funding for outcomes that could never match those from pristine forest. Integrated development is examined as the only proven option for maintaining some natural forest alongside a commodity crop. Such an environment stores up to 50% of the ecosystem carbon that successful rehabilitation might store. The other 50% of carbon drives agricultural commodity markets that pay for the benefits for as long as there are strong markets for palm oil and fibre pulp. The time scale of estate concession license periods of up to 100 years along with the business corporate model, are appropriate for mitigation attempts of the extended time of the carbon cycle. .

**Key words: Peat swamp forest, soil carbon, climate change, deforestation, agriculture, livelihoods, palm oil, fibre plantations, drainage, Riau, Indonesia**

**Glossary**

**Atmospheric haze** – dust, smoke or other dry particles that obscure clari- ty of the sky.
**Biomass** – biological material from living or recently living organisms of flora and fauna.

**Biodiversity** – the degree of variation of life forms within a given ecosys- tem or region.
Beyond compliance – conductin business with environmental protection more than required by law.

**Carbon cycle** – the movement of carbon atoms, originating as CO2 through various organic and other molecular combinations in nature, returning as CO2.

**Integrated development** – crop production and conservation are delivered from a common area of land.

**Palm oil** – cultivated crop that produces edible oil from fruits of the palm.
**Peat swamp forest** – tropical moist forests where water-logging pro- duces thick deposits of organic soil.

**Plantation fibre** – cultivated hard- wood trees that produce short-fibre pulpwood.

**Selection logging** – practice of har- vesting a portion of natural forest stands while retaining a forest struc- ture on that area of land.

**Abbreviations**

**BAPPENAS** Indonesian National Development Planning Agency; **CO2** carbon dioxide; **CO2e** carbon dioxide equivalent; **FSC** Forest Stewardship Council; **GDP** gross domestic product; **GHG** green house gases; ha hectare; **M** million; **RSPO** Roundtable for Sustainable Palm Oil; **t** tonne, metric

## Background

### Carbon Conservation and Development

There is increasing international interest and pres- sure from concerned stakeholders that tropical peatlands be managed for the purpose of environ- mental services alone. The rational is that if the vast stores of soil carbon to be found in peat swamps are left intact, then global climate will benefit. In coastal Riau, Sumatra, Indonesia, com- mentators have taken this to mean that current land use development trends involving deforesta- tion must be halted (Verchot et al. 2010). A second- ary benefit of such an intervention would be the maintenance of biodiversity within these forests.

In principle the climate mitigation concept is sim- ple enough. Local participants, opportunistic log- gers and farmers, would forego imminent defor- estation and their loss of livelihood would be com- pensated by beneficiaries of climate mitigation. This list would also have to include plantation com- panies with rights to develop licensed land areas, although the principles and mechanism for com- pensation here are less clear. There are, however, many questions that need to be answered before this could become reality.

First the time frame. The global carbon cycle has a long feedback and stabilization period during which carbon stocks must be kept out of the atmosphere to effect climate mitigation. Project funding and project management need to stay in place throughout this process, which is likely to be at least a century?

Second, criteria for peat carbon conservation need to be determined. Most carbon in peat lands is soil carbon that was accumulated under a climate dissimilar from that of today (see for example Page et al. 2004). Waterlogged swamp conditions have been a key requirement for tropical peat soil car- bon to accumulate. It is often assumed that by maintaining peat swamp forest conditions under the current climatic conditions that carbon stocks will be maintained; although there is no evidence of this, it is possible carbon investors would require proof.

Third is the necessity to maintain the present healthy economic growth that mirrors the popula- tion growth of Riau province. To halt deforestation, mechanisms will need to be developed that secure livelihoods and economic benefits for the many people who depend for livelihood on informal log- ging, shifting cultivation and plantation agriculture.

### The Political Setting

Indonesia's democratic awakening since the 1990s has been accompanied by much opening up of forested state lands for the production of agricultural commodities. Decentralization of resource control has been a key driver of this land use change (Poulter & Badcock, 2001). Coastal Riau is no exception; its peat swamp forests are now almost the last source of additional productive lands in that province. An

estimated 0.62 Mha of intact peat swamp forest and 0.67 Mha of degraded peat swamp forest remained in 2009, with another 2.11 M ha of peat that is developed or totally deforested (Figure 1).

Peat swamp forest has been reduced by selection logging, village agricul- ture and conversion to oil and tree plantations and the accompanying side effects of drainage and fire. While some of this development is planned and can be controlled i.e. the larger estate plantations, much is not. This uncontrolled development becomes the agricultural frontier - the rural poor's last chance to share in income from rich natural resources.

The chaotic initial process produces much deforestation and atmospheric haze for small initial output of agriculture. The environment is paying for the rapid transition to a devolved market econo- my. Indeed, the government estimates that all Indonesia's peatlands con- tribute 50% of national GHG emis- sions for just 1% of GDP (BAPPENAS, 2009).

Central Government, under interna- tional pressure on its peat carbon record, has announced a ban on new development of peat swamp forest and tighter compliance with existing legislation.

Deforestation in Riau has resulted in massive losses in biodiversity with the most visible and tragic impacts being to the mega fauna – Sumatran Elephant and Tiger. However, the remaining forested peatland landscape cannot be conserved no matter how much the world would like it to be.

Maintenance of the formal protect- ed area network, that government endorses and gazettes, must be of the highest priority for national as well as international national strategies on for- est and biodiversity conservation in Indonesia – as these areas are not exempt from development pressures (Figure 2). The formal agricultural sec- tor while still impacting on the envi- ronment is and can be driven further to control more of its impact. The informal sector will unavoidably lag behind in terms of being able to miti- gate impacts on environment.

**The Geographical and Economic Setting**

Riau is currently one of the richest provinces in Indonesia, with abundant natural resources: petroleum, natural gas, palm oil and fibre. Extensive log- ging has led to a massive decline of

forest cover from an estimated 78 % of land area in 1982 to just 33 % in 2005 (Central Bureau of Statistics, 2011) (Figure 3). Since the 1970s, the majority of Indonesia has experienced declining population growth rates that currently stand at about 1.5 % annual. Riau is a significant exception, with increasing rates every decade since 1970, reaching a peak in the 1990s at 4.3 % annual with a population of 5.55 M in 2010 (Central Bureau of Statistics, 2011). The economy of Riau

expanded faster at 8.6 %, than the Indonesian average of 6.04 %, for 2006. Local government benefits from an increased share of tax revenue due to decentralization. The economy is natural resource-based, led by crude oil.

**Topography**

Coastal peatlands make up around 3.4 Mha of the province with much of it in a modified condition and said to be a major contributor of GHG (Proforest 2005, Hooijer et al. 2006). A similar situation exists in Kalimantan, but is not discussed here.

Tropical peat swamp is a raised ground water dome. The swamp for- est cover maintains its own essential environment by retarding runoff, in part by surface roughness of soil, roots and vegetation (Figure 4). Continuous inputs of forest debris, particularly tree roots (Brady, 1981) have built and maintained the huge stores of peat soil carbon over the last 5-6,000 years (Supardi et al. 1993). In the last 1- 2000 years the area of tropical peat deposits has shrunk and now there are concerns for the effects of global warming on existing deposits.

Riau's coastal peat swamps 30 years ago were almost exclusively a public owned landscape of pristine forest. Government zoning of the land was mostly present as permanent produc- tion forest (by selection logging) with minor areas for conservation and con- version to agriculture. Community lands were confined to small enclaves. Today, land zone is no guarantee of condition. Uncertainty is linked to ownership and the competing inter- ests and claims among government agencies, communities and develop- ers.

Forests may be physically removed and lost, or often they may be altered, perhaps permanently, by the peripher- al impacts of neighbouring develop- ments such as drainage (Figure 5). There is little agreement on definition of what constitutes viable forest that will recover in time if the natural hydrology is restored – as opposed to that damaged beyond a point of no return. In the Kampar Peninsular, Page et al. (2008), estimated from satellite images that 6 % of the forest cover was good.

That figure is in agreement with an assessment of forest cover made from the 2009 images for this present paper (Figure 1). The Kampar Peninsular core is the largest tract of intact peat swamp forest remaining in Riau. Deterioration at margins of peat swamp forests is affected by ground water drainage and other edge effects, but the exact mechanisms are unclear.

Following repeated cylcles of log- ging and burning, within a period of twenty years or so, little is left of the original peat swamp environment. The forest has disappeared and water tables are lowered. Restoring water levels across the peat dome would almost certainly provide a huge tech- nical challenge – requiring at the very least, that the forest is restored.

Given the extent and severity of the forest degredation, restoration at scale is unlikely. The forest environment is replaced by pioneer shrubs and ferns that continue to be destroyed at regu- lar intervals by buring.

**The Agricultural Frontier**

The agricultural frontier has not been government policy. It is an outcome of pressure on land since the political reform of the 1990s that has seen the population of the province and contri- bution to national GDP grow. The ini- tial pressure for farm land is from rural people who need a source of income from low-investment slash and burn agriculture - low yielding and unsus- tainable as it may be (Figures 5, 6 & 7). Although not always sequential, some of the steps in the process of transforming closed-canopy peat swamp forest to agriculture are:

*Stage 1:* Concession Selection Logging. Typically this is several rounds of selec- tion cutting on a 20 year cycle. Most logs are extracted by manually pushed carts on portable light rail systems that can be relocated as the logging front moves. This system does not require drainage of the surrounding land to operate. Canopy opening leads to lowered humidity and forest drying; in exceptional dry spells fire can spread. But if selection cutting is controlled and other impacts are minor, the for- est can recover.

*Stage 2:* Illegal Logging. Often this is organized around a local community. Since ca 1990 tracked excavators have been used widely to dig narrow ditch- es about 1 km apart that connect to the nearest small river or canal, for log extraction (Figure 6). These 'wild' drains are never closed after their brief use and flow continuously, slowly reducing ground water levels in porous soils of surrounding peatlands.

This widespread illegal logging and accompanying drainage often starts irreversible decline and loss of forest cover.

*Stage 3:* Slash & Burn Encroachment. Drainage of peat is essential for any agricultural crop (except for sago on the coast). Small ditches left from pre- vious illegal logging are often the ini- tial source of 'borrowed' drainage. Encroachment is opportunistic and fol- lows available access - extending up to 0.5 km on each side of ditches, canals, and floating roads.

Fire is always used to clear the land as there is no other means available (Figure 7). Peat can smolder for weeks until rains arrive; farmers have no capacity or motiva- tion to douse fires. Burnt peat ash is the cheap fertilizer that greatly raises the scarce mineral content of peat soil (Figure 8).

Initial planting is patchy. Clumps of fruit trees, oil palm or rubber trees are planted at strategic points to claim the land boundaries, and simple thatched structures erected for shelter or tem- porary habitation. Often the process is repeated several, or many, times as dry periods allow; later fires take a toll on earlier plantings. A patchwork emerges of scattered remnants of degraded

forest, scrub, fern, grassland and sea- sonal agriculture (Figure 9). Corn, chili and pineapple are common initial crops. Rice is cultivated in a few river- side places offering tidal irrigation. Investment in tree or palm crops tends to increase as the fire phase passes.

These frontier activities bring tempo- rary benefits but yields are often low and the system inefficient for the amount of soil carbon emitted. The frontier produces degraded and poorly utilized forest land that does strength- en the case for organized develop- ment to be given access to these now degraded public lands.

*Stage 4:* Productive Agriculture. Over a decade the frontier patchwork of for- est, re-growth and subsistence crops is transformed into organized plantations of palm oil and rubber Whereas the agricultural frontier was mostly infor- mal slash-burn driven by individual farmers, in the new landscape dominated by organized plantations only small enclaves of individuals' gardens remain.

The initial pioneers are bought or pushed out by larger schemes with land titles. Most plantations are devel- oped on public land of either Agriculture or Forest status. Legal requirement to conserve the original forest is different for each but in gen- eral are minimal – the focus being at most – legal compliance.

*Stage 5:* Integrated Land Use. In the last few years the emerging green markets for commodities have led some national and international owned estates to voluntarily set aside larger areas of conservation in order to demonstrate commitment to a busi- ness model that extends 'beyond com- pliance'. Such schemes include the Round Table for Sustainable Palm Oil (RSPO) and the Forest Stewardship Council (FSC) for wood origin certifica- tion.

Legal and voluntary constraints can result in 30 % or more of conces- sion land being set aside from devel- opment as natural forest - in various states of original structure and func- tion. However, to implement such standards, no matter how desirable, is proving to be a challenge in the pres- ent development setting. This model is termed here Integrated Development as conservation and development outcomes are integrated (Figure 10 & 11).

**Peatland Carbon Reserves**

A review by BAPPENAS (2009) con- cluded that annual emissions from all Indonesian peatlands are about 500 M t of CO2. This is lower than estimates made previously, e.g. Hooijer (2006). Recent monitoring of soil respiration from drained agricultural peat indicates rates in the range 30-60 t CO2 /ha/year when root respiration gas exchange is excluded (Hatano 2009; Hooijer et al. 2009). Monitoring of local atmospheric CO2 levels has com- menced in Sarawak Malaysia (AsiaFlux, 2010) and is now planned for Riau, to provide better estimates peat soil emissions.

Despite uncertainty over the values, where water tables have been low- ered, there is no doubt that peatlands are emitting large quantities of CO2. This is where Indonesia's reputation as a major contributor to global carbon emissions and

climate change warm- ing has originated – owing to the deforestation and the drainage based agricultural systems that follow.

A key question to be asked is: what are the main factors that could be controlled to reduce peatland emissions, and by how much?

One integrated development project in Riau has monitored soil and biomass carbon stocks and fluxes in plantations and conservation set asides in its con- cessions, (Bathgate 2010). In the last 5 years, soil carbon is being lost at sig- nificant rates from both these domi- nant land use types. It is possible that in the conservation areas, previous deterioration has not had time to respond to the recent mitigation of logging and drainage impacts.

A much longer monitoring period is required to understand the expected recovery process. However, at this stage several tentative conclusions may be drawn. The pristine state is rare and soil car- bon accumulation expected of pristine peat has not been found (or reported in Indonesia).

Deterioration in peat swamp forest is difficult to recognize without intensive monitoring on the ground; therefore it may be wide- spread and largely unreported. The forest recovery expected to follow mitigation of disturbing factors may take several or many decades to happen.

Mindful of uncertainties, indicative carbon stock projections for peatland development in Riau are reproduced here, from Bathgate (2010). Carbon fluxes measured over the previous five years have been used, with modifying assumptions on rising water tables and declining production, to project long term trends in stored carbon. While the projections are speculative, they suggest that outcomes for peatland carbon storage and hence climate could be very different depending on the development scenarios implement- ed.

An horizon of a century is used in order to better reflect the carbon cycle and the maximum term of formal licenses (Figure 12). A start date of 1975 is when coastal swamp forest was pristine. Vegetation removal, e.g. forest clearance for plantation, is treat- ed as an immediate release of carbon. An initial value for stored carbon in the peat swamp system of around 10,000 t CO2/ha is based on values of peat soil and biomass volume and density and carbon content that have been measured in Kampar Peninsular interior peatland.

**1.** 'Society's default'; informal devel- opment that results in a landscape entirely of small agriculture holdings.

**2.** 'Integrated development; environ- mental 'green' certification with volun- tary best practice that sets one third of the landscape aside for conservation management.

**3.** 'Integrated development with product'; this accounts for carbon in products like palm oil or pulp fibre that is transferred out of the peatland. Transferred carbon while no longer in stored form is an important transac- tion for development and

merits inclu- sion in this carbon account.

**4.** Rehabilitation; in theory with suffi- cient funds and technical input all remaining degraded forest areas could be rehabilitated to being largely forest- ed areas storing carbon. It should be noted that most international assis- tance projects provide funding for 3 to 5 years. These funding cycles would need to be extended in order to impact the carbon cycle.

**5.** 'Undisturbed nature'; an option that remains for the estimated 0.62 Mha, of Riau peatland forests that are still intact.

In the case of intact forest, clearly total conservation delivers the opti- mum outcome for carbon storage. It makes little difference whether soil car- bon stocks continue to build slowly, as modeled, or not. What is important for climate is that soil stocks do not decline.

By today's understanding this requires the landscape to remain pris- tine. Such a change to the status quo requires a substantial and sustained intervention – that in turn requires that society reaches a consensus to do so.

In theory one option for conserving carbon in degraded forest and scrub is rehabilitation. As modeled here it retains, and even increases existing stores of biogenic carbon. In practice it is entirely unproven and would require enormous funds for results that might not equal those achieved by conservation; both in terms of carbon and biodiversity.

So, the only effective option for modified forests is likely to be the inte- grated development option. It has the potential to store up to 50 % of the ecosystem carbon that, rehabilitation, the best theoretical option, can store (Bathgate, 2010).

The other 50% drives agricultural commodity markets that pay for the benefits – carbon, conservation and development. Some of the consumed carbon is immediately released to the atmosphere and some is transferred in commodities that may stay intact for some years, e.g. timber and writing paper.

The latter, at least in Asian markets, provides further benefit of energy or recycling at end of life. Importantly, society is not asked to find more funds – provided the planet continues to have a strong market for agricultural commodities like palm oil and short fibre pulp. In addition, concession license periods of up to 100 years along with the business corporate model, are appropriate to the long run of the carbon cycle.

In peatland frontier areas, integrated development has done more for conservation than any other land use. While each district of coastal Riau has created its own land- use plan, integrated development is the only spatial model in practice across all (Figure 13).

This model has a conservation core often located on a central peat dome, buffered by a controlled activity zone giving way to an outer zone of intensive production and then on the outmost periphery to permanent settlement even by local communities.

Calls for widespread conservation of all remaining forest areas as a direct alternative to development, whilst desirable, are idealistic. Most land being converted to agriculture is far from pristine and in some cases is con- tinuing to deteriorate. While enclaves in the development landscape are valuable to conserve, for most of the non-pristine forests the conservation option foreclosed some time ago. The carbon storage trends shown in Figure 7 may be used to provide guidance on the most effective way of integrating land use and carbon charging to opti- mize society needs.

**Carbon Finance**

Attention is drawn here to some fun- damental issues that need to be con- sidered before carbon funding could be made to work for peatlands. Large scale agricultural projects are funded on long term projected benefits – identified at design stage. The benefits produced from a project would have to track its stocks of carbon reliably over an extended period and accom- modate human development factors. Unfortunately at present there is insuf- ficient confidence in estimates of car- bon emissions, and hence in relative savings from various alternative land uses.

If agriculture uses soil carbon stocks less rapidly than the informal frontier operating alongside, should society pay? If the agriculture producer has promised to deliver climate benefits, for which consumers pay, should the producer be paid extra for what has already been 'sold' i.e. reductions in carbon emissions?

Protecting a resource from develop- ment in one locality should not trans- fer pressure to resources elsewhere. Ultimately that means the poverty underlying the frontier must be elimi- nated. Conservation incentives must provide alternative livelihoods for the rural poor, the loggers and cultivators. At the same time incentives must give good value and remain affordable to investors; but society should not pay for what would have happened with- out incentives.

A fundamental issue is society's trust in institutions to have the necessary legal and structural stability to reduce carbon emissions over 100 years. Funds need to be dispensed now, on trust, that future generations will con- tinue to withhold peat development, and that carbon emission reduction and climate benefits will accrue. There are spatial and temporal issues of who pays and who benefits. Climate miti- gation benefits are global and very long term – so should all society con- tribute payment, perhaps on the basis of consumption of exported commodi- ties.

The rates of annual emissions being reported from drained agricultural land, multiplied by today's trading val- ues of biomass carbon, roughly match values of agricultural production. Compensation to forego agriculture might be payable from

carbon income. In the long term society may well demand a reduction in public land emissions, in which case pay- ments to forego emitting carbon would become affordable.

**Toward Solutions**

The outcomes that this paper exam- ines for coastal peatlands – agricultural production, conservation and carbon – are bound up in a complex process of political, social and geographical developments. A key question is:  development and progress for whom? For the world the priority is conserva- tion. An urgent and obvious solution to conserve Riau's peat soil carbon, forest and unique biodiversity is to stop deforestation.

For Riau, a halt to economic and social development now could be disastrous and might lead to even more environmental destruction. At this 'just-emerging stage' Indonesia cannot be expected to curtail economic growth significant- ly for the benefit of global climate. It would appear that the expectations of concerned international environmen- talists clash with local demands. Democracy, reform and a market led economy in Indonesia are still fragile.

As one study of Indonesian rural poor farmers noted, being in geographically remote locations means being out of reach of institutional health, education and economic assistance to the poor (Yurisinthae, 2010); farmers have little choice but to diversify their subsis- tence income according to opportuni- ty. The ordinary individual's needs of providing for his household's liveli- hood should be realized.

While high rates of economic growth in Indonesia are maintained with social and political stability, outside assistance with inter- ventions could be entertained. This is surely unlikely if the economy were to stagnate nationally or internationally.

An estimated 1.3 M ha of undevel- oped peatland remains in Riau. Its careful development following the integrated model could deliver per- haps 0.6 M ha of secure additional conservation and 0.7 M ha of agricul- ture inside a decade. This area of agri- culture when fully developed could potentially add about 7 % to today's regional economy.

Even with support of the interna- tional community the Indonesian gov- ernment does not have the resources to manage the existing commitments on conservation. So, adding large areas of peatland to the existing con- servation burden is not a way forward. The proven way is to use the integrat- ed development of agricultural estates in which embedded conservation areas are protected by zones of develop- ment that buffer against drainage, illegal logging and fire.

Markets for prod- ucts pay for this integrated conserva- tion. For example, the conservation set-aside legal minimum today for industrial tree plantations is about 10 % of concession land. Government has signaled tougher regulation of the for- mal sector. If legal minima for set- asides were raised to 20 or 25 % of holdings,

which a few extreme conces- sions have set aside, the green-end of growth-demand markets for com- modities like palm oil and fibre pulp may well accept this extra cost.

However, if nearly half of the remaining area of undeveloped peat swamp is to be conserved, a larger more inclusive model is required. To achieve an expanded protected area network centered on the least accessi- ble peat domes, buffered by integrat- ed development on the periphery, concession holders and local commu- nities would need to be compensated. This indicates a role for international finance. Carbon and biodiversity can be protected in a well planned and managed integrated landscape, where local development and poverty allevia- tion are fulfilled, providing outcomes from both a business-as-usual “green- er” agriculture and from new business in carbon conservation credits.

Government has targeted lowering carbon emissions from public lands, particularly those from drained agricul- ture. This will remain problematic

while the science on peat soil emis- sions is so unclear. A network of GHG emission monitoring stations is needed to establish the climate outcomes of land use alternatives: degraded peat- lands for formal agriculture versus informal agriculture and pristine peat land conservation. At present there is no rehabilitation to monitor.

More difficult to envisage is how to close completely the informal agricul- ture frontier. Unless this is achieved, the production and development ben- efits referred to above will be degrad- ed and conservation options will be permanently lost.

Rural communities are the forest gatekeepers with tradi- tional rights of use, and a presence in the otherwise unoccupied public lands. There is a need to break the dependence of communities on infor- mal logging. Local communities could be paid to forego frontier activities – from carbon funds administered through government. How this would work is, however, far from clear. Payment of annual rent on the value of carbon tied up in standing biomass

is small. Annual rent based on the value of stored carbon in peat soil is some 10 fold higher. Another payment option is on the value of soil carbon that would be emitted annually under drainage based agriculture practices. But another question remains: what would these individuals then do in order that they might generate mar- ginal wealth?

If a way forward is found in time, the informal frontier will cease, carbon stocks in conservation lands will stabi- lize and agricultural emissions will be in the spotlight. Society at large will insist on lowered GHG emissions in future – and will accordingly need to be prepared to pay through a variety of market transactions in what is, increasingly, a global market based economy. How rapidly this can occur is unknown.

Meanwhile, inevitably the environmental costs will mount with the inclusion of climate change impacts from developing peatlands;– but for conservation to be successful economic development is a necessary condition for peat swamp forest.

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# 1315



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17th September 2013


## Comments