Investment in carbon stocks in the eastern buffer zone of Lamandau River Wildlife Reserve, Central Kalimantan province, Indonesia

a REDD+ feasibility study

Project Report

World Agroforestry Centre

Investment in carbon stocks in the eastern buffer zone of Lamandau River Wildlife Reserve, Central Kalimantan province, Indonesia:

a REDD+ feasibility study

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Abstract

The buffer zone of the Lamandau River Wildlife Reserve is part of a landscape with an average human population density of 40 km^{-2} (three times the average for Central Kalimantan province). The buffer zone is used for fishing and small-scale extractive activities and is one of the main production areas of jelutung (Dyera costulata) trees in Indonesia. Jelutung are managed through a locally recognized tree-tenure system. Nearly a fifth of the people in four surrounding villages reported involvement in activities inside the buffer zone, dominantly (82%) as *jelutung* tappers. The majority of *jelutung* tappers, however, are landless people from other sub districts. The average aboveground carbon stock of the current vegetation is 84 t/ha plus 840 t/ha belowground in the peat soil. Current threat levels to this carbon stock are modest but the existing forest classification allows conversion to oil palm or fastwood plantations; companies interested in oil palm conversion have made applications to local government. There is empirical evidence that the existing, NGO-supported system of guard posts protects the current vegetation, but the costs of doing so are high when expressed per unit of avoided CO_2 emission; primary interest in the area is the biodiversity values of the adjacent wildlife reserve. Meaningful investment in both carbon stocks and local livelihoods can focus on the *jelutung* trees; there is little reason for concern about leakage (negative effects on carbon stocks outside the project area) if this type of protection is pursued. New funding sources, at the end of the current externally supported conservation efforts, will be needed and can, in part, be justified on the basis of carbon stock protection, depending on how strictly additionality rules are interpreted.

Narrative summary

Global interest in reducing the net emissions of greenhouse gases from deforestation, land-use and land-cover change in developing countries has lead to the emergence of a REDD+ (reducing emission from deforestation and degradation plus) framework for maintaining and restoring terrestrial carbon stocks in 'forests'. While the international rules and (financial) incentives at a national scale are still being negotiated, a large number of sub-national and site-specific 'REDD+ demonstration projects' have been identified and designed and many more are in the making under the REDD+ umbrella. REDD+ demonstration projects are not only about reducing carbon emission, but should also effectively and efficiently address the land use–livelihood nexus while exploring alternative development pathways, with implications for both carbon emission and local livelihoods. A key risk in designing REDD+ demonstration projects with a narrow focus on climate change is that this may continue to reward poor governance and do little to alleviate poverty.

The Lamandau River Wildlife Reserve (LRWR or 'the reserve') forest conservation and community development project is one of a portfolio of four REDD+ projects being supported by the Clinton Climate Initiative–Forestry program, "Addressing the challenges of scaling-pp REDD+ activities in Indonesia". The program is demonstrating how REDD+ projects can contribute to 1) helping forest-dependent communities move out of poverty, 2) conserving tropical forests and degraded peat lands, and 3) ensuring real reductions in GHG emissions associated with land use, land-cover changes and deforestation. The program is aligned with governments at national and sub-national levels and will contribute to the development of national REDD+ policies, strategies and regulations by addressing the key technical and financial barriers of entry which currently limit the supply of good quality and independently validated REDD+ demonstration projects. The program is building capacities at national and sub-national levels of government, non-governmental organisations, private sector and communities to implement REDD+ projects by improving national REDD screening processes, learning-by-doing using a generic five-stage (due diligence, feasibility, carbon development, validation and marketing) and ten-step carbon development process, establishing links between project-based, sub-national and national forest carbon accounting systems, exploring options for benefit-sharing mechanisms and communicating lessons learned.

The World Agroforestry Centre (ICRAF), in collaboration with Rare Conservation, the Clinton Climate Initiative–Forestry, Yayasan Orangutan Indonesia (Yayorin) and Orangutan Foundation (UK), conducted a feasibility study assessing the potential for enhancing carbon stock in the eastern buffer zone (23 600 ha) of Lamandau River Wildlife Reserve (LRWR), Central Kalimantan province. Beyond the current carbon stock and a projected baseline of 'business as usual', assessment of current rights and livelihood strategies in the area is needed for study of 'additionality' (carbon stock increases above baseline attributable to project interventions), 'leakage' (negative impacts on carbon stocks outside the project area attributable to project interventions) and 'permanence' (or leakage in time). We used the

RESFA (REDD/REALU Site-level Feasibility Appraisal[1] as the framework for studying the key livelihoods, land-use change, carbon stock and tenure issues to develop prospective scenarios and impact predictions.

Overall feasibility was assessed through answers to five questions.

A) Who are the land users, what do they do and what alternative options exist for them?

B) Who has claims of ownership and legality of current land use, who not?

C) How much carbon is currently stored in the landscape, linked to land-use practices?

D) Where do the various land-use practices take place and how much are they changing?

E) What can be done to reduce threats to carbon stocks and enhance carbon storage? How can leakage be prevented, additionality be claimed and permanence made likely?

Summary of findings

A) The socio-economic part of the feasibility study indicated that nearly a fifth of the people in four surrounding villages reported involvement in activities inside the buffer zone, dominantly (82%) as *jelutung* (*Dyera costulata*) tappers. The majority of *jelutung* tappers, however, are landless people from other sub-districts who can be regarded as forest-dependent communities who depend on buffer zone (and the reserve) for their daily livelihoods. While there is an active migration history of local people (changing jobs, opportunistic behaviour), interest in farming has declined significantly. This is also because of the chronic problem of flooding and sea water intrusion in the fields. There are very little logging activities at present. *Jelutung* tapping, fishing and salvaging submerged timber in the river derived from previous logging activities are important economic activities, all with low carbon impact. Old rubber agroforests in the buffer zone indicate a further step in forest domestication. Newly planted rubber is common in the villages surrounding the buffer zone. Illegal logging still takes place, but not at a large scale. However, if protection of forests is relaxed, there is a good possibility of increased logging as this is still seen as an easy way to make quick money. Diversification of crops and active management and planting of *jelutung* trees in and around the reserve may offer viable options.

B) The study on tenure rights found that prior to declaration as a protected area, the buffer zone was used by local people for shifting cultivation, hunting, settlements and collection of firewood, building materials and *jelutung* tapping. Some local communities still claim that the land is theirs; however, legality of this claim is rather weak. There is an interesting tradition of tree-level tenure where, within customary rules, individuals make private claims

[1] http://www.worldagroforestrycentre.org/SEA/Publications/files/leaflet/LE0155-09.PDF

over valuable trees like *jelutung*. The local government considers the buffer zone as Production Development Zone (*Kawasan Pengembangan Produksi*), while the Forestry Department treats it as Convertible Production Forest (*Hutan Produksi Konversi*). In principle, both types can be legally allocated for forest plantation concessions or crop estates such as oil palm. Enhanced community control over the buffer zone may enhance the security of the existing woody vegetation and avoid conversion to an intensive system. Village Forest (*Hutan Desa*) and People's Plantation Forest (*Hutan Tanaman Rakyat*) designations are among the viable options to provide such security. However, a Community Forestry (*Hutan Kemasyarakatan*) arrangement might offer better options for tenure security as many local communities outside the villages also use the forest buffer zone. Their interests need to be taken into account, as well as those of neighbouring villages.

C) Regarding existing carbon stock, the peat soils of the buffer zone contain approximately ten times as much carbon (841 t/ha) as is stored aboveground (average 84 t/ha). Lowland peat swamps have an average depth of 1.3 m, but depths of up to 4.5 m were measured, with a carbon stock of 7 t/ha per cm of peat. Aboveground carbon stock in high density logged-over forests is about 77 t/ha, or only 33% of the 230 t/ha reported for non-logged lowland forests in Kalimantan. The current carbon sequestration rate for the buffer zone is about 1.3 t/ha per year. Grassland has a low carbon stock (< 1 t/ha). Pandanus and *nypa* palm stands contain about 40 t/ha; rubber agroforests mixed with *jelutung* have 75 t/ha, while young rubber agroforests have only about 22 t/ha.

D) Analysis of the patterns of land use and land-use change indicated that, in general, there has been little recent land-use change within the buffer zone in terms of clearance and agriculture intensification, perhaps because of the protection measures in place. There are some agricultural activities within the buffer zone and particularly alongside the river where access is relatively easy and where secondary swamp forests have been converted to shrubs and in some cases to more open areas. However, outside the protected areas, the land-use change is more dynamic with significant increases in managed tree-based systems (tree crops and forest plantations) at the expense of forest. There was no significant change of land-cover types in the period 2000–2006 although some changes were observed along the riverbanks and some inland. The baseline scenario indicates positive carbon gain (1.3 t C/ha/year); enrichment planting with species like *jelutung* may provide both carbon benefits and income benefits to local forest-dependent people. Among the various scenarios explored, conversion to oil palm plantation has the highest carbon emission (also highest profitability and preferred by local people for job opportunities). This is the biggest threat.

E) The current state of the buffer zone of the reserve is the result of a dynamic history of pressures and response by local communities to emerging opportunities and of initiatives that are effective in protecting the wildlife reserve and the buffer zone. The protection of the reserve and the buffer zone since 2005 has been quite effective in terms of forest restoration, biodiversity conservation and consequently carbon storage. Compared to areas close to guard posts, areas at greater distance have lower carbon stocks. Additional controls and guard posts may also have some positive influence. The primary challenge may be to maintain this level of protection, which has been based on voluntary, time-bound project resources. Additional measures or activities are unlikely to significantly enhance carbon stocks and reduce carbon emission. Additional planting of tree species, especially in open and degraded areas may be beneficial. At present the biggest threat seems not from the forest-dependent people or the communities around the protected area, but from possible large-scale oil palm plantations. The idea has been discussed in the past and is still on the table[2]. This would lead to a net aboveground carbon loss of 40–50 t/ha, with belowground (peat) losses dependent on the level of drainage and type of land management regime, but potentially larger and spread out over a longer time period than aboveground losses.

Conclusion

Regarding feasibility of a REDD$^+$ project in the buffer zone, the carbon stock gains may be modest compared to other locations in Kalimantan or Sumatra where larger above- and belowground carbon stock losses may occur with greater likelihood. The co-benefits of biodiversity conservation and livelihood improvement for forest-dependent people will have to be a major consideration to justify project costs. The study concludes that a credible and potentially creditable emission reduction through a REDD+ pilot project will be feasible if the project includes activities to strictly control logging, land clearing and burning inside protected areas, in combination with enhancement of *jelutung* (for controlled tapping) and other valuable trees in and outside the forests and allowing local people to continue fishing and extracting submerged logs. This will increase the likelihood of success of any project for reducing carbon emissions while protecting local livelihoods of the forest-dependent people.

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2 Documents and data support to this statement are available through the local regional development planning agency office (Bappeda Kabupaten Kotawaringin Barat) and our partners (Yayorin and UN Habitat's Partnership for Local Economic Development (KPEL)). We cannot publish the evidence in this report, however.

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Project overview

Introduction

Tropical deforestation continues to be a major source of greenhouse gas emissions, particularly in developing countries. Despite the significant technical, methodological and policy challenges that still need to be met, it is likely that reducing emissions from deforestation and degradation in developing countries (REDD+) will represent an important component of any post-2012 climate change agreement given the decisions taken at COP 13 and COP 14, the continuing work by the Subsidiary Body for Scientific and Technological Advice and the growth in voluntary carbon markets.

At the international level the modalities for funding of REDD+ continue to be discussed with 'carbon markets' based on 'offsets' still a contentious issue and current international funding for this form of emission reduction not directly linked to the national commitments of industrialized countries. Indonesia's commitment to a 26% emission reduction below the expected 2020 baseline (effectively a stabilization of national emissions at the 2006 level) with an expectation of a further 15% national emission reduction based on bi- and multilateral funding indicates that the country is serious in supporting international negotiations that break through the standoff between 'developing' and 'developed' countries, but implementation is still under discussion.

REDD+ demonstration activities often start at a project or sub-national scale while progressively working towards national-level carbon accounting. New standards and initiatives that support the environmental integrity of the voluntary carbon market were introduced in 2007–2008. Indonesia has expressed its strong interest in REDD+, which is seen as an effective mechanism to channel financing in support of national sustainable forest management efforts. Nevertheless, a key risk in designing REDD+ demonstration projects with a narrow focus on climate change is that this may continue to reward poor governance and do little to alleviate poverty.

REDD+ in the Indonesian context

Indonesia, under the leadership of the Ministry of Forestry, is in the process of developing a clearer national framework to develop the market for REDD+ in the country. Deforestation and land-use changes accounted for about 74% of the country's carbon emissions in 1994. Indonesia is committed to piloting REDD, to build a national framework for long-term implementation and to address outstanding REDD+ methodological issues. There are significant pressures on Indonesia's land use, notably land-cover changes associated with the timber industry, oil palm and pulp and paper industries and large-scale, bio-fuel plantations. Policies and programs which aim to promote REDD+ will need to convince the Government of Indonesia that forest carbon credits are at least as profitable as any of these alternative land uses or can be developed in a way that is complementary to continuing development plans.

Indonesia has five forest policy priorities for a total forest estate of 132 million ha or 70% of the total land area: curbing illegal logging; conservation and rehabilitation of forest land; restructuring of the forest sector; community engagement and empowerment; and clarifying land tenure. The net rate of deforestation remains at approximately 1 million hectares per year. Degradation of the country's forests and a decline of biodiversity have occurred on a large scale due to unsustainable forest management, forest fires, illegal logging and forest conversion (Figure 1).

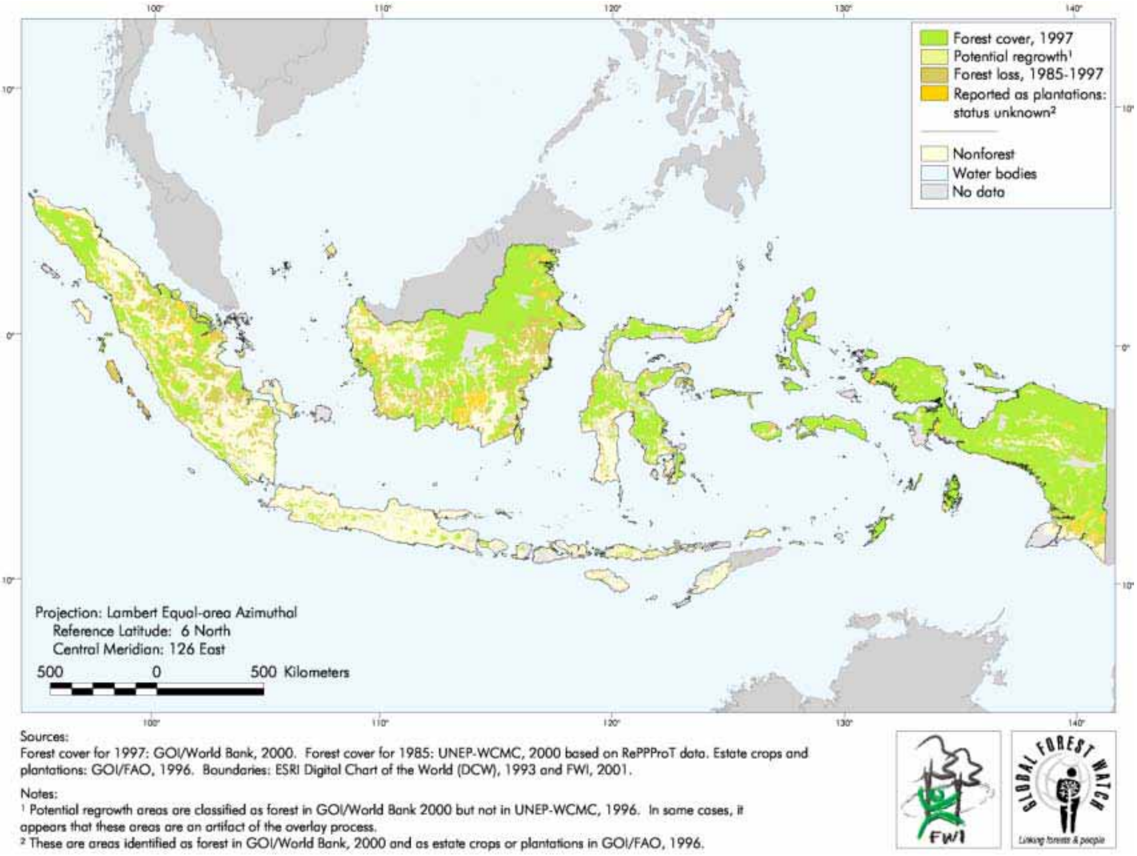

Figure 1. Natural forest-cover change in Indonesia 1985–1997

Indonesia's forest lands (*kawasan hutan*) are divided into four categories: Production Forest (*Hutan Produksi*, HP) and Limited Production Forest (*Hutan Produksi Terbatas*, HPT) utilized for logging and industrial forest plantations (82.8 million ha); Conservation Forest (*Kawasan Konservasi*, which includes national parks and nature reserves) allocated for biodiversity and wildlife conservation (19.7 million ha); Protection Forest (*Hutan Lindung*, HL) set aside for protecting environmental services such as watersheds, carbon stocks, steep terrain, rivers and littoral habitats (29.9 million ha); and Conversion Forest, used for other purposes including estate crops, agriculture and settlements (22.4 million ha). Outside state forests another 8.3 million ha of land is forested (non-designated forest land, *Area Peruntukan Lain*, APL) and can be converted for agricultural use under the jurisdiction of district and provincial governments.

The central government has played a dominant political and administrative role throughout most of the country's history. Significant reforms occurred following Indonesia's 1997–1998 economic and political crises and the promulgation of two decentralisation laws in April 1999. These did not come into effect until January 2001 and included provisions to transfer natural resource management authority to regions, albeit with a number of ambiguities and contradictions (Colfer and Resosudarmo 2002). It remains to be demonstrated that decentralisation works both for the communities and the forests of Indonesia. The adoption of Government Regulation No. 6/2007 (building on earlier regulations No. 34/2002 and No. 1/2004) provided the enabling environment to promote larger-scale implementation of community forestry in Indonesia. Community-based forestry can now be practised through four legal structures.

1. Village Forest (*Hutan Desa*, HD)
2. *Kemitraan* (Partnerships between communities and concessionaires)
3. Peoples Plantation Forest (*Hutan Tanaman Rakyat*, HTR)
4. Community Forest (*Hutan Kemasyarakatan*, HKM)

In such cases, forest management units must be established within local governments for managing defined forest areas located in one or more administrative areas (districts). A 35-year timber utilization license (IUPHHK) is issued by the Bupati (district head) based on a forest management plan developed and/or approved by the forestry administration. Any customary or indigenous management practices can be accommodated in any activities conducted in the working area through a participatory planning process. The licensing of an estimated 400 000 ha of community forestry areas will be completed in 2009. The Ministry of Forestry is committed to allocate 2.1 million ha of forest areas to be managed through community-based schemes by 2010.

In mid-2007, the Indonesia Forest Climate Alliance (IFCA) was established as a government–development agency partnership to analyse the existing legal and policy frameworks governing the forest sector and opportunities for climate-change-related interventions. Eight studies were collated in a key document, "REDD+ methodology and strategies summary for policy makers", presented at the COP 13. The Minister of Forestry issued decisions establishing a Working Group on Climate Change (WGCC) (SK.455/Menhut-II/2008; SK.13/Menhut-II/2009), a regulation on the implementation of REDD+ demonstration activities (P. 68/Menhut-II/2008) and the appointment of resource persons to the WGCC in December 2008 and January 2009 (SK.21/Menhut-II/2009) (Annex 1).[3]

Additional government regulations are still needed to provide a comprehensive set of guidelines which will establish the framework for a national REDD+ process and set out a plan. These will include defining REDD+ approval and implementation procedures to undertake demonstration projects; guidelines to define the various forestry classifications, updated mapping and demarcation of these classifications and alignment to forest management units; where projects can be implemented; and how benefits will be shared.

The Ministry of Forestry, with support from AusAID, has started to develop a National Carbon Accounting System (NCASI), which will provide a comprehensive and credible account of Indonesia's land-based emissions profile and sinks capacity. It will eventually allow Indonesia to develop a robust modelling and projections capacity for land-based carbon accounting and therefore robust emissions and removals estimates (Forest Planning Agency 2008). Specifically regarding revenues generated from REDD, regulations will be prepared separately in consultation with the Ministry of Finance. A concept paper to establish an Indonesia Climate Change Trust Fund has already been drafted by the national planning and development agency, BAPPENAS (Badan Perencanaan dan Pembangunan Nasional).

Feasibility study for REDD+ project in the buffer zone of Lamandau River Wildlife Reserve, Central Kalimantan

The LRWR forest conservation and community development project is one of a portfolio of four REDD+ projects being supported by the Clinton Climate Initiative–Forestry program, "Addressing the challenges of scaling-pp REDD+ activities in Indonesia". The program is demonstrating how REDD+ projects can contribute to 1) helping forest-dependent communities move out of poverty, 2) conserving tropical forests and degraded peat lands, and 3) ensuring real reductions in GHG emissions associated with land use, land-cover changes and deforestation. The program is aligned with governments at national and sub-national levels and will contribute to the development of national REDD+ policies, strategies and regulations by addressing the key technical and financial barriers of entry which currently limit the supply of good quality and independently validated REDD+ demonstration projects. The program is building capacities at national and sub-national levels of government, non-governmental organisations, private sector and communities to implement REDD+ projects by improving national REDD screening processes, learning-by-doing using a generic five-stage (due diligence, feasibility, carbon development, validation and marketing) and ten-step carbon development process, establishing links between project-based, sub-national and national forest carbon accounting systems, exploring options for benefit-sharing mechanisms and communicating lessons learned.

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[3] See also *Developing a market for REDD+ in Indonesia: report on implementation of a Learning Workshop*, January 2009. Jakarta: World Bank

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The initial plan was to propose a REDD+ demonstration project site comprising a total of 77 600 ha: the 54 000 ha LRWR and an additional 23 600 ha of buffer zone between the Lamandau River and the eastern border of LRWR (Figure 2). However, owing to doubts raised by several advisors on the eligibility of LRWR (legal and additionality issues), it was later decided to limit the feasibility study to the buffer zone.

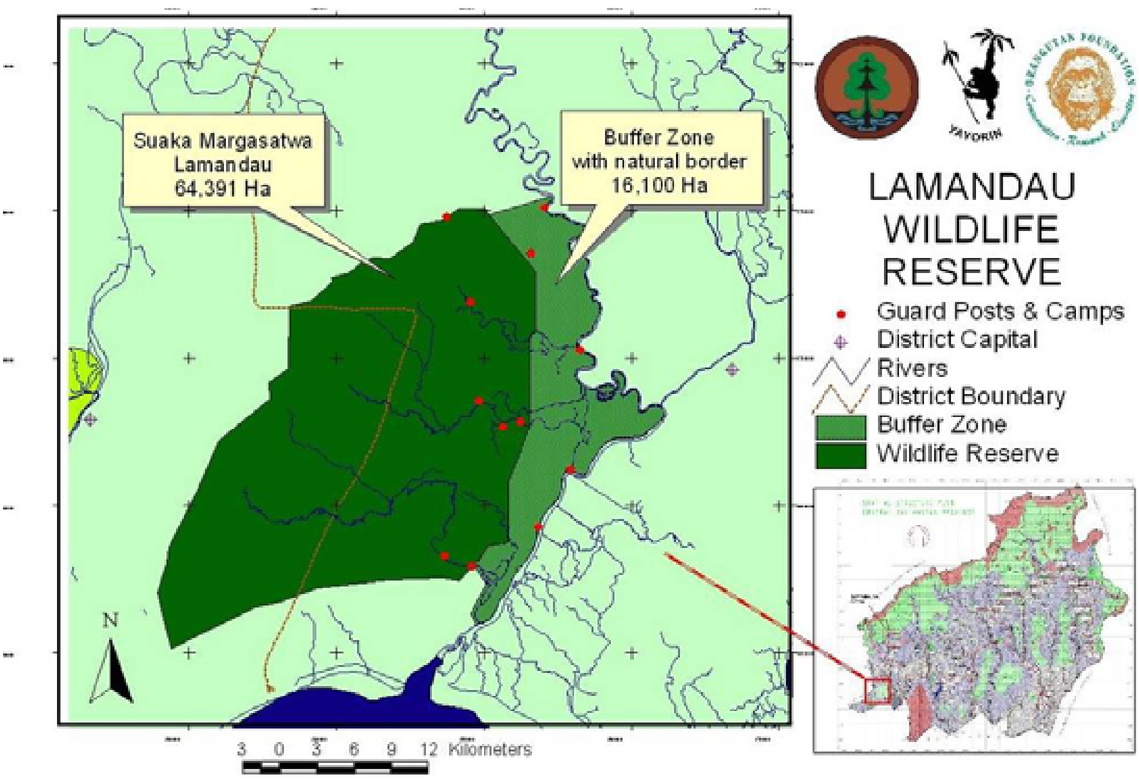

Figure 2. Lamandau River Wildlife Reserve and the buffer zone

[4] http://www.worldagroforestrycentre.org/SEA/Publications/files/leaflet/LE0155-09.PDF

Research framework

The study was conducted using the framework REDD/REALU Site-level Feasibility Appraisal (RESFA) developed by the World Agroforestry Centre (ICRAF). The framework covers the relevant livelihoods, land-use change, carbon stocks, land tenure issues, scenario development and testing for carbon emission and livelihood development and attempts to answer the basic question of whether a REDD+ project can/will reduce net emission while addressing the needs of local communities. The framework has five key components: A: Livelihoods; B: Land tenure and policy history; C: Carbon stock; D: Land-use change analysis; and E: Scenario testing (Figure 3).

Figure 3. Feasibility study framework[5]

The feasibility study was conducted in various (often overlapping) steps:

1. Compiling background information about the site, current land use and land-use change, available maps and datasets, socioeconomic context, local ecological knowledge, major habitat types;
2. Clarifying project boundaries and leakage belts based on the Pedroni methodology;
3. Quantifying carbon storage and current and projected deforestation rates at the site.

[5] http://www.worldagroforestrycentre.org/SEA/Publications/files/leaflet/LE0155-09.PDF

4. Developing a baseline scenario for the site;
5. Describing project scenarios and estimating the emission reduction benefits from these scenarios over the coming 30 years;
6. Analyzing risks related to permanence, leakage and additionality and providing initial recommendations for how these can be addressed at the site;
7. Summarising conclusions and recommendations on the overall feasibility of the proposed project.

Component A: Socio-economy of communities

Elok Mulyoutami, Muhammad Sofiyuddin, Suseno Budidarsono, Janudianto

Introduction

As part of the overall REDD+ feasibility study for the eastern buffer zone of LRWR, a socio-economic assessment of communities living in the area was planned and implemented. The purpose of the study was to understand better the current condition of the local communities in the vicinity of LRWR as well as the people actually using the area. The study included demography, employment and household incomes that are linked to activities in and around LRWR.

Methodology

The study site

The socio-economic study was carried out in the buffer zone of LRWR and the settlements surrounding the buffer zone. The site is administratively situated in Arut Selatan sub-district (*kecamatan*) Kotawaringin Barat district (*kabupaten*), Central Kalimantan province. Kotawaringin Barat district is between 1°19′–3°36′ south latitude and 110°25′–112°50′ east longitude.

Data collection

Most of the data collection was done through village studies and household surveys. General information about local livelihood, land-use practices, current on- and off-farm activities, local institutional arrangements, livelihood dynamics and socio-cultural information was gathered through village studies using semi-structured interviews. Observations, in-depth interviews with key informants and a series of group discussions were employed. The village study was conducted in four villages surrounding the buffer zone. Observations were also made in the vicinity of the buffer zone and in-depth interviews undertaken with local people with activities in the area.

Data on household, labour, employment, economy, capital and income were gathered through household surveys using a structured questionnaire. A total of 60 sample informants were interviewed. These included fishermen and *jelutung* tappers.

Table **1** lists the villages, settlements and number of households interviewed. The inhabitants of the temporary settlements within the buffer zone come from neighbouring villages and make their livelihood in the study site.

Table 1. Surveyed villages and interviewed households

Settlements		Main livelihood Activities	Related Activities to LRWR and the buffer area	No Respondent	Ethnic group
Village	**Sub Village**				
Pendulangan (Tanjung Putri)	RT 2,3,4	Trade Fishing	Fishing	10	Malay Javanese Dayak
	Serumpun	Farming (padi, vegetables), Fishing	Fishing		Banjarese Javanese
Mendawai	RT 2,3	Dry-land farming Fishing	*Jelutung* tapping Fishing	10	Dayak Malay Javanese
Mendawai Seberang	RT 3,4,5	Off-farm labour Fishing Floating net fish culture	Fishing (some poison as well as electricity used)	15	Dayak Malay Javanese,
Tanjung Terantang	RT 7,8	Farming Oil palm workers (outside the village) Fishing	Fishing *Jelutung* tapping	10	Malay Javanese very few Dayaks
Temporary Settlements within the buffer zone	Not applicable	*Jelutung* tappers and fishing (direct fishing and fish culture)	Fishing *Jelutung* tapping	15	Banjarese Malay Dayak

Note: RT (Rukun Tetangga) is a neighbour hood; the smallest unit of settlement within and under a village administration

Results

Area, demography and community characterization

In the past, there were more than ten timber-processing factories (sawmills and plywood factories) along the Lamandau River and close to the LRWR. The factories provided income for Kotawaringin Barat district and attracted many migrants from outside. **Table** 2 presents details of population dynamics in the study site.

Population growth in the study site was mostly due to net in-migration. The annual population growth of Kotawaringin Barat and Arut Selatan sub-district (based on 2002–2007 data) was higher (5.61% and 2.93% respectively) than population growth at the provincial level (1.26% per year).

Tanjung Terantang, a newly established transmigration village since 1987–1989, had negative net migration as well as negative natural population growth. This transmigration village was a rice-producing village in the past. Since 2000, frequent flooding from the Lamandau River made rice cultivation risky and difficult. Many people sought other sources of employment and income, such as working in oil palm plantations in other areas, for example, in Babual Baboti. Some people relocated seasonally, some found permanent jobs and moved out from the village. By contrast, Mendawai Seberang had a high net migration (50 persons per million), mainly owing to on-going urbanization and regulations to limit access inside LRWR and its buffer zone for non-timber forest products (NTFP) extraction. Harvesting of forest products now requires a permit issued by the natural resources conservation agency, BKSDA (Balai Konservasi Sumber Daya Alam), of Central Kalimantan upon recommendation from the village head.

Table 2. Area and population of the study site

No	Village Sample	Area (km^2)	Population 2007	Pop. Density (person/ km^2)	Population Growth: Annual Growth Rate (2002-07) (%)	Population Growth: Natural Growth Rate 2007 (per mil.)	Population Growth: Net Migration 2007 (per mil.)
1.	Tanjung Putri	19	1652	86.95	1.26	11.5	6.1
2.	Mendawai	469	15 957	34.02	2.02	3.6	8
3.	Mendawai Seberang	26	2380	91.54	5.07	5.9	50
4.	Tanjung Terantang	12	900	73.47	nd	-3.3	-20.0
Arut Selatan subdistrict		2400	89 607	37.34	2.93	9.7	30.2
Kotawaringin Barat district		10 759	223 431	20.77	5.61	7.7	74.8
Central Kalimantan province		153 565	2 028 300	13.21	1.28	nd	nd

Sources: BPS Kabupaten Kotawaringin Barat 2007a, 2007b, 2007c, 2007d, 2008a, 2008b, 2008c; Bappeda Kabupaten Kotawaringin Barat 2007, 2008

The villages/settlements in the study area can be categorized into three groups based on economic activities (Figure 4; details in **Table 3**).

Table 3. Economic activities of three communities in the vicinity of the buffer zone

Village	Pendulangan–Tanjung Putri	Serumpun (Tanjung Putri) Kelurahan Mendawai (RT23) Tanjung Terantang village	Mendawai Seberang
Main activities	Fishery sector: males (sea and river/lake); females (salted fish production) Farm (padi) Trade (*warung* or small shop)	Farming (subsistence food-crop agriculture) Newly planted rubber Oil palm workers (50%) Non-farm workerS	Fishing (floating fish net and direct line) Off-farm activities (boat operator, civil servant etc) Farming

		Jelutung tapping Rubber tapping Fishing	
Activities within buffer zone and LRWR areas	Drinking Water tapping Logging Fishing	*Jelutung* tapper Firewood Fishing	Fishing *Jelutung* and rubber tapping Floating net fish culture

Sources: observation and in-depth interview

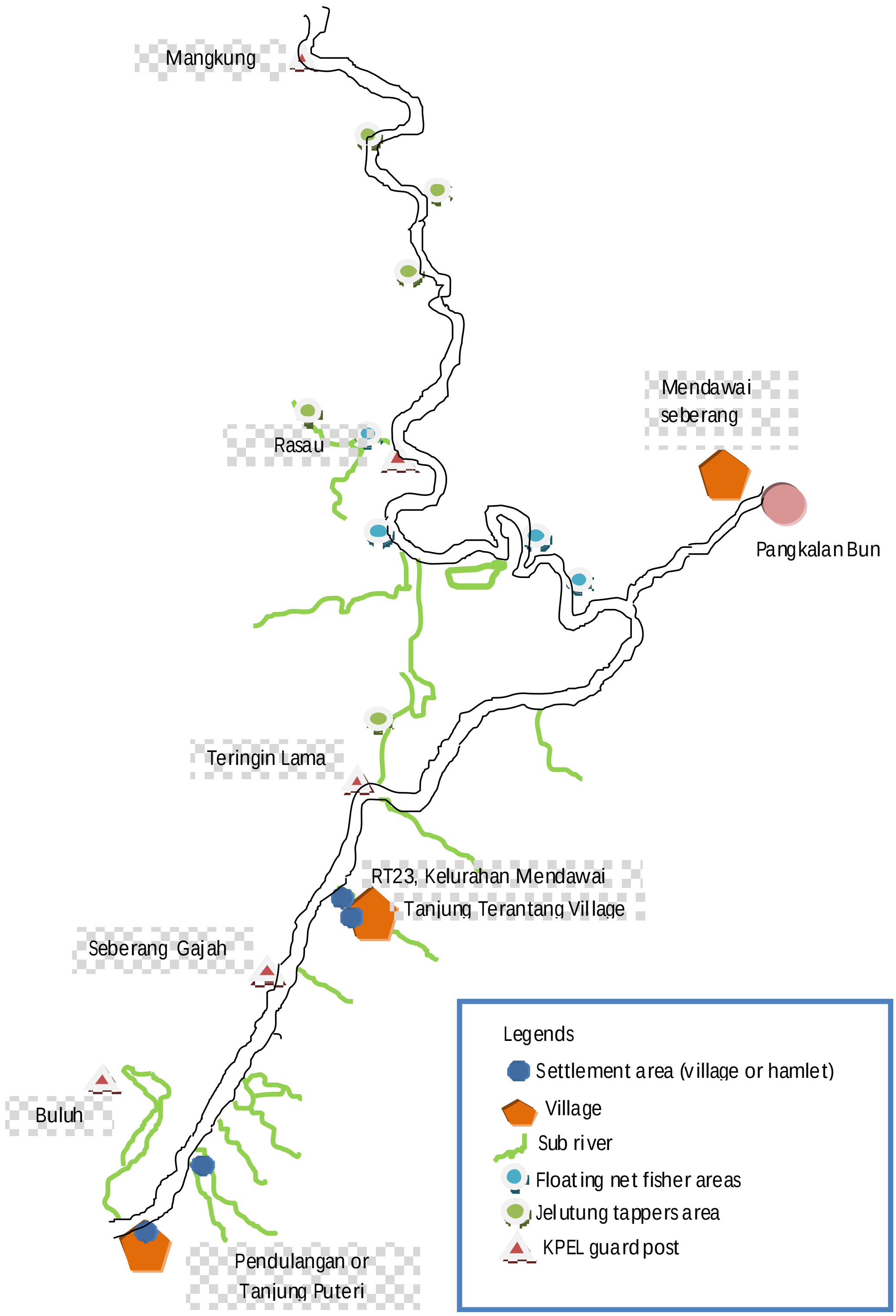

Figure 4. Sketch map of communities along the Lamandau River and in the buffer zone

Fishing communities: Pendulangan villagers rely on fishing as the main source of their income. These people originally came from Tanjung Putri, which is located on the coast. In search of a better life, they established a new settlement that was later given the status of a separate village administration. Initially, the migrants in Pendulangan were involved in traditional gold mining (locally called *mendulang*: the word *pendulangan* means 'place for mining') with occasional fishing. After the mining activities stopped they worked in timber logging. After the end of logging activities, fishing became the dominant occupation for most people.

Farming communities: Farming is the dominant activity for the second group of settlements: Serumpun (administratively part of Pendulangan village), Rukun Tetangga and Tanjung Terantang, a transmigration village. The three settlements have similar problems: low soil fertility (acidity) and frequent floods. Sea water intrusion often occurs in the estuary area (Serumpun hamlet) and damages crops almost every year. However, the Serumpun community continues their farming by improving tillage and sea water intrusion control techniques (dykes) with technical support from the agricultural and public works agencies of Kotawaringin Barat district. Some people from Tanjung Terantang have moved from the village for alternative jobs. Some have established rubber plantations.

Mixed-income communities: People living in and near Mendawai Seberang have diverse sources of income. Some are still engaged in floating net fishing while some still maintain agricultural activities. Understandably, off-farm activities such as the service sector (boat operators, civil services) are important and dominant in these communities. Communities around the buffer zone comprise diverse ethnic groups. The majority are Malay/Mendawai (81.76%) with remaining groups of Banjarese, Javanese, Dayak and Bugis. Many people came from outside more than a decade ago. There is a history of people moving around, normally in pursuit of better incomes. As in Pendulangan, people in Serumpun (centre of the logging industry in the past) originally came from Banjar. Likewise, Tanjung Terantang is a migrant village. Initially, the population was 1105 people in 250 families, but recently the population has decreased to 964 but the household number has risen to 266. Twenty households moved out from the village about three years ago. Frequent floods and crop failure, better job opportunities and income are the main reasons for current movements of people. In villages with stable income sources, such as Pendulangan–Tanjung Putri, where fishing and *selam kayu*[6] (extracting submerged logs) are profitable, there is less out-migration. Table 4 presents migration patterns of the settlements.

[6] The activity of *selam kayu* is usually dominated by younger people in groups. It is only done based on requests of buyers, usually about once a week. The revenue per diver per month is about Rp 300 000–500 000, depending on the species.

Table 4. Migration patterns of the settlements

Migration	Settlements		
	Pendulangan–Tanjung Putri	Serumpun, Mendawai (RT23), Tanjung Terantang	Mendawai Seberang
Out-migration	Low	High Tanjung Terantang village, due to flooding, has permanent out-migration Temporary migrants: oil palm workers (50% of population)	Medium Temporary migrants: oil palm workers Permanent migrants
In-migration	Medium (fishing)	Low to high *Jelutung* tappers from Kubu village (temporary migrants)	Medium Semi-permanent migration: floating net fish culture and fishing

Sources: observation and in-depth interview

There is semi-permanent spontaneous migration out of Kotawaringin Barat district for fish cultivation using floating nets in the Arut River. The people come from Banjar, South Kalimantan province. They rent houses in Mendawai or Mendawai Seberang and go to the river every two days to maintain their floating nets. There is also semi-permanent spontaneous migration from the area within Kotawaringin Barat district, from Kubu subdistrict. The people live in Mendawai area, in RT 23, as *jelutung* tappers.

Household characteristics

Looking at the age structure, 67.5% of the people are considered to be Economically Active Population (EAP) (15–64 years). The dependency ratio of the household sample in Tanjung Terantung is the highest, meaning the labour force in the village is relatively lower than that in other villages. Many adults also work outside their village.

Regarding education, 61.7% of the people have only elementary school education; very few have been to secondary school. Table 5 summarizes the demographic profile of the sample households. Average family size was 4-to-5 persons per family; nearly two-thirds of the households had less than five members. There are some households with more than eight family members, most of them in an extended family system.

Table 5. Demographic profile of sample households

	Tanjung Putri	Tanjung Terantang	Mendawai	Mendawai Seberang	Temporary settlements within buffer zone	Total
Population						
Number of household samples	10	10	10	15	15	60
Number of family members	50	45	39	65	66	265
Family size						
Range (person/family)	2–12	2–6	2–8	2–7	2–9	2–12
Average family size	5	5	4	4	4	4
Percentage distribution of household sample by family size (%)						
1 – 4	70	40	80	66.7	46.7	60.7
5 – 8	20	60	20	33.3	46.7	36.0
9 <	10				6.7	3.3
Percentage distribution of household members by age group (%)						
< 15	32	40	23.1	27.7	37.9	31.2
15–64	64	57.8	76.9	72.3	62.1	67.5
64 <	4	2.2				1.3
EAP*(%)	64	57.8	76.9	72.3	62.1	67.5
Dependency ratio (%)	56	73	30	38.3	61	48.2
Respondents' educational attainment (%)						
Never attending school	20		20	6.67	13.3	11.67
Elementary school	60	70	80	46.7	60	61.67
Junior secondary school	10	20		26.7		11.67
Senior secondary school	10	10		6.67	26.7	13.3
College				6.67		1.67

* EAP stands for Economically Active Population; hence 15–64 years old
Source: household survey

Data on housing condition, summarized in Table 6, show that most of the houses were made of wood. The average floor size was 53.2 m^2, ranging between 12 and 230 m^2. Large houses (floor size more than 180 m^2) were normally owned by households with activities in the buffer zone of LRWR. These houses often had around ten households living together, as in Mendawai and Mendawai Seberang, and all of them engaged in fish culture using floating nets, a reasonably capital intensive system. Five sample households in the buffer zone came from further villages and they were all *jelutung* tappers. About 57% of the households have access to electricity from the public power company, 23.9% use electricity generators and the rest use kerosene lanterns for lighting.

Table 6. Housing conditions of the household sample

	Tanjung Putri	Tanjung Terantang	Mendawai	Mendawai Seberang	Temporary settler within buffer zone*	Total
Number of houses (n)	10	10	10	15	15	60
Floor size m^2 (range)	30–100	12–100	24–60	25–180	20–230	12–230
Floor size m^2 (average)	53.8	45.8	41.6	58.8	63.4	53.10
Building material (%)						
Cement	20		10	6.67	13.3	10
Wooden	80	100	90	93.3	86.7	90
Floor type (%)						
Cement/ tile	10	10	20		20	11.7
Wooden	90	90	80	100	80	88.3
Lighting (%)						
Public supply		13.4	1.5	22.4	19.4	56.7
Generator	14.9	1.5	7.5			23.9
Kerosene pressure lantern			1.5		1.5	3
Simple kerosene lantern		1.5	7.5	1.5	6	16.4
House with lavatory (%)	40	100	50	53.3	46.7	56.7

** Housing referred to here is not the hut of the sample households in the buffer zone of LRWR, but the permanent houses people have in their own village*

Source: household survey

Household economy

The main sources of household income of people in the study area include farming, fishery and non-timber forest products extraction. Table 7 shows estimates of annual income of the household samples. It is worth noting that people in their temporary settlements, along the Arut and Lamandau rivers, had higher incomes than in other settlements. On average, their income is about Rp 34.5 million per household per year whereas in other places it is between Rp 7.2 million and Rp 24 million.

The income data indicate a higher income among people engaged in fish culture using floating net (Rp 2.9 million per month for those along Arut and Lamandau rivers). From NTFP extraction, especially for *jelutung* tappers, households earn on average Rp 2.53 million per month; this is consistent with the income of temporary settlers along the Lamandau and Arut rivers. In general, except in the household sample in Tanjung Terantang, income per capita of sample households is higher than the poverty line of Indonesia and West Java province.

Table 7. Income of sample households (Rp 000)

	Tanjung Putri	Tanjung Terantang	Mendawai	Mendawai Seberang	Temporary settler within buffer zone	Total
	(n=10)	(n=10)	(n=10)	(n=15)	(n=15)	(n=60)
Household income						
RANGE						
Minimum	4100	1935	1680	2190	6000	1680
Maximum	53 650	35 400	61 950	84 600	95 000	95 000
Median*	16 450	7200	15 000	24 000	31 700	20 290
Average*	22 429	11 794	22 408	28 552	34 533	25 209
Sd	18 465	11 340	20 141	22 705	23 568	21 112
Income per capita						
RANGE						
Minimum	701	760	560	448	1200	448
Maximum	21 675	5900	11 667	42 300	34 850	42 300
Median*	4113	1410	4766	5250	7667	5028
Average*	5955	2326	5442	8235	9585	6742
Sd	6484	1875	3848	10 600	8370	7669

** The study uses two Central Tendency estimates. For number of samples below 30, median is a better estimate than the average. In reverse, for samples more than 30, average is a better estimate than the median.*

Table 8. Monthly household income by occupation

Occupation	Household sample		Range of Income Rp 000	Median (Rp 000/month)	Standard Deviation
	n	%			
Fishing	19	31.7	183–5600	2000	1986
Fish culture (floating net)	5	8.3	833–3854	2904	2840
Agriculture	16	26.7	190–4471	1015	1592
NTFP extraction (*jelutung*)	10	16.7	140–7917	2529	1062
Non-farm	10	16.7	355–3600	1255	1216

Source: household survey

Table 9. Per capita income (gross)

	Tanjung Putri	Tanjung Terantang	Mendawai	Mendawai Seberang	Temporary settler within buffer zone	All Household Sample Total
Number of households members	50	45	39	65	66	265
Income per capita (Rp 000/year)	4113	1410	4766	5250	7667	6742
Proportion of people below poverty line						
Number of households (%)	40	60	20	13.3	13.3	26.7
Head count (%)	50	51.1	15.4	15.4	15.2	27.9

Source: household survey

Caution in interpretation of the data is required owing to the skewed distribution of household incomes (see Figure 5). There were 27.9% of households below the official poverty line. In Tanjung Putri and Tanjung Terantang about half of the population was below the poverty line. There was also evidence of uneven distribution of income: 80% of the population receives 51% of the total income, meaning remaining 20% of the population receives 49% of the total income.

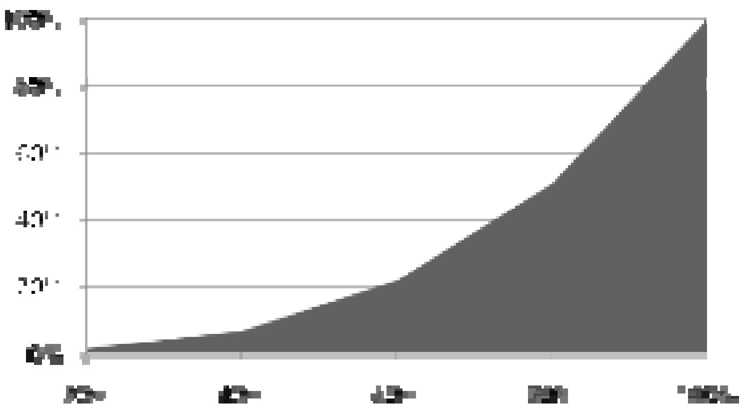

Figure 5. Cumulative distribution of annual household income

Local institutional arrangements

The major ethnic group in the study area is Malay and most of them are not original inhabitants. There is no strong local customary institution. Islam is the dominant religion and informal religious groupings are important.

Table 10. Local institutions

	Institution	**Role**
Formal institution	Village head with some help from 'leading person'	Consultation on some resource management problem etc
Informal institution	Women's groups: through PKK *tagonian* (Islamic musical group involving mainly middle-aged women), prayer (*pengajian – yasinan*) Men's groups: prayer	Social relations in the community as well as relations with other villages *Arisan* (saving system)
	Farmers' groups	Usually formed for a purpose: under program *bantuan* or aid
On-farm activity	*Gotong royong* or working in groups (reciprocity)	On several farming activities, padi system

Source: observation and in-depth interview

Farmers' groups exists in each village, but mostly are formed under development program. *Gotong royong* (in particular, for farming activities), a socio-cultural ethos of mutual aid and reciprocal work, is applied to many activies in Indonesia, however, within the villages surrounding LRWR it is only used with the padi system.

Lamandau River Wildlife Reserve and community livelihoods

The reserve was established on 26 February 1998 through Ministry of Forestry Decree No. 162/Kpts-II/1998 with the primary objective of conserving and protecting biodiversity. Later, in order to improve the management and to promote conservation of the wildlife reserve, BKSDA of Central Kalimantan, Orangutan Foundation (UK) and Yayorin established the Lamandau Ecosystem Conservation Partnership (Kemitraan Pelestarian Ekosistem Lamandau/KPEL), to maintain the function of the Lamandau ecosystem as a tropical forest and to support sustainable forest-dependent community development. Five guard posts are now located at the river intersections of the sub-river near the buffer zone. This is to guard the area and prevent illegal logging, over-fishing, hunting and forest clearing. The camps are located on the border area of the wildlife reserve for research and monitoring purposes, as well as orangutan (*Pongo pygmaeus*) monitoring. The animals had been released inside the reserve. Posts have been set up within the buffer zone also. It appears human activities of extraction of timber and other NTFPs have reduced since the establishment of the reserve and guard posts. Local people are aware that logging, fishing using poison and electricity, and wildlife hunting are not allowed inside the reserve and the buffer zone. However, access to the reserve area is allowed with an entry permit from BKSDA to extract NTFPs such as *jelutung* tapping and traditional fishing.

The survey showed that activities in the the reserve and its buffer zone are still, to some people, important livelihood activities (Table 11). *Jelutung* tapping is the most important reason why local people enter the reserve and its buffer zone. Many people from Pendulangan use the buffer zone, both for fishing and *jelutung* tapping.

Source: household survey Livelihood activities in the buffer zone

Village/ Settlement	Population	Agriculture		Fishery		NTFP Extraction		Total	
		No. people involved	Entering buffer zone (%)	No. people involved	Entering buffer zone (%)	No. people involved	Entering buffer zone (%)	No. people involved	Entering buffer zone (%)
Pendulangan	1652	20		433	92.4	6	98	459	88.4
Tanjung Terantang	900	197		27	92.6			224	11.2
Mendawai	15 957	738	0.1	996	not available	18	88	1752	1
Mendawai Seberang	2380	115	0.9	35	85.7	2	100	152	21.7
Total	20 889	1070	0.2	1491	30.5	26	91.2	2587	18.6

Source: BKSDA (KPEL)

There are various livelihood activities within the buffer zone.

1. *Jelutung* is tapped mostly inside the buffer zone, but often people go deep inside the reserve.
2. Some people fish in the buffer zone once every month, particularly during the dry season.
3. Villagers in Mendawai and Mendawai Seberang still claim the land inside the buffer zone; the land is used for rubber cultivation and animal grazing.

In the process of banning logging in the forest area, in early 2005, the local government (subdistrict level) also allocated plots of 30 x 200 m^2 (0.6 ha) of arable farm land to each household within the villages. However, it is reported that only about 15% of the households cultivate their land, such as the 20 farmers in Serumpun (Pendulangan). Some people have migrated to other places. Those who do not cultivate their allocated land prefer to remain engaged in other activities that provide them with faster cash income, such as working in oil palm plantations in other areas such as Babual Baboti.

Many *jelutung* tappers in the reserve and its buffer zone are landless people who come from Kubu village, Kumay subdistrict. They normally tap in Kadang inside the buffer zone where they temporarily reside. Other tappers come from RT 23 Mendawai Seberang, do not have their own farming land or fishing skills and they normally live in rented houses.

The livelihood options in the study area are provided in Table 11 and their importance for trade and subsistence are listed in Table 12. Table 13 provides products, main ethnic groups and other details for these activities.

Table 11. Livelihood activities inside and outside the buffer zone

Area of work	Fishing	*Jelutung* collection	Rubber farming	Fish culture using floating net	Logging	Agriculture	Hunting (deer)
Buffer zone	**	***	*	**	*	*	*
Non-buffer zone	***	**	***	***	***	***	**

Note: * = less frequent; ** = frequent; *** = very frequent

Table 12. Main livelihood sources, their importance and purpose

Livelihood source	Tanjung Putri	Serumpun hamlet (part of Tanjung Putri village)	Tanjung Terantang	RT 23, Kelurahan Mendawai	Kelurahan Mendawai Seberang
Fishing	α***	β *	β **	β *	α ***
Jelutung collection				α ***	
Rubber farming	α *	α *	α **	α **	α *
Fish culture using floating net	α ***	β *	β *	β **	α ***
Logging	β *	β *	β *	β *	β **
Agriculture	γ **	β ***	β ***	β ***	γ *

Note: *** dominant activities; ** moderately important, * only few people rely on these
α = market oriented; β = both for market and subsistence; γ = subsistence use only

Table 13. Some details about livelihood activities and main products

Livelihood source	Main products	Ethnic group	Detail
Fishing	*Haruan* (Channa striata), *toman* (Channamicropeltes), *baung* (Hemibagrus), *Lais* (Kryptopterus sp), *belida* (Notopterus chitala) and *jelawat* (Leptobarbus hoevenii).	Mendawai (Malay)	Fisher (net) Some use of poison and electricity
Jelutung collection	Latex	Malay	
Rubber farming	Rubber latex	Malay	
Fish culture using floating net	*Nila* (*Oreochromis* sp.), *ikan mas* (Cyprinus carpio Linn), *patin* (Pangasius hypopthalmus fowler)	Banjar Malay	
Logging	*Belangeran* (*Shorea belangeran*) wood (25–55 cm)	No data	
Agriculture	Padi, chilli, eggplant, watermelon, cassava	Banjar Malay	Traditional agriculture Improved land management (Banjar in Serumpun hamlet)

Jelutung tappers and their livelihoods[7]

Jelutung is commonly found on the lowland peat forests. In Kotawaringin Barat district, it is usually found in DAS Sekonyer–Kumai, Sungai Buluh–Mendawai Seberang, Arut Selatan, Arut Utara, Lamandau River and Kotawaringin Lama. At present, Lamandau River is a large *jelutung* production area.

Jelutung latex is the raw material of gum, electric cable, carpet and plastics for household items and also popular for automotive equipment, while *jelutung* timber is used for blackboards, art carving, frames, pencil, furniture parts and packing cases. The conservation status of *jelutung* was defined in IUCN Conservation category (ver 2.3, 1994) as LRlc and in the Singapore Red Data Book was categorized as rare [R] (taken from UNEP WCMC 2007).

From the early 1980s to mid-1990s, *jelutung* latex production was popular in Central Kalimantan, particularly in Kotawaringin Lama. During the 1990s, when timber logging was intense, *jelutung* latex production declined. This is due to some tappers moving to logging for faster cash income. Timber of *jelutung* was also harvested owing to its higher value: twice the value of *meranti*, *ramin*, *agatis*, *rasau* or *keruing*. *Jelutung* tapping resumed after logging activities slowed.

[7] Some information was adapted from Dinas Kehutanan Kabupaten Kotawaringin Barat (2008) and Monika (2002).

Jelutung latex is exported to Singapore, Japan and Hong Kong. The export figures for *jelutung* latex for 1993 to 1998 are 1192 t, 585 t, 301 t, 2142 t and 2785 t respectively (FAO 2002 taken from Biro Perencanaan 1999). Table 14 shows exports from 1988 to 1993. Monika (2002) reported that between 1998 and 2000 there was no record of export. At this time, timber logging was intense and *jelutung* prices were falling. In early 2001, *jelutung* latex production rose again as demand from Japan increased[8].

From her research, Monika (2002) concluded that *jelutung* with intensive management (monoculture) around Palangkaraya has potentially good returns for farmers with an internal rate of return (IRR) of 69% and a benefit-cost ratio of 1.45. In-depth study of *jelutung* productivity within traditional agroforestry systems would be necessary to assess profitability of a range of *jelutung* management options in the buffer zone.

Jelutung is still collected from the wild and its supply depends on the condition of the forests and remaining *jelutung* trees. Trees are spread sporadically with no clear ownership status. The tapper who finds a *jelutung* tree makes a claim to the tree and other *jelutung* trees around it. Local people generally do not tap trees claimed by others. Those who 'steal' latex from other people's trees can be punished.

[8] We have no data on *jelutung* exports after 2000.

Table 14. Jelutung export from Indonesia from 1988 to 1993 (tonnes)

	1988	1989	1990	1991	1992	1993
TOTALS	2358	5373	6495	3700	2712	1182
Raw	48	612	1444	552	313	6
Pressed	932	838	1393	695	630	222
Refined	1378	2472	1958	1335	1063	516
Other	-	1451	1700	1118	706	438
Destinations						
Singapore	2358	5339	6287	3039	2145	751
Japan	-	-	56	443	446	268
Italy	-	-	38	57	121	141
France	-	-	101	-	-	-
Korea, Rep. of	-	-	13	81	-	-
China (Taiwan)	-	-	-	80	-	-
Malaysia	-	34	-	-	-	-
Hong Kong	-	-	-	-	-	22

Source: FAO 1995

Jelutung inside the buffer zone

The majority (66%) of *jelutung* tappers in the buffer zone comes from Kubu village, Kumai subdistrict, Kotawaringin Barat, and they normally have official permission to work in the area. The newcomers rent houses in the villages where they maintain their families. These tappers enter the buffer zone every week, where they build temporary houses. About 22% of the tappers are Mendawai residents and the rest are from Tanjung Putri and Mendawai Seberang.

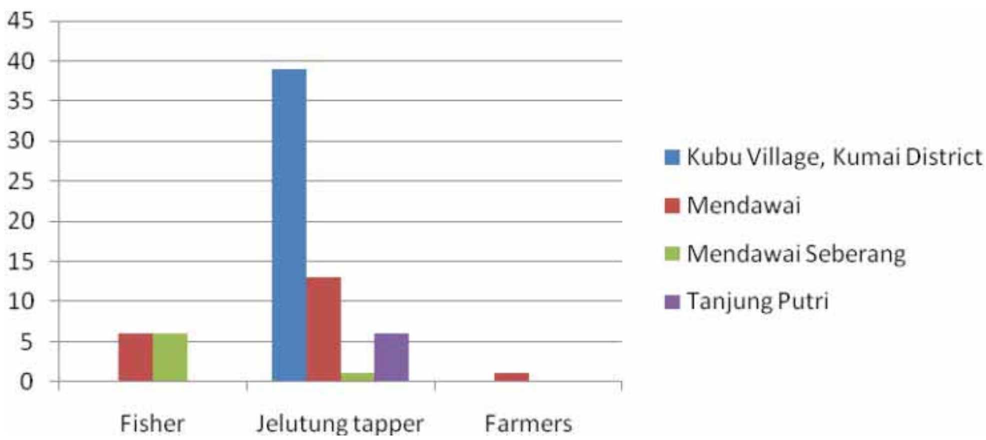

Figure 6. Number of people, by origin, working within LRWR and the buffer zone (Source: BKSDA)

Kubu village is located near Tanjung Puting National Park and is about 28 km from the town of Pangkalan Bun. Before 2000, logging of *kayu ramin* was one of the main activities. Many migrants came to work in the logging, trade and transportation of *kayu ramin*. Following government restrictions on logging in 2005, the migrants moved to other areas while some continued to live in the villages but shifted to fishing and fish trading. Young people without land moved to other villages to find jobs. Some became *jelutung* tappers around the Lamandau River area where tapping was still permitted, but not logging. As the number of *jelutung* trees in nearby forests declined, these tappers have had to explore further afield.

Jelutung tappers must report the quantity of collected latex to the guardian. The data below (Figure 7) are the recapitulation of *jelutung* latex collected from January to July 2009, however, they do not represent *jelutung* productivity per hectare. The data show that the amount of *jelutung* latex collected from Buluh post, which is close to Tanjung Putri and Pendulangan villages, is the highest (33 725 kg) and the lowest at Mangkung post (1200 kg). *Jelutung* tapper settlements are located in the Buluh River area, not on the main river, but further inland in the buffer zone and even in the reserve. *Jelutung* tappers should be checked at the post before they exit the buffer zone. In Mangkung, *jelutung* tapper settlements are located along the main river, therefore *jelutung* tappers can go to other areas without passing the post.

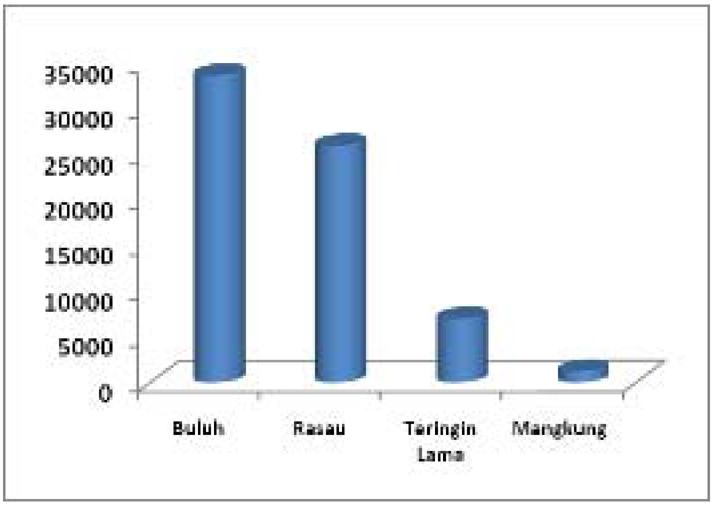

Figure 7. *Jelutung* latex recapitulation data from each sub-river (Source: BKSDA)

Based on field observation, productive *jelutung* trees in the buffer zone and surrounding areas are about 10–15 years-old, diameter around 30 cm. Large diameter trees (about 90 cm) can also be found, with an estimated age of around 60 years-old. Productivity of *jelutung* trees is about 0.99 t/ha/year.

Jelutung farmers depend on intermediaries to sell their latex. Whenever their stock of *jelutung* latex has reached 100–200 kg (which may take about a month), the tappers sell it in

Pangkalan Bun using small boats. *Jelutung* prices at farmgate level were reported to be Rp 5000–6000 per kg.

They may sell the latex individually or even in groups to cut transportation costs. Sometimes, intermediaries come to them to collect the latex. However, the tappers preferred go to Pangkalan Bun themselves because they could get a better price than if the intermediary collected the latex. The intermediaries sell the latex to exporters.

Logging history

Central Kalimantan was dominated by logging activity before 2000. The favorite wood species was *ramin* (*Gonystylus bancanus* and related species). In 1983, Central Kalimantan was the largest (41%) from the total area (13 333 100 ha) of *ramin*-potential peat swamp forest as detailed by the Directorate of Forestry Planning. The standing *ramin* stock in Central Kalimantan in 1000 m^3 lots is 50 390.30 trees of diameter more than 50 cm and 76 106.60 trees of diameter between 35 and 50 cm.

Ramin is listed in CITES Appendix-III as requested by the Government of Indonesia. The listing lead to the imposition of a logging ban through Minister of Forestry decree No. 127 of 2001. The right to harvest and export *ramin* was granted only to concessionaires holding a certificate of Sustainable Forest Management (Proceeding of Convention on International Trade in Endangered Species of Wild Fauna and Flora in Bangkok in 2004).

However, illegal logging activities still continued. In 2004, Greenpeace found illegal activities in Pangkalan Bun[9]. In early 2008, BKSDA also found some illegal activities[10]. At present, only one sawmill is still active, located in Pendulangan village.

In 2005, the Forest Land Gazettement Agency (Balai Pemantapan Kawasan Hutan/ BPKH) defined the boundary of Lamandau River Wildlife Reserve, which lead to guard post establishment and patrols. Positioning guard posts at stream mouths (at the junction) on the main river had a positive impact on halting illegal activities not only inside the reserve but also in the buffer zone. Communities across the buffer zone perceive that the areas behind the guard posts are included in the reserve. They usually called the area *kawasan lindung* or protected area. *Bahkan kupu-kupu pun tidak boleh diambil di kebun lindung sana*… ("Not even butterflies are allowed to be caught inside the buffer zone and the reserve") is an iconic statement from the people of Pendulangan village regarding the buffer zone.

The main objective of KPEL, which was formed in 2007, is to manage and control the reserve. This also lead to regulation formation in controlling all activities inside the buffer zone as well as the reserve. Permitted activities inside those areas are *jelutung* tapping, net fishing and floating net fishing and also water tapping. People wanting to work inside the buffer

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9 http://weblog.greenpeace.org/warrior/forests-2004-pacific/press.html

10 http://polhut08.wordpress.com/2009/05/28/pembalak-suaka-margasatwa-lamandau-ditangkap-kalteng-pos-8-mei-2009

zone must obtain a license from BKSDA, a process which is managed by the villages which have been given authority over the location.

Alternative livelihoods

In the face of future threats based on current conditions, improving agriculture and enriching agroforestry systems with high economic and ecological values is necessary in most villages (Table 15). Fishing using chemicals and electricity are the main threats identified for fishing culture. However, the greatest threat to the agricultural community is oil palm expansion. In Tanjung Terantang, villagers were interested in converting some of their open land (former burned areas) for oil palm plantations. This also occurred in RT 23, where the villagers were in negotiation with the local government authority to plant some of their open land with oil palm.

Table 15. Livelihood alternatives

	Threat in the future	Current condition	What would be better alternative?
Fishing: **Pendulangan–Tanjung Putri**	Over-fishing and river pollution (poisons)	Available land, low skill and technology	Promoting agriculture and agroforestry (rubber and *jelutung*) Empowering farming technology Floating net culture
Agriculture: **Tanjung Terantang,** **RT 23, Mendawai** **Serumpun (Pendulangan)**	Land conversion	Available land, low skill and technology, frequent flooding Available land, high skill and technology Sea water intrusion	Maintain crops, rubber gardens and enrich with *jelutung* trees Empowering farming technology Fish culture (*tambak*)
Mixed income: **Mendawai, Mendawai Seberang**	Over-fishing and river pollution (poisons)	Off-farm work Available land	Promoting agriculture and agroforestry (rubber and *jelutung*)
Floating net fishers	River pollution and floods	High income	Good replacement for fishing with electricity and poison
***Jelutung* tappers**	Unproductive age and low availability	Density on *jelutung* plots is 78 trees per ha Density overall area of *jelutung* trees is 22 trees per ha	Plant more *jelutung* trees

Conclusions

The majority of the people are in a transitional stage from logging to emerging cash-oriented activities. Restrictions on harvesting forest products are in place although some extraction of *jelutung* and some fishing are allowed inside the buffer zone in a controlled manner.

Some people rely heavily on the buffer zone and the reserve as other livelihood options are very limited. Although the government[11] had given some land to the local people for farming, this is not seen as appropriate or sufficient by the people. The interest in farming is low as people prefer sources of quick income such as fishing, off-farm labour and oil palm plantation work. Threats to the forest ecosystem include illegal logging and hunting activities, oil palm expansion and the use of poisons or electricity for fishing.

Frequent flooding and sea water intrusion also make farming risky. Alternative farming technology and flood control methods may help retain some people in agriculture as it seems in Serumpun hamlet, Tanjung Putri[12]. Diversification in crop land with *jelutung* can be a good alternative since *jelutung* is well adapted to peat. A program to increase *jelutung* trees inside and outside the buffer zone may also help the *jelutung* tappers who are normally landless. Analysis of the markets and value chain of *jelutung* trees would be essential in designing a *jelutung* planting program since only few literature sources were found on market channels.

Specific studies are required to provide more detailed information to guide and correct the course of REDD+ pilot project, such as:

- Institutional and social dynamics in developing collective action
- Market and value chain analysis of *jelutung* and other potential non-timber forest and agroforest products. Currently there is scant information—papers, research results—on *jelutung* production and markets

[11] As mentioned in the previous section, in early 2005 the local government (subdistrict level) of Mendawai and Mendawai Seberang allocated plots of 30 x 200 m^2 (0.6 ha) for agricultural activities of each household. But in reality, only a few (15%) of the households manage their land for agriculture.

[12] As supported by the agricultural and public works agencies of Kotawaringin Barat district.

Component B: Tenure assessment

Gamma Galudra

Background

With a steady degradation of the Indonesia's tropical forests and reduced confidence in the protected-area model, attention has turned to the potential role that community-claimed forests could play in carbon sequestration and biodiversity conservation. In Indonesia, customary lands often comprise tapestries of homesteads and farms, fallow fields, mature secondary forest and the hinterland of riverine and primary forests, which could potentially serve as refuges for threatened forest and biodiversity. With long histories of residence, active use of the forest landscape, and an apparent affinity to the forest, many local or indigenous community lifestyles have been seen to represent a more gentle and peaceable future for tropical forests.

However, the lack of legal rights of ownership and access to designated state forest areas has proven to be a major stumbling block to this idea becoming a practical reality. Customary claims are frequently not adequately recognized by modern government administrations or the same forest resources are classified under the eminent domain of the state (Brookfield et al 1995). In such instances, strengthening local tenure in collaboration with local residents can be considered a valid endeavour to stem imminent threats to important natural areas. This is also underscored by the belief that this could contribute to the restoration of communal management systems and, in the process, establish spaces where biodiversity, carbon and community interests might coexist. Two aims were set for this study.

1. To unearth the possible forest land-use claims and rights in the eastern buffer zone of the reserve.

2. To acknowledge the potential for synergy between strengthening forest tenure, conserving biodiversity and carbon sequestration.

Methodology

In line with the Rapid Land Tenure Assessment (RaTA) procedures, research at this site was complemented by, and combined with, different approaches, such as stakeholder analysis, land tenure analysis and policy analysis. These approaches were utilized in different phases of the study.

1. **Stakeholder analysis** was used to determine and understand the positions of associated individuals and institutions with respect to competing claims. Several

important groups of stakeholders who were directly or indirectly involved in land use and claims in the buffer zone were interviewed.

2. **Land tenure and claims analysis** was used to examine the existing land tenure system and how changes have resulted in possible conflicts. The analysis used some methods from Rapid/Participatory Rural Appraisal, such as participatory mapping, focus group discussion and semi-structured interviews.

3. **Policy analysis** was used to explain the policies that have determined stakeholders' access to, and use of, the buffer zone. The policies collected were mainly concerned with land-use management, ownership rights and institutional arrangements.

One landscape, three competing interests

Biogeographical and conservation significance

Administratively, the reserve is located in two districts or regencies: Sukamara, covering the western part of the reserve; and Kotawaringin Barat, covering the eastern part. The wildlife reserve was created by Ministry of Forestry Decree No. 162/1998 of 26 February 1996 (Figure 8).

Globally, Lamandau is of considerable conservation significance. It is believed to rival Tanjung Puting National Park in terms of plant endemism and species diversity, particularly with pockets of endangered orangutan (*Pongo pygmaeus*) throughout the area. This lowland ecosystem of freshwater swampy forest is the habitat for other endangered fauna such as deer (*Cervus sp*), *kancil* (*Tragulus sp*), *owa* (*Hylobates agylis*), *bekantan* (*Nasalis larvatus*) and honey bear (*Helarctos alayanus*). The area is considered as the last reserve of some endangered vegetation species such as *ramin* (*Gonystylus bancanus*), *belangiran* (*Shorea belangeran*), *meranti* (*Shorea sp*), *jejambu* (*Eugenia sp*), *cemara* (*Cassuarina sp*), *ulin* (*Eusidexroxylon zwageri*) and *koompas* (*Koompasia malaccensis*). Many of these species are nearly extinct following the forest logging of the 1980s–1990s.

Owing to this conservation importance, in 2004 the government decided to delineate and gazette the area as a designated wildlife reserve to protect the reserve legally. The gazettement process was finalized in 2005, but the planned size of the reserve decreased to only 56 584 ha. The reason for this reduction is that many of the areas, physically, cannot be classed as wildlife reserve. The regency government of Sukamara had already allocated around 11 770 ha within the designation area for oil palm and community settlement (Departemen Kehutanan 2005a, 2005b). The new size is considered too small to support conservation of the area.

KPEL manages around 23 600 ha of the eastern part of the reserve as a buffer zone. The buffer zone was previously managed by two forest concessions, but at that time it was abandoned and became an open access area. Currently, it still contains some preserved forests and several scattered habitats of orangutan.

Community claims to land and forest

The eastern part of the reserve comprises four villages (Mendawai, Mendawai Seberang, Tanjung Terantang and Tanjung Putri–Pendulangan) with a combined population of approximately 20 789 people, centred at the mouths of the Arut River and downstream of the Lamandau River (BPS 2007). The people of these villages are mainly fishermen and wet-rice/dry-rice farmers, although rubber, vegetables and tubers are also grown. Rivers supply fresh water and fish and the forest land is an important source of firewood and building materials (bamboo, rattan and wood). Previously, wild game was the primary source of protein and hunting was an integral part of these people's identity. Local people still regularly access forest resources far beyond existing farms and homesteads, particularly for collecting *jelutung*, which only grows in pristine forest areas. The seasonality of cash income makes the forest both a lifeline and a safety net for local people.

Generally, the local people of these villages assert customary claims to forest land that their forefathers used for clearing and farming, hunting and forest product collection. Through their activities, local people reaffirm their long history and connection with the area. Some people of Tanjung Terantang and Tanjung Putri–Pendulangan villages previously cleared and farmed according to the traditional system. Evidence of ex-rubber trees, rice-fields and old settlements are put forward as part of their customary claim. *Jelutung* trees are also viewed by this community as a customary claim since this product was previously under customary control and holds local values (Dinas Kehutanan 2008). Another claim made by the villagers is the communal traditional right. They declare the area of 2.5 km from the Lamandau and Arut riverbanks as their ancestral land. They view this area to be their ancestral heartland and see maintaining aspects of their unique way of life as essential to their ethnic identity. This claim was apparently supported by the Governor of Central Kalimantan in 1999, although his support did not have legal standing (Biro Pemerintahan Desa 1996).

Beside residents with customary claims, the area contains migrants from Java, Banjar and Bugis. These people settled mostly during the forest concession era and transmigration program in the 1980s and they claim some part of this forest land as their cultivated land. Around 91 people in Mendawai Seberang claim this area based on land ownership certificates that were issued by the national land agency. However, their claim does not conform to the local branch of the agency.

The legal status of the buffer zone forest and oil palm interests

There are common viewpoints among policy makers regarding the legal status of the buffer zone forest. Based on Provincial Regulation No. 8/2003, the buffer zone is allocated mostly as Production Development Zone (*Kawasan Pengembangan Produksi*). However, based on Ministry of Agriculture Decree No. 680/1981, the area is designated as Convertible Production Forest (*Hutan Produksi Konversi*) and Production Forest (*Hutan Produksi*) (Figure 8 and Figure 9)[13]. Both policies indeed provide a legal status for the government or investors to convert the forest for different land uses such as crop-estate plantations, transmigration or to be licensed to forest concessionaires as they are explicitly defined in Ministry of Forestry Decree No. 53/2008 and Government Regulation No. 26/2008.

This legal status attracted an investor seeking the opportunity to build an oil palm plantation and mill within the forest. However, owing to difficulties in terrain and lack of supporting infrastructure, the investor withdrew. To date, the only oil palm concessions are located in the northern part of the reserve. Nevertheless, the industry is likely to seek opportunities to exploit the buffer zone forest in the future unless the legal status changes.

In May 2010, the governments of Indonesia and Norway signed a Letter of Intent for bilateral support to REDD+ activities in Indosia, with a performance-based provision of up to $1 billion. The Government of Indonesia will channel the funds to activities in peatland areas, considering that release of carbon dioxide in such areas is highest. The government declared a two-year moratorium on new licenses in natural forests and peatlands. However, the forestry, pulp and palm oil industries challenged the government's position, arguing that it was ignoring the national interest in natural resource-based development. This debate implies that the general moratorium cannot be relied on to fully protect areas such as the the reserve's buffer zone and specific REDD+ activities are still relevant to guard the area, supporting the evidence of the relevance of protection and monitoring the effectiveness.

[13] Under Law No. 26/2007, this zoning means that the area can be used for development purposes such as cultivation and housing. However, based on Law No. 41/1999, 'convertible production forest' means that the area can be converted for other purposes than forest such as oil palm and transport infrastructure as long as the forestry department and local governments have finalized the forest land lease procedure. Both categories under Law No. 26/1997 fall under 'cultivation area' (*kawasan budidaya*) rather than 'protected area' (*kawasan lindung*).

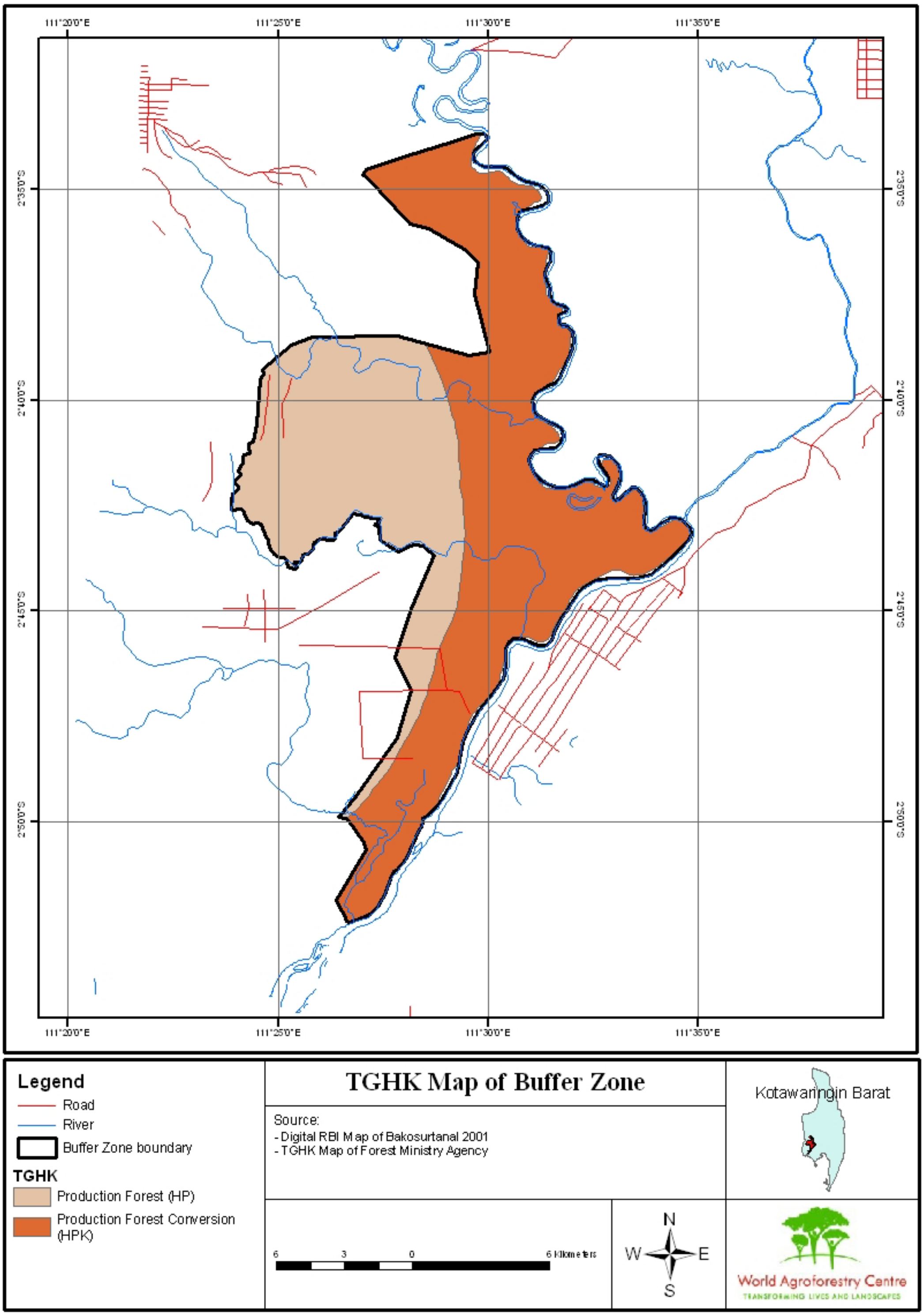


Figure 8. Legal status of the buffer zone forest based on TGHK (Tata Guna Hutan Kesepakatan/Forest Land Use Agreement) map (MoF Decree No. 680/1981)

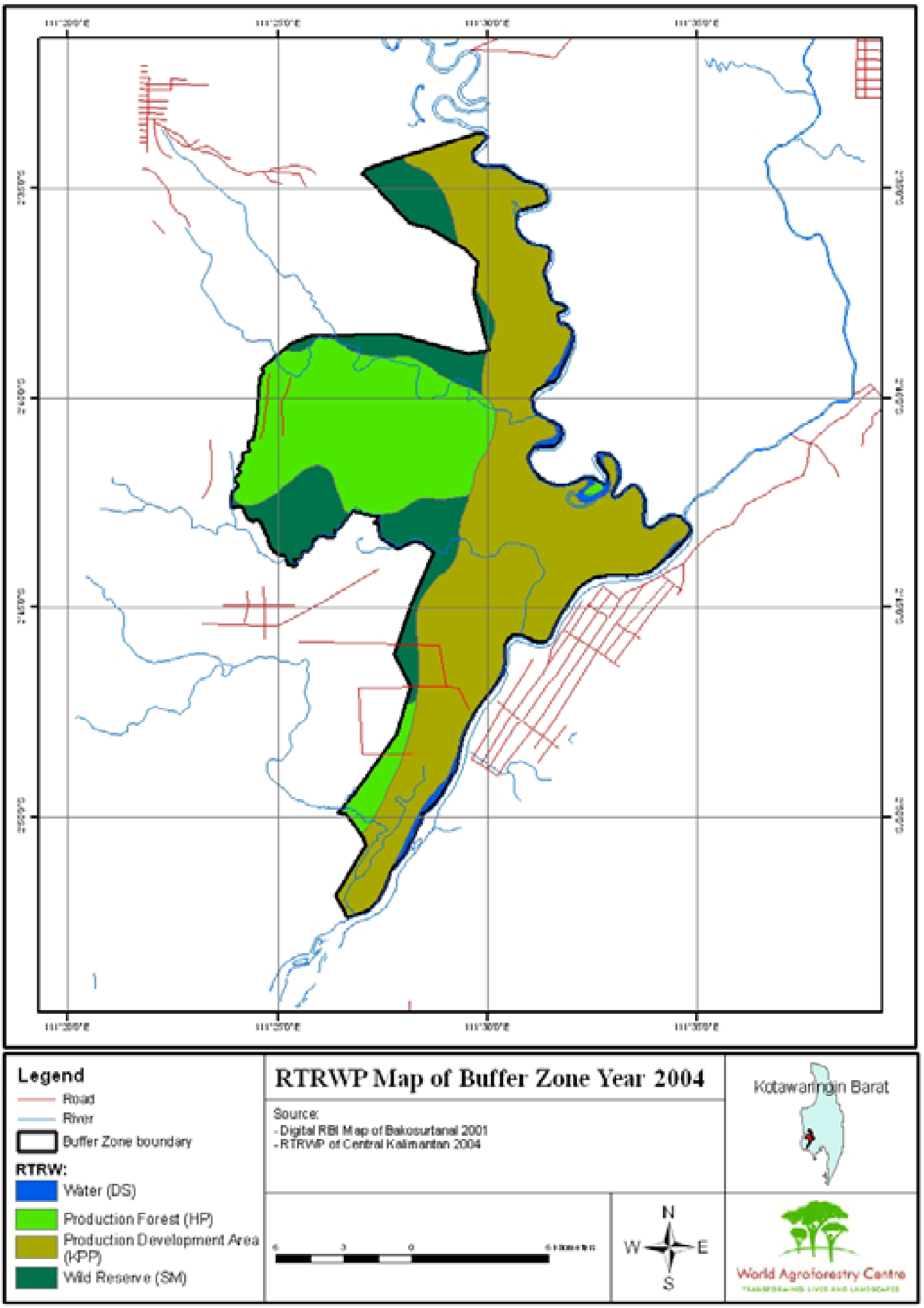


Figure 9. Legal status of the buffer zone forest based on RTRWP (Rencana Tata Ruang Wilayah Propinsi/Provincial Spatial Plan) map (Provincial Regulation No. 8/2003)

Significant threat of conflict

The imperative to secure biodiversity of forests in the reserve intensified with the profound changes in the surrounding landscape between 2006 until now. Currently, any community access to the buffer zone forest is fully controlled by BKSDA. Residents could access and use the forest for collecting *jelutung*, *gembor* and *nypa* as well as fishing and rattan, only if they had a permit issued by the agency. The agency forbids the community to use the forest for shifting cultivation, hunting and cutting trees. The agency tries to control the unsustainable exploitation of forest resources by the communities as there is no institution governing the area. Consequently, this prohibition changed the communities' livelihoods from land-use-based to fishing. Nevertheless, the communities are concerned that further restrictions and control could undermine their livelihood options. The agency should become fully aware of the communities' livelihood dependency on the forest. If not, conflict might arise.

Likewise, the agency also controls the local communities' access to the buffer zone through a permit system. Local community members can only enter the area and collect non-timber forest products, for example, *jelutung* resin, if they have a permit from BKSDA. The legal basis of this agency issuing of permits, however, is challenged by the local community. Further legal analysis is needed. Furthermore, it is also uncertain how effective the system is, relative to local tree-tenure rules, in securing sustained exploitation of non-timber forest products and in stimulating non-forest cultivation of the relevant species.

Discussion: Teasing out the tenure situation for biodiversity and carbon

Strengthening customary law to govern rights and access

The shift to individual proprietary rights runs the risk of undermining the importance of shared forest resources (Li 1996, Stevens 1997). The buffer zone was established on state land to safeguard resources for domestic access. Traditionally, for the Mendawai community, in common with many other peoples living in Central Kalimantan, certain rights of resource use applied to all individuals and these rights could be asserted in the area called communal traditional territory. Within this territory, any village member could clear the forest to make a swidden. If an individual cleared a patch of forest without knowing the history of clearance, he and his descendants could lay claim to this land (Abdurahman 1996). A hundred years later, the Mendawai community pattern is unlike that of the past. Migrants from Java, Banjar and Bugis, through spontaneous migration during the forest concession era and government transmigration programs in the 1980s, now live in this area and have changed the communal traditional territory.

There are contrasting points of view about traditional land territorial claims. The Mendawai community claims 2.5 km inland from the Lamandau and Arut riverbanks as their traditional right. This right covers all local communities' access and use such as shifting cultivation, settlement, hunting grounds, protected areas and rights to extract NTFPs. Their claim is in line with the governor of Central Kalimantan province's statement in 1998 that a distance of 2.5 to 5 km from the riverbanks should be given back to the communities under customary land-use rights, although his statement did not have any legal standing. However, not all community members are aware of this territorial right, raising the question of whether this right is actually held and passed down from their ancestors' customs or whether it is only an introduction from the local government during the Reformasi period. During Reformasi, opportunities arose to exploit ambiguities and confusions in translating customary claims into legal title. The superimposition of statutory legal systems on customary systems creates new windows of opportunity for people to take advantage of multiple systems of claiming resources (Peluso 1995).

The villagers' traditional history claims that in this area there was an existing customary institution that controlled and governed communities' access. During that time, the area was held as a common right. The authors did not find any customary institution that currently has any jurisdiction in the area. Even though the communities have a weak legal land claim on the forest, they have some claim toward the trees within the forest. Some members of the community stated the customary rule on tapping *jelutung*. A villager who first discovers an unmarked *jelutung* tree can tap and own the tree. This tree can be regarded as a private right. According to customary law, others who tap these trees without the owners' consent will be fined.

Strengthening customary institution to govern rights and access may be an option for tenure security, but it will need considerable effort as currently there is no customary institution in this area and the communities now have diverse members. Some may argue that this situation has arisen because local authority over customary lands and resources has been undermined in recent decades. The absence of tenure security and the impacts of monetisation and opportunism during the forest concession era have weakened community institutions. Support from local government through Provincial Regulation No. 16/2008 could revive a strong customary institution, but it would still be necessary to determine how such an institution would operate to preserve biodiversity and sequester carbon.

A village land-use map and future development plans could be part of a community's access recognition. Several designated sensitive areas and common property resource areas could be identified with the mediation and supervision of government officers and other facilitators. The integrity of these plans would need to be upheld by all government agencies, including those who currently restrict communities' activities within the forest.

However, the buffer zone had also been accessed by other people from outside the villages: the Kumai tribe. This tribe settled within the buffer zone forest and collects *jelutung*. So far, there is no competition for *jelutung* trees between the local villagers and the tribe. For this reason, to revive a strong customary institution requires a thorough understanding of who would have access to, and use of, the forest land, what kind of rights would need to be given, and what kind of rules and sanctions would need to be imposed. If any such institution-building process failed to understand these issues, conflict could erupt.

Community forestry under state policy

Our research in the reserve also demonstrates the potential of collaboration in conserving conservation forests. Government officers, conservation practitioners, oil palm concessions and, of course, local people have the potential to complement and reinforce each other's contributions. KPEL had successfully facilitated an agreement with two oil palm concessions that operate in the northern part of the reserve, PT Sungai Rangit and PT Bumitama Gunajaya Abadi. Both concessions allocate their concession area as a buffer zone along the border of the reserve. They have committed to not operating within this designated buffer zone.

Such commitments and agreements can be built with local communities who access the buffer zone forest. Those who directly depend on forest are naturally perceived as having a greater right to defend their livelihoods and living environments. Indirectly, they stand to be a voice for forest conservation. Some immediate options based on government regulations can be used to improve current policies and practices governing the management of buffer zone forest. The forestry department has issued a number of regulations concerning local communities' management and control of forest land. Table 16 shows several community forestry schemes within the production forest category, based on government regulations. These regulations provide tenure security for local communities to access and use the buffer zone forest resources.

Table 16. Government regulations for community forestry schemes in production forest (Hutan Produksi)

Community forestry schemes	Governing institution	Type of right held	Duration of rights
Community Forest (*Hutan Kemasyarakatan*)	Forest farmer groups, but after five years must create a farmers' economic enterprise (*koperasi*)	Group utilization and harvesting rights. A quota for these rights is imposed each year. • Planted timbers to 50 m^3 • Non-timber products to 20 t	35 years with renewal option. Evaluated every five years
People's Plantation Forest (*Hutan Tanaman Rakyat*)	Individuals and farmers' economic enterprise (*Koperasi*)	Private or group utilization and harvesting rights. No quota is imposed.	60 years and can be extended for another 35 years
Village Forest (*Hutan Desa*)	Village institution (*Lembaga Desa*), based on village regulation	Management right. A quota for these rights is imposed each year. • Planted timbers to 50 m^3 • Non-timber products to 20 t	35 years with renewal option. Evaluated every five years

Source: MoF No. 22/2009; No. 18/2009; No. 49/2008; No. 5/2008; No. 37/2007 and No. 23/2007

The Village Forest (*Hutan Desa*) category provides different rights compared to the other community forestry schemes. However, it is uncertain whether these rights are really different, as the rules of use and access are fully controlled by the government. On the contrary, the people's plantation forest (*Hutan Tanaman Rakyat*) gives longer access to the forest. Unfortunately, this scheme is more centralized: planning, monitoring and evaluation are under the jurisdiction of the central government. The other schemes give more role to the local government in planning, monitoring and evaluation.

Even though these schemes offer legal tenure security for conservation, carbon sequestration and community participation, it is still uncertain how these schemes can fully integrate with customary rules and a local tenure system. Yet, these schemes certainly help to settle land tenure conflicts. Several case studies, such as in Lampung, Jambi, Gunung Kidul and Lombok, show the success of minimizing land tenure conflicts and settling competing claims and interests among different actors (Nurka *et al.* 2006, Suyanto, n.d, Wiyono and Santoso 2009a, 2009b[14]). Providing secure access for local communities to obtain benefits from timber and non-timber products inside the state forest zone and measured guarantees from local communities to protect the forest's environmental services help to minimize tension among conflicting actors. Despite that all of these schemes, based on Ministry of Forestry Decree No. 30 and 36/2009, could also receive REDD+ incentives. The community forestry schemes (*Hutan Kemasyarakatan*) may offer a promising way to synergize different and competing interests for biodiversity, carbon and livelihoods. Since many people outside the villages access and use the forest products, it is better to set-up a farmers' groups to manage the forest. The village boundaries within the buffer zone are still unclear, so that develop village forest (hutan desa) in this area may create further conflicts among different villagers who use the same piece of land.

Apart from these community forestry schemes there is Timber Forest Product Utilization in Ecosystem Restoration in Natural Forest (IUPHHK-RE) that can help to rehabilitate forest for REDD+ purposes. However, it is still uncertain how this scheme, based on Ministry of Forestry Decree No. 18/2004, could settle competing claims and fully integrate with customary rules and any local tenure system.

Conclusion and way forward

Across the globe, the spaces reserved for biodiversity conservation are decreasing dramatically and very few wilderness areas can be considered free from land claims. Each party has different interests and these interests manifest in land claims. The most agreeable solution is for each party to acknowledge the interests of the others in order to come to a synergistic solution. The danger for conservation entities is that the urgency to preserve forest and its biodiversity can overwhelm community rights and livelihoods and in doing so threaten the forest.

The solution is that communities assume some responsibility for biodiversity and carbon. Integrating communities' values and norms for forest access and use can benefit preservation efforts. However, the government has a prominent role to play in providing tenure security and supporting compatible economic activities in such areas. The current

[14] For more information, see http://wg-pemberdayaan.org/ and http://www.wg-tenure.org/

policy that is being used has the tendency to undermine communities' rights to access and use forest. Current policy cannot protect forest from being legally converted to other land uses. Legal arrangements such as community forestry schemes that integrate with communities' rights, norms and values can offer tenure security. However, to decide which scheme is the most appropriate will depend on a negotiation process with several stakeholders.

Component C: Land-use/cover change analysis

Sonya Dewi, Andree Ekadinata and M Thoha Zulkarnain

Introduction

Within the Rapid Carbon Stock Appraisal (RACSA) method (Hairiah et al. 2009), emission factors for a pair of land-use systems within a time period is defined as the stock differences between initial and subsequent land-use system per unit area. Total emissions in a landscape owing to land-use changes are emission factors multiplied by total area of each pair of land-use systems. Therefore, quantification of area changes and trajectories of land-use systems in a landscape are required to calculate total emissions of a landscape. Analysis of land-use/cover trajectories (ALUCT) was conducted to serve this purpose. In the context of the REDD+ feasibility study, the key outputs of ALUCT are: 1) time series land-cover maps of the area of the Lamandau River Wildlife Reserve and its buffer zone; 2) land-cover changes analysis to be used as an input to carbon stock calculation at landscape level.

Materials

ALUCT was conducted on the basis of time series land-use/cover maps interpreted from satellite images. Satellite images were selected using three criteria: time coverage, spatial resolution and cloud cover. Time coverage of satellite images has to capture the relevant period of land-use/cover change trajectories in the study area. In this case, we used images from the 1990s and 2000s, which are considered important in the ongoing discussion of REDD+ in Indonesia. Spatial resolution is the area on the Earth's surface that is represented by one pixel, and therefore one digital number, in the satellite image. It determines the size of the smallest object, thus the level of detail, recognizable from the satellite image. Therefore, it affects the spatial scale of the land-cover map produced. Considering the size of the study area and the need to recognize classes of land use/cover with different carbon stocks, we used medium resolution images from Landsat (30 m spatial resolution) with minimum cloud cover. Table 17 shows the list of Landsat images and their acquisition date. Figure 10 provides visualization of the time series Landsat images.

Table 17. Satellite images and acquisition dates

Scene-ID	Satellite/Sensor	Acquisition dates
P120-R062	Landsat 5 Thematic Mapper	January 16, 1989
P120-R062	Landsat 7 Enhanced Thematic Mapper	August 13, 1999
P120-R062	Landsat 7 Enhanced Thematic Mapper	August 16, 2006

Other materials used in this study are field reference data recorded using the Global Positioning System (GPS) during field work. Field reference data provides information on geographic position of various land cover in the study area. The field reference data serve two purposes: (i) as guidance during the image interpretation stage; and (ii) as a reference in assessing accuracy of the land-cover map being produced. We also compiled secondary spatial data to be used in the analysis of land-cover change (**Table 18**).

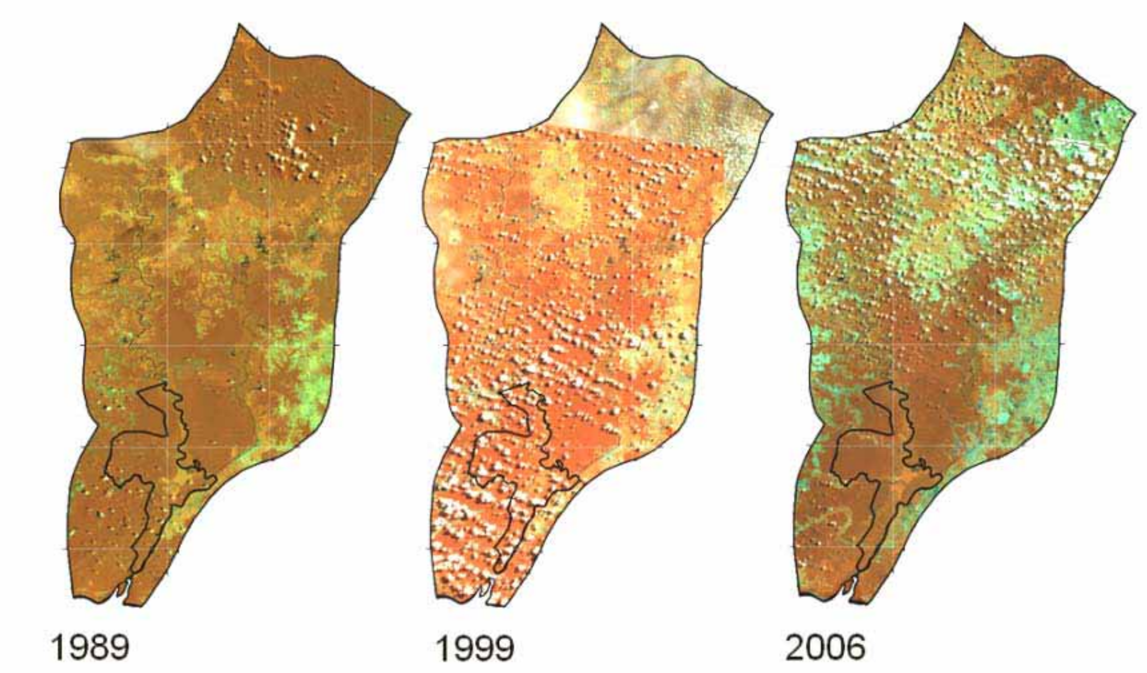


Figure 10. Time series satellite image of buffer zone and its surroundings

Table 18. List of thematic maps

Name	Scale/ resolution	Sources
Administration (subdistrict boundary, village boundary)	1 : 250 000	Bakosurtanal
Topographic feature (road, river, populated places)	1 : 250 000	Bakosurtanal
Forest (HPH, HTI, plantation area, TGHK, transmigration location)	1 : 250 000	Ministry of Forestry
Land cover (2000, 2003, 2006)	1 : 100 000	Ministry of Forestry
Peat land	1 : 250 000	Wetland Indonesia
GPS point of guard post		Orangutan Foundation

Methods

Before implementing ALUCT it is required to conduct inventories and to define classes of land use/cover in the study area. The classes are designed such that they are recognizable from the satellite images, they embrace all the dominant land-use/cover types that exist in the study area and they are meaningful in terms of representing different levels of carbon stock. A list of relevant land-use classes was developed through field work in the study area.

The list is essential in constructing a look-up table that connects ALUCT with plot-level carbon measurement. These integrated elements are used as the basis for calculating carbon stock. ALUCT workflow (Figure 11) can be classified into three stages: (1) image pre-processing; (2) image classification; and (3) post-interpretation analysis. The first stage, image pre-processing, aims to rectify geometric distortion in satellite images using ground control points (GCPs) collected from reference datasets. In this case, orthorectified Landsat 2006 image from the United States Geological Survey (USGS) is used as reference data. At minimum, we used 20 GCPs in geometric correction; we imposed geometric precision of 0.5 pixel (< 15 m) for each image.

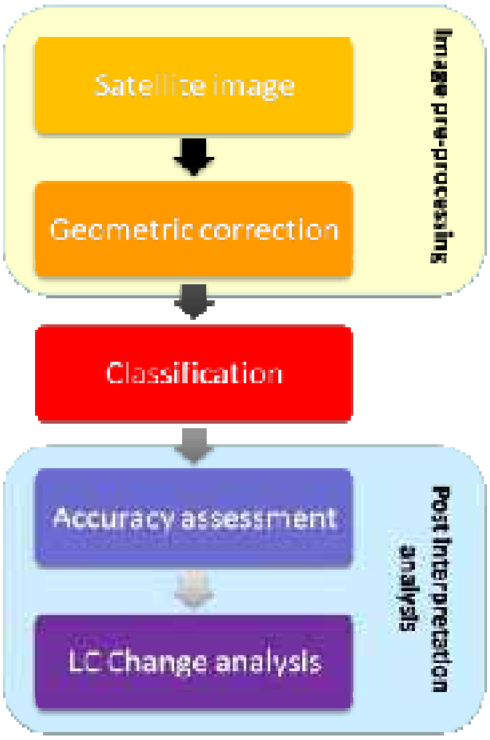


Figure 11. Overall work flow of ALUCT

The second stage of ALUCT is image classification. The main objective is the interpretation of spectral information contained in satellite images into land-use classes. The object-based hierarchical classification approach is used at this stage. In this approach, image classification begins with an image segmentation process. The purpose is to produce image objects, a group of pixels with a certain level of homogeneity in terms of spectral and spatial characteristics. Image objects have to be able to represent the actual features on the satellite images; several phases of segmentation were conducted to get the required levels of detail. The results of these phases are called multiresolution image segments, which serve as a basis for the hierarchical classification system. The segmentation process is illustrated in Figure 12.

Figure 12. Segmentation process

Following the segmentation process, image classification is conducted using a hierarchical structure shown in Figure 13. The hierarchy is divided into two levels; within each level land-cover types are discriminated using some spectral and spatial rules. The details and complexities of land-cover types to be differentiated increase in each level, manifested by different sets of rules. Level 1 consists of general classes such as forest, forest on peat, tree-based system, tree-based system on peat, non-tree-based system, non-tree-based system on peat, non-vegetation and non-vegetation on peat. These classes can easily be distinguished using visual examination, a simple vegetation index and a thematic map of peat. The vegetation index is a ratio of spectral value between vegetation-sensitive channels (near infra red spectrum) and non-vegetation-sensitive channels (visible spectrum) in a satellite image. The thematic map of peat identifies peat land or non-peat land. The result of Level 1 is further classified into Level 2. At this level, spectral value is not the only parameter used; spatial characteristics such as distance to settlement, proximity to logging road, forest concession, plantation map, field reference data and Nearest Neighbourhood algorithm are incorporated as rules in the classification process. Level 2 consists of 20 land cover types such as undisturbed forest, logged-over forest (high density), logged-over forest (low density), undisturbed swamp forest on peat, logged-over swamp forest on peat, undisturbed mangrove, logged-over mangrove, timber plantation, timber plantation on peat, estate, estate on peat, agroforest, agroforest on peat, crop land, crop land on peat, grass, grass on peat, shrub, shrub on peat, settlement, settlement on peat, clear land and clear land on peat.

Figure 13. Hierarchical classification structure

A post-classification analysis process is the last stage of ALUCT. It consists of two processes: accuracy assessment and land-cover change analysis. The objective of accuracy assessment is to test the quality of information derived from the image classification process. It is conducted by comparing field reference data with the most recent land-cover map. For the emission estimation from land-use changes, it is advised that an accuracy level of at least 80% should be reached. The last step in ALUCT is the land-cover change analysis itself.

Two types of land-cover change analysis are conducted for each study site: area-based change analysis and trajectories analysis. An area-based change is a simple analysis conducted by comparing total area of each land-use/cover class in each time period. For this analysis, we differentiate two areas within the overall study area. Those areas are: (1) buffer zone of the reserve; and (2) outside of the buffer zone. The result will show a clear indication of the overall trend of land-cover changes in the buffer zone and its surroundings. However, there is no information provided on the location and trajectories of changes. Trajectories analysis is conducted to solve this problem. Trajectories of changes quantify and summarize the sequences of changes over all time periods observed for each pixel.

Results and discussion

Land-use/cover types identified within the buffer zone

Land-cover classes were identified during field work in the the reserve. Due to limited time and field accessibility, field work was focused on the buffer zone of the reserve. A total of eight land-use/cover classes can be identified in the buffer zone: 1) undisturbed swamp forest; 2) logged-over swamp forest; 3) shrub; 4) crop land; 5) cleared land; 6) grass; 7) settlement; and 8) water body. Photos of some land-cover classes are shown in Figure 14. Detailed descriptions of each land-use/cover class in the buffer zone are provided in **Table 19**. For the area outside the buffer zone, additional land-cover types were identified through satellite image interpretation.

Figure 14. Land-cover types in the buffer zone: swamp secondary forest (upper left), swamp shrubland (upper right), water (lower left), open swamp (lower right)

Table 19. Description of land use/cover types

Undisturbed swamp forest	A swamp forest is a wetland featuring temporary or permanent inundation of large areas of land by shallow bodies of water with natural vegetation cover, has never been logged in the past and not degraded or affected by any human activities.
Logged-over swamp forest	Logged-over swamp forest is swamp with natural forest cover that has been logged or degraded.
Shrub	Shrub land is a non-tree-based system consisting of non-tree vegetation usually less than 5–6 m tall, usually resulting from swidden practices, having been left for 2–3 years as part of fallow/rotational systems.
Crop land	Crop land is cultivated land and is mostly planted with annual crops such as staple food.
Grassland	Area dominated by grass.
Cleared land	Area where almost no vegetation covers the land. It can be a former logging area or slashed and burned area prepared for agriculture.
Settlement	City, town or village, settlement along roads, main roads, secondary roads, logging roads.
Water body	An area covered with water.

Time series land-use/cover maps: 1989, 1999 and 2006

A time series of land-cover maps of the buffer zone are presented in Figure 15. In 1990, the buffer zone was dominated by swamp forest. The swamp forest was mostly logged-over by then, although some patches of undisturbed swamp forest were spread across the area and a relatively large undisturbed swamp forest block could still be found in the north-western part of the buffer zone. In 1999, some patches of undisturbed swamp forest had gone and almost all were shrinking in area, causing high fragmentation. The undisturbed forest mostly changes into logged-over forest, indicating logging activity in the area. In the eastern part of the buffer close to the river, some new settlements appeared. Forest loss is quite obvious in the decade 1990–2000 as patches of shrub replace logged-over swamp forest in the area close to the river. The 2006 land-cover maps showed even more patches of shrub appearing in the area. More settlements emerged in the eastern part of the buffer zone. Except for the expansion of the settlements in the eastern part of the buffer zone, mostly close to the river where accessibility is relatively easy, the extent of forest cover in the period 1990–2005 is relatively stable even though the quality of forest reduces and the fragmentation of undisturbed forest increases. Consequently, environmental services such as climate change mitigation, biodiversity maintenance and watershed functions also declined.

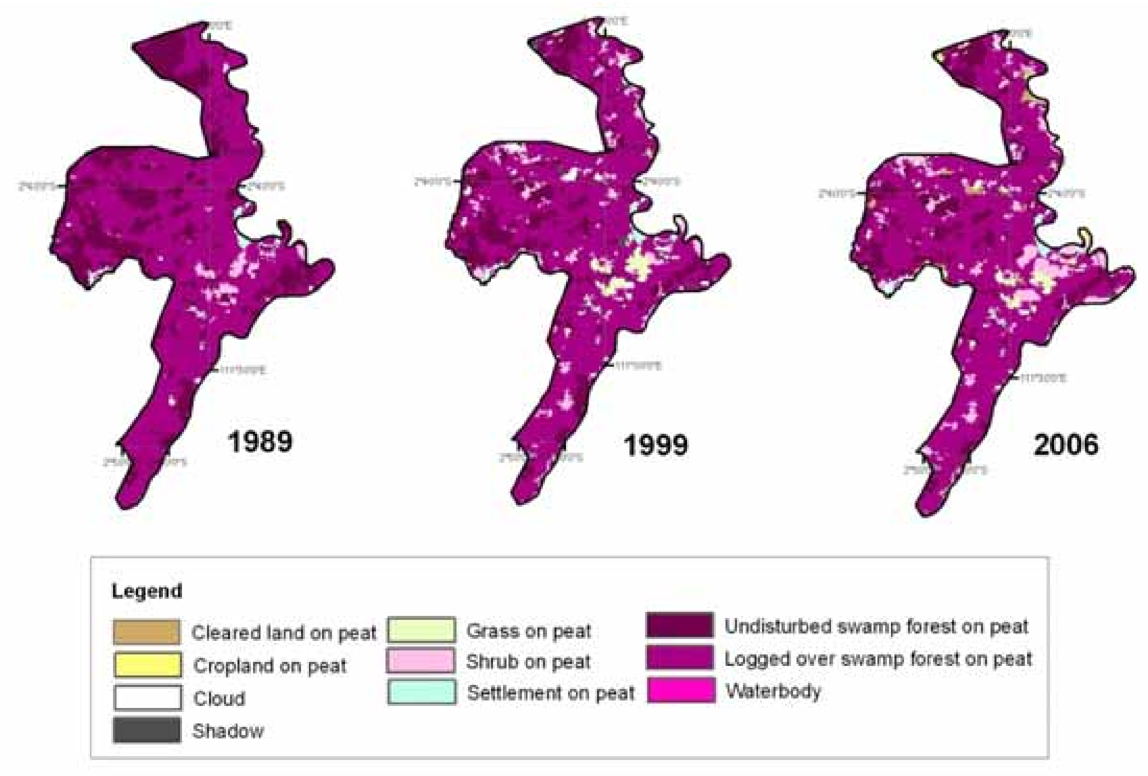


Figure 15. Land-cover maps of the buffer zone for 1989, 1999 and 2006

Accuracy assessment of land-use/cover classification within the buffer zone

An accuracy assessment was conducted for the land-use/cover map of 2006 by overlaying and comparing the 40 GPS points collected in July 2009. The three-year gap in time between the image acquisition and the field visit may lead to some biases in the results of the accuracy assessment, since land use/cover might have changed during the period. However, we learned during the ground-truthing process through discussions and interviews that land use/cover did not change significantly or rapidly in the buffer zone so that the potential error level from the gap should be low. **Table 20** shows the accuracy matrix of the land-use/cover map of 2006. The overall accuracy of the classification is 90.5%.

The GPS points collected from the field refer to more detailed land-use/cover types, that is, grassland (grazing areas for cows), grassland (tall grasses, two years after fire), grassland (permanent), logged-over forest (high density), logged-over forest (medium density), logged-over forest (low density), *Nypa fruticans, Pandanus helicopus,* rubber agroforest, shrub land (*Mikania sp*, one year after fire), fern. For the purpose of accuracy assessment, these 40 points were aggregated into the eight classes of land-use/cover maps.

Table 20. Accuracy matrix of the land-cover map 2006; numbers outside of the main diagonal represent misclassification

		CLASSIFIED						
		Crop land on peat	Estate on peat	Grass on peat	Logged-over swamp forest on peat	Shrub	Shrub on peat	Undisturbed swamp forest on peat
REFERENCE	Crop land on peat	**3**	0	0	0	0	0	0
	Estate on peat	0	**2**	0	0	0	0	0
	Grass on peat	0	0	**4**	1	0	0	0
	Logged-over swamp forest on peat	0	0	0	**26**	0	0	0
	Shrub	0	0	0	0	**1**	0	0
	Shrub on peat	1	0	0	0	0	**5**	0
	Undisturbed swamp forest on peat	0	0	0	0	0	0	**2**

Land-use/cover composition and changes within the buffer zone 1989–2006

In 1989, 95% (22 718.4 ha) of 23 720 ha of the buffer zone was covered by swamp forest, which consisted of 16 082.82 ha (68%) logged-over swamp forest and 6635.61 ha (27%) undisturbed swamp forest. Because these areas should serve as a buffer to the reserve, management and protection are active. However, forest cover in the area has slowly declined. In 1999 and 2006, the total area of forest was 20 370 ha (85.6%) and 19 590 ha (82%) respectively. The rest of the area (7%) was covered by swamp shrubs and very little (72 ha) of swamp with minimum vegetation as grassland or crop land. These particular covers were only found alongside the river where access is easiest.

Table 21. Summary of land use/cover of the buffer zone in 1989, 1999 and 2006

Land cover	**Area in 1989**		**Area in 1999**		**Area in 2006**	
	Ha	**%**	**Ha**	**%**	**Ha**	**%**
Undisturbed swamp forest on peat	6635.61	28	4400.19	18	3615.03	15
Logged-over swamp forest on peat	16 082.82	68	15 970.41	67	16 075.62	68
Shrub on peat	602.1	3	1507.32	6	2284.92	10
Crop land on peat		0		0	80.01	0
Grass on peat		0	666.45	3	514.8	2
Cleared land on peat		0		0	315.9	1
No Data	74.79	0	825.66	3	306.54	1
Settlement	299.61	1	339.84	1	369.27	2
Water body	80.19	0	80.19	0	80.19	0
Grand Total	23 794.47	100	23 794.47	100	23 794.47	100

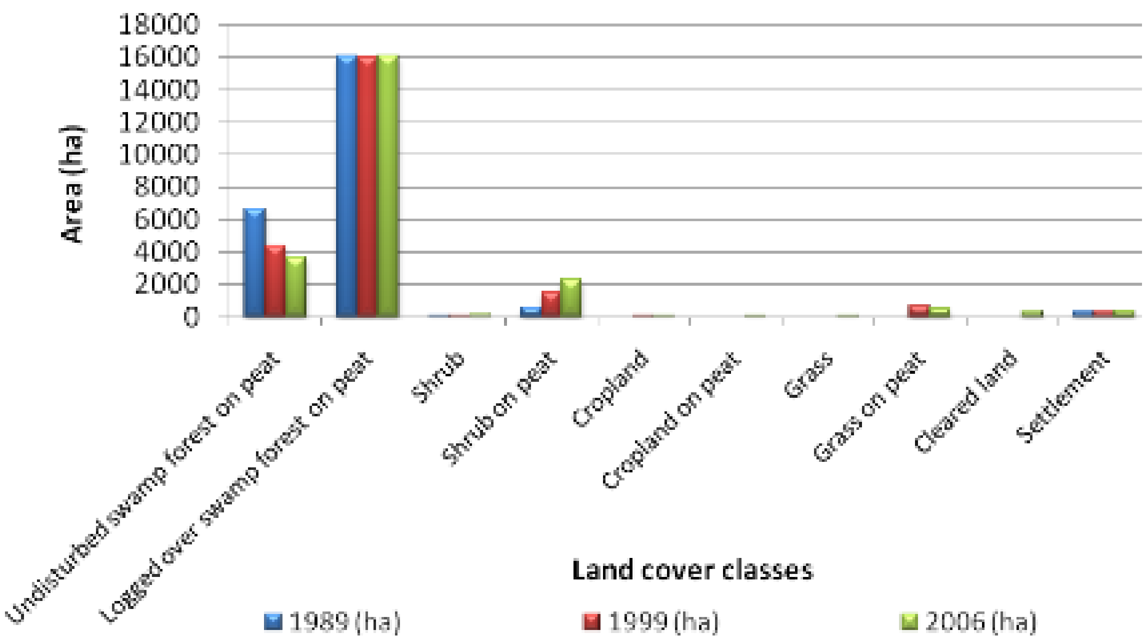


Figure 16. Land-use/cover changes within the buffer zone 1989–2006

In addition to looking at the changes in the total area, we also looked closely at the pixel-by-pixel comparison by overlaying the two maps and found that the loss of secondary shrub forest mostly took place in the areas closest to the river, mostly owing to human activities such as logging and burning. The logged-over swamp forest was mostly changed to shrubs (alongside the main river) and some to settlement (along the small rivers). **Table 22** and Table 23 summarize the land-cover changes for 1989–1999 and 1999–2006 respectively.

Table 22. Change matrix for the buffer zone 1989–1999

1989 (ha)	1999 (ha)							
	Undisturbed swamp forest on peat	Logged-over swamp forest on peat	Shrub on peat	Crop land	Grass on peat	Settlement	Water body	Grand Total
Undisturbed swamp forest on peat	4400.19	1234.35	597	1.08	90.8			6326
Logged-over swamp forest on peat		14 736.06	681		231	40.23		15688
Shrub on peat			168		343			511.6
Settlement						299.61		299.6
Water body							80.19	80.19
Grand Total	4400.19	15 970.41	1460	1.08	665	339.84	80.19	22920

Table 23. Change matrix for the buffer zone 1999–2006

1999 (ha)	2006 (ha)									
	Undisturbed swamp forest on peat	Logged-over swamp forest on peat	Shrub on peat	Crop land	Crop land on peat	Grass on peat	Cleared land on peat	Settlement	Water body	Grand Total
Undisturbed swamp forest on peat	3615.03	774.18								4400.19
Logged-over swamp forest on peat		15 301.4 4	490.23				106.92	1.89		15 908.0 4
Shrub on peat			1329.66		44.82		54.09	9.18		1454.67
Crop land				1.08						1.08
Grass on peat			148.41			514.8	1.08			664.29
Settlement								339.84		339.84
Water body									80.19	80.19
Grand Total	3615.03	16 075.6 2	1968.3	1.08	44.82	514.8	162.09	350.91	80.19	22 851.6 3

Figure 17. Forest-cover change in the buffer zone 1989–2006

Land-cover change within the buffer zone and its surrounding area (subdistricts Arut Selatan and Kotawaringin Lama)

The variations of land-use/cover types found in the two subdistricts are higher than those in the buffer zone. We found 23 land-use/cover types in these areas compared to only eight in the buffer zone. Time series land-cover maps of the two subdistricts are presented in Figure 18. Logged-over swamp forest on peat is the dominant land-use/cover type. In 1989, most areas in the two subdistricts were still covered by forested land. Drastic changes in land uses occurred 1989–1999. Most of the undisturbed swamp forest became degraded into logged-over swamp forest, while undisturbed forests in the northern part of the subdistrict were converted into estate and crop land. In 1999–2006, more land-use conversion to estate plantation occurred in the northern part of the two subdistricts. The swamp areas in the southern area experienced a lower intensity of land-cover changes compared to the other parts of the subdistricts. However, swamp forests clearly decreased in this area, while patches of shrub and plantation emerged on the edge of swamp and non-swamp.

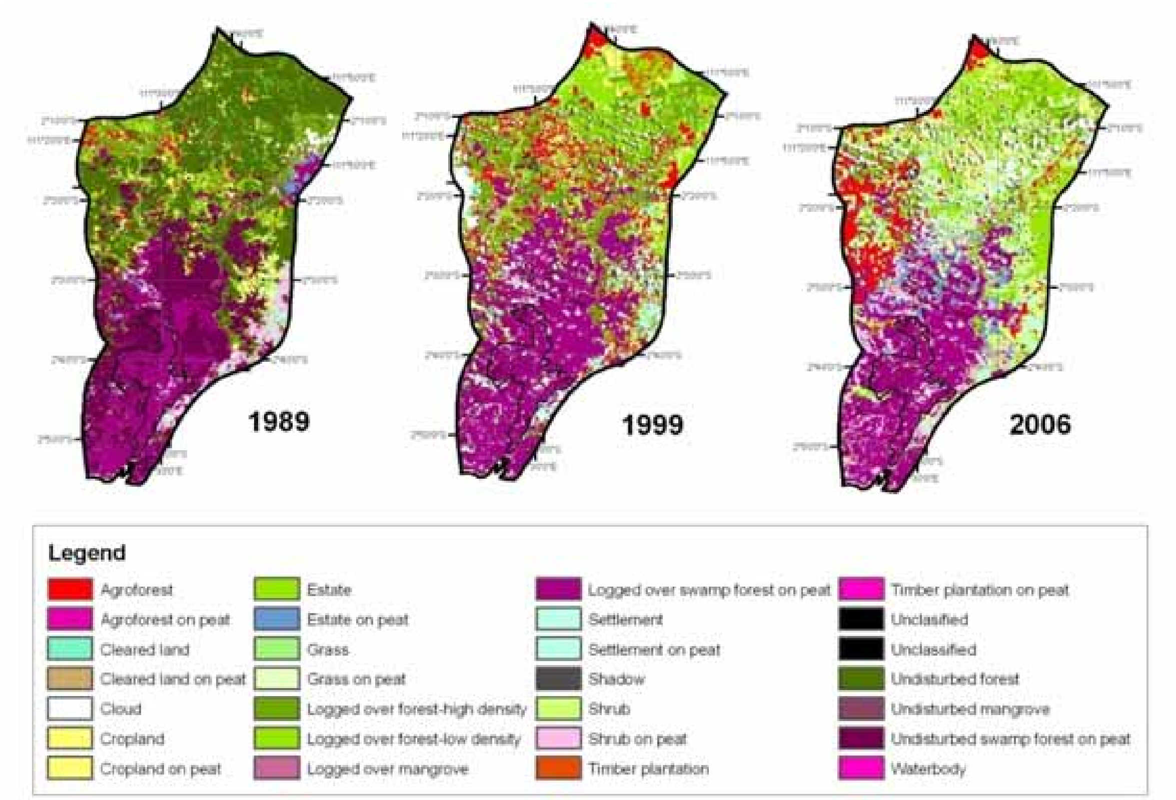


Figure 18. Land-cover maps 1989, 1999 and 2006 of Arut Selatan and Kotawaringin Lama subdistricts

In 1989, 317 143.6 ha (84%) of Arut Selatan and Kotawaringin Lama subdistricts were covered by forest. The primary forest consisted of 123 589.98 ha (32%) undisturbed natural dry forest, 2 389.05 ha (10%) of undisturbed mangrove and 88 626.15 ha (23%) of undisturbed swamp forest. These areas had almost completely vanished by 1999, with only 13 641.21 ha (4%) of primary forest left in the area. Significant increases of logged-over forest (23%) and logged-over swamp forest (29%) suggest that extensive logging activities have occurred in the subdistricts. Other land uses are quite stable in the area, although estate plantations increased from 18 046.62 ha (5%) in 1989 to 22 872.15 ha (6%) in 1999. More recently (1999–2006), conversion to estate plantation was notable in the two subdistricts, that is, increases of estate area from 22 872.15 ha (6%) in 1999 to 43 950.42 ha (11%) in 2006. Total forest areas in the subdistricts decreased significantly from 215 785 ha (56%) in 1999 to 131 985 ha (33%) in 2006. However, during 1999–2006 swamp forest areas are relatively stable compared to other forested areas in the subdistricts. Summary of land-cover changes in Arut Selatan and Kotawaringin Lama subdistricts is shown in Table 24.

Table 24. Summary of land-use/cover change in the buffer zone and its surrounding area (subdistricts Arut Selatan and Kotawaringin Lama) 1989, 1999 and 2006

Land cover	**Area in 1989**		**Area in 1999**		**Area in 2006**	
	Ha	**%**	**Ha**	**%**	**Ha**	**%**
Undisturbed forest	123 589.98	32				
Logged-over forest	40 985.01	10	90 448.52	23	32 174.91	8
Undisturbed mangrove	2389.05	1	2257.74	1	495.72	0
Logged-over mangrove	843.39	0	3.87	0	1652.67	0
Undisturbed swamp forest on peat	88 626.15	23	11 383.47	3	10 591.02	3
Logged-over swamp forest on peat	60 710.04	16	111 693.33	29	87 061.23	22
Agroforest	7483.41	2	37 687.86	10	26 641.44	7
Agroforest on peat	5.94	0	4.59	0	5.49	0
Timber plantation	364.5	0	4129.38	1	2369.61	1
Timber plantation on peat	14.22	0	4.14	0	7.29	0
Estate	18 046.62	5	22 872.15	6	43 950.42	11
Estate on peat	2709.27	1	2.97	0	14 790.69	4
Shrub	5489.37	1	21 523.95	6	45 552.87	12
Shrub on peat	11 293.29	3	8310.6	2	22 491.54	6
Crop land	10 392.03	3	7750.08	2	14 107.68	4
Crop land on peat	2.97	0	3.6	0	2734.83	1
Grass	31.32	0	1476.09	0	2112.12	1
Grass on peat	4.59	0	4500.45	1	1939.41	0
Cleared land	40.05	0	6602.67	2	4556.61	1
Cleared land on peat	694.53	0	1381.41	0	7182.99	2
Settlement	6556.23	2	8523	2	22 833.54	6
Water body	2938.23	1	2938.23	1	2938.23	1
No Data	5554.44	1	45 268.92	12	42 565.32	11
Grand Total	**388 764.63**	**100**	**388 764.63**	**100**	**388 764.6**	**100**

Figure 19. Forest-cover change in Arut Selatan and Kotawaringin Lama subdistricts 1989–2006

Conclusions

The analysis of land-use/cover changes in the buffer zone of Lamandau River Wildlife Reserve and the surrounding areas, that is, the two subdistricts of Arut Selatan and Kotawaringin Lama, shows that land-use/cover changes within the buffer zone are much lower in extent, percentages and conversion to more intensified land uses. This shows that the management and protection of the buffer zone has been largely successful. Within the buffer zone, the changes took place mostly alongside the river owing to human activities made possible by accessibility. More specifically, the changes along the main river were mostly from secondary swamp forest to shrubs while further inland, in the areas that are accessible along smaller rivers, changes were mostly from secondary swamp forest to more open, less vegetated swamp.

Outside the buffer zone and wildlife reserve, in which the designation of lands vary from production forest (both convertible and non-convertible) and land for other uses, the land use/cover has been much more dynamic during the study period. Managed tree-based systems (both as tree crops and forest plantation) have doubled in area, as well as crop land and settlements. In 2006, a small area of mining emerged, which was non-existent in 2000. The percentage and total areas might not be highly accurate owing to substantial areas with no data (cloud and shadow coverage) in 2000.

Component D: Carbon stock measurement

Subekti Rahayu, Lili A Sadikin, Dedy, Meine van Noordwijk and Laxman Joshi

Introduction

The buffer zone of Lamandau River Wildlife Reserve in Kotawaringin Barat district, Central Kalimantan, is dominated by peat swamp forests with high potential as carbon storage. It has been reported that aboveground carbon stock range between 75–275 t/ha of carbon (MoFor 2008) and belowground carbon of peat is about 2000 t/ha in 4 m peat depth, density of peat 0.1 g/cm^3 and 50% of carbon content (Jaenicke et al. 2008).

Previously, this area was a habitat of *ramin* (*Gonystylus bancanus*), an important timber species with vulnerable status on the IUCN Red List 2006 and also included in CITES List Appendix 2. The tree population of *ramin* decreased significantly owing to overexploitation during 1999–2003 by private companies with forestry concessions and by the local community until 2005. Besides *ramin*, *jelutung* grows in this area and is an important source of income for local communities.

Protecting the buffer zone of the reserve from timber extraction can enhance the total forest carbon stock from both total forest area and total carbon per hectare of forest (carbon density). It has the potential to reduce emission by increasing carbon densities. This area also has conservation value especially for plant and animal diversity such as *ramin*, *jelutung*, orangutan and *bekantan* (*Nasalis larvatus*), which is endemic in Kalimantan. The area can also generate income for the local community through *jelutung* tapping.

The objectives of carbon stock measurement in the buffer zone of the reserve were: 1) to estimate aboveground carbon stock at plot level for various land uses; 2) to estimate belowground carbon stock at plot level; 3) to estimate growth rate of carbon stock; and 4) to analyse the impact of guard posts on carbon stock.

Method

According to the IPCC method, there are five carbon pools that can be measured to estimate emission from forest land: aboveground biomass (tree and understorey), dead wood, litter and belowground (soil organic carbon and peat). The sampling method used in this survey refers to ASB protocol (Hairiah et al. 2001). However, the most practical method of estimating emission is to monitor only aboveground biomass (Murdiyarso et al. 2008).

Forty sample plots were set up across the buffer zone of the reserve covering all land-cover types (**Table 25**).

Table 25. Number of sample plots for carbon stock assessment in the buffer zone

No.	Land uses	Plot number (n)
1	Logged-over forest (high density)	5
2	Logged-over forest (medium density)	15
3	Logged-over forest (low density)	9
4	Grassland	4
5	Fern	1
6	Pandanus	1
7	*Nypa*	1
8	Old rubber plots mixed with *jelutung*	1
9	Young rubber plantation	2
10	Shrub land	1

The land types were based on visual estimation of canopy cover and tree population density, particularly for logged-over forests. The vegetation density was determined by canopy cover and stem density.

- Low density: canopy cover of 40–60% (with approximately 10 trees 5–30 cm diameter per 200 m^2 and 1–2 trees > 30 cm per 2000 m^2).
- Medium density: canopy cover of 60–80% (with approximately 20 trees 5–30 cm diameter per 200 m^2 and 1–2 trees > 30 cm per 2000 m^2).
- High density: canopy cover of > 80% (with approximately 30 trees 5–30 cm diameter per 200 m^2 and 1–2 trees > 30 cm per 2000 m^2).

The rubber agroforests were differentiated into young rubber (< 15 years) and old rubber (> 15 years) normally mixed with old *jelutung* trees.

Three nested sub-plots were set up in each sample plot area depending on vegetation: 40 m x 5 m sub-plot for counting trees and dead wood between 5 to 30 cm diameter; 100 m x 20 m plots for measuring trees and dead wood of more than 30 cm diameter; quadrant of 2 x 0.5 m x 0.5 m set up inside sub-plot used to count understorey in logged-over forest, shrub and grass, *nypa*, pandanus and fern. All tree species were identified using local names and their diameter at breast height (dbh) was measured. Destructive samples were taken from 2 x 0.5 m x0.5 m plots for *nypa*, pandanus, shrub, fern and grassland and then weighed fresh and dry. At least three plots were recorded for each land-cover category.

Peat depth, peat classification, bulk density and peat carbon content were estimated from peat samples taken using a peat auger. Bulk density and carbon content in mineral soil were estimated from soil samples taken using metal box 20 cm x 20 cm x 10 cm. A total of 32 samples (7 samples of mineral soil and 25 peat soils) were taken during the study.

Results

Land uses

The buffer zone is dominated by logged-over peat swamp forests of different densities with some patches of grassland, young shrub, pandanus and *nypa*. Low density logged-over forests are found in the southern part of the buffer zone (Tanjung Putri and Tanjung Lingga). Illegal logging by local people is still taking place in some areas, especially further away from guard posts. *Nypa* is dominant in the southern part, across to Tanjung Putri and Serumpun village, particularly on the banks of Lamandau River. The riverbanks receive regular floods and tides. *Nypa* occupies 2–3 m of riverbank (Figure 20).

Figure 20. Natural growth of nypa along streams

Pandanus grows in the large flooded area along Rasau's river and grows up to 1–2 km from the riverbank. In some areas there is indication of pandanus burnt about three years ago and currently starting to recover. There is no other vegetation inside the pandanus area, since the pandanus grows in a high density population (Figure 21).

Figure 21. Natural growth of pandanus

Large areas of grass land are found in Seluluk, Simpang Tiga and Kondang with a different type of grass that grows in mineral soils (Figure 22). There is no indication of fire in Seluluk. It may be that this area is the result of a sedimentation process, which produces a mineral soil type preferred by the grass type. In Simpang Tiga and Kondang, grassland occupied 0.5–2 km inland from the riverbank. Fires may have occurred two to three years ago in both areas, with some *bungur* trees still surviving in Simpang Tiga and some *jelutung* trees in Kondang. During the rainy season, the grassland area in Kondang is flooded and can only be reached by small boat. Shallow mineral soil (about 7 cm depth) indicates that sedimentation occurred in this area.

A B C

Figure 22. A. Grassland in Seluluk; B. Grassland in Simpang Tiga and C. Grassland in Kondang

Large areas of fern are found across Teringin Lama and Seluluk in peat soil. There are no trees inside the fern area. It seems that there has been an attempt to cultivate *jambu mete* (*Anacardium occidentale*) and vegetables such as chilli, eggplant, long beans and groundnut on the dykes (Figure 23).

A **B** **C**

Figure 23. A: Fern in Teringin Lama; B and C: Jambu mete and vegetables grown in the dyke

Shrub grows in the burnt area of Seluluk (Figure 24). People have cleared land to establish rubber trees.

Figure 24. Shrub in Seluluk

The buffer zone of the reserve is dominated by logged-over forest classified by low, medium and high density status with different types of understorey (Figure 25).

A

B

C

Figure 25. Logged-over forest with different densities: A. Low density; B. Medium density and C. High density

There is rubber agroforest about 15 years-old and more than 40 years-old mixed with *jelutung* in Rasau. The rubber agroforest is still well managed by the owner (Figure 26).

A

B

Figure 26. A. Rubber agroforest 15 years-old; B. Old rubber mixed with jelutung

Soils

The area is mostly peat land. The southern part, from Tanjung Putri to Teringin Lama, is strongly influenced by flood tides with peat depth ranging from 1 to 2 m. In Teringin Lama, there were various soil types comprising mineral soil, peat soil and sandy soil. Mineral soil was found in the central to northern part, from Simpang Tiga to Mangkung, particularly along the riverbank up to 2–3 m. The Rasau area had deeper peat, 2 to 4.5 m, with deepest peat located about 750 m from the riverbank. The average peat depth was 134 cm.

Carbon stock at plot level

Aboveground carbon stock

Trees contain 80% of carbon stock in logged-over, low density forest and more than 90% in logged-over, medium and high density forests. All of the carbon stock in fern, grassland, *nypa* and pandanus is in the understorey in the absence of trees (Figure 27). Carbon stock in logged-over, high density forest was similar to old rubber in the area: 71 t/ha. It was significantly less in medium density forests (46 t/ha) and low density forests (24 t/ha). Open areas with grass and shrubs had very low carbon stock: 1 t/ha. There were three types of grasses: low grass for animal grazing in Simpang Tiga; medium grass (50 cm height) in Seluluk; and high grass (100 cm height) in burnt areas of Kondang. Fern had higher carbon density than grassland, about 7 t/ha. *Nypa* contained 28 t/ha of carbon and pandanus 54 t/ha. Rubber agroforests located in Rasau had different carbon stocks depending on the age of the plantation. Young rubber (< 15 years-old) in sandy soil had 24 t/ha of carbon while old rubber mixed with *jelutung* had 77 t/ha.

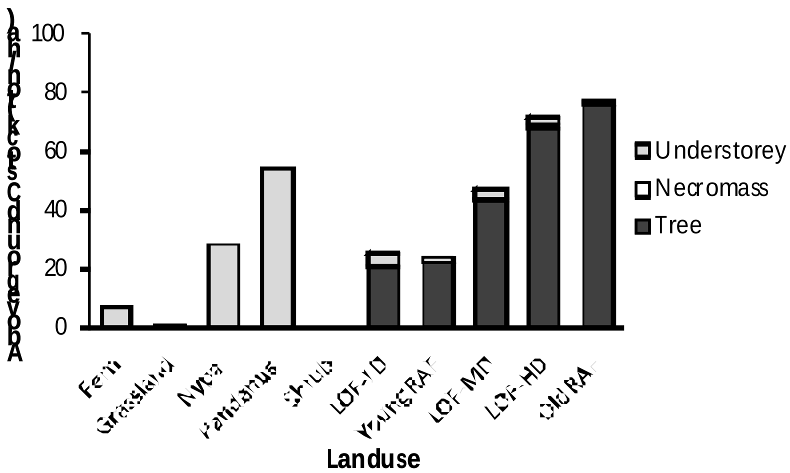


Figure 27. Aboveground carbon stock in various land uses of the LRWR buffer zone

Belowground carbon stock

Compared with the Ministry of Forestry (2008) report of 40–80 t/ha of carbon, belowground carbon stock in mineral soils of the buffer zone was found to be low: 31.5 t/ha of carbon up to 30 cm depth. Also comparing with Silvius (2008), who reported 3000 t/ha soil carbon in peat land, carbon stock of peat in the buffer zone was low: only 841 t/ha, which may be due to shallow peat ranges of 16–450 cm with average depth of 134 cm and bulk density of 0.08–0.6 g/cm^3, with an average of 0.21. The belowground carbon stock is ten times as large as the average aboveground value. Bulk density in the deeper layer is commonly higher than in the upper layer. Bulk density and ash content (complement of organic matter) of soil layers are related in Figure 28.

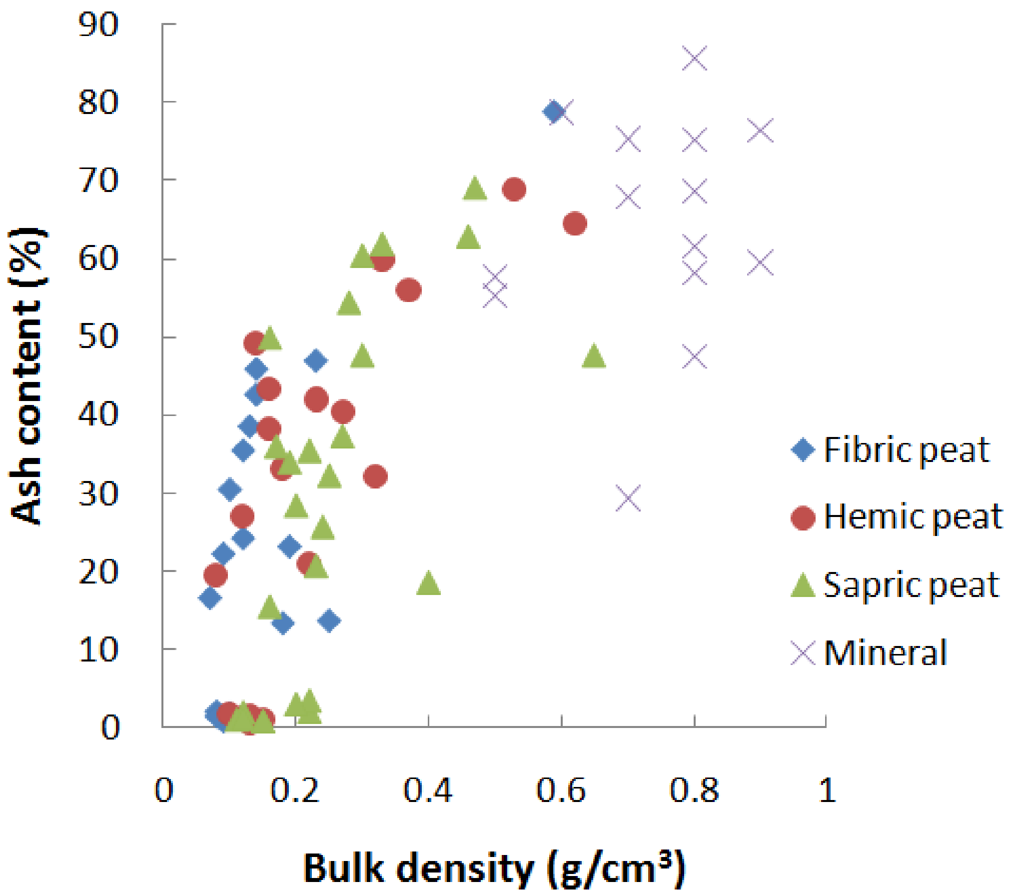


Figure 28. Relationship between bulk density and ash content of samples, classified by type of peat (fibric, hemic, sapric) or mineral soil

Average carbon content in the mineral soil was lower (0.13) compared to peat (0.4). In the southern part, carbon content in the peat was lower (0.3), but in the middle to northern part was higher (0.44) and, in some areas, as in Rasau, it reached 0.57. Deepest peat also occurred in this area. The carbon content tends to be low in the boundary between peat and mineral soil.

Increasing peat depth increased belowground carbon stock (Figure 29). Based on research results in the buffer zone, an increase of 100 cm depth adds 729 t/ha to belowground carbon stock.

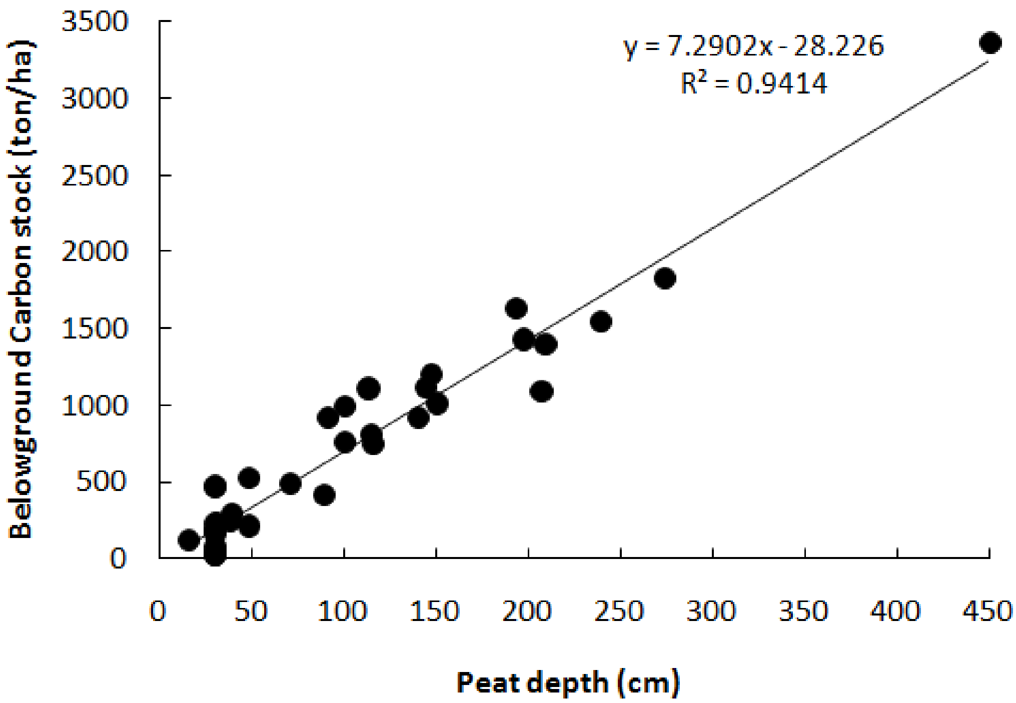


Figure 29. Relationship between peat depth and belowground carbon stock in peat land

Annual carbon stock increment

Assuming low density, logged-over forest recovered since five years ago (since the establishment of guard posts), medium density growth since 10 years (when *ramin* and ulin started to be extracted) and high density since 30 years ago (selected diameter *ramin* and *ulin* started to be extracted), the annual carbon sequestration rate was estimated at 1.3 t/ha/year (Figure 30).

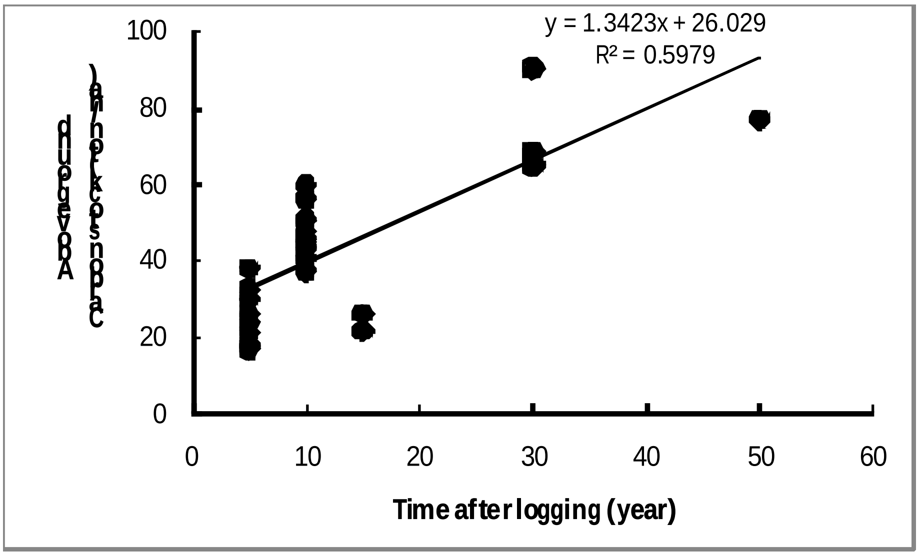


Figure 30. Annual carbon stock increment in logged-over forest from low through medium to high density

Estimating carbon stocks protected by the guard posts

The carbon stock data of forest plots are negatively correlated with distance from the nearest guard post. The relationship is about the same for plots and guard posts that are close to the river and those that are further inland. A combined equation explains about 34% of the total variation in forest carbon stock (Figure 31).

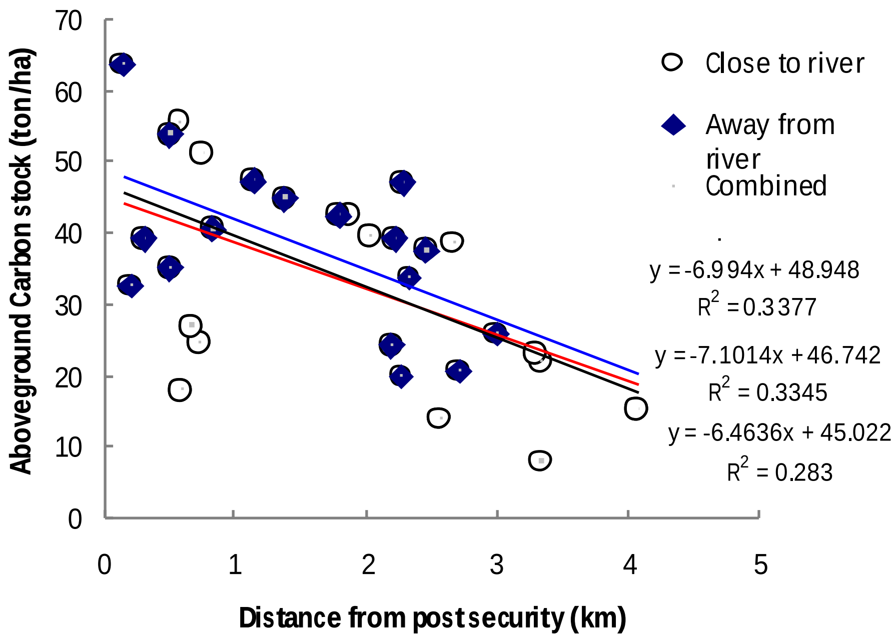


Figure 31. Relationship between aboveground forest carbon stock and the distance of measured lots to the nearest guard post or camp, for plots and guard posts within 0.5 km of the river and those that are further inland

After rejecting a null-hypothesis of a random effect, we still have at least two ways of interpreting this apparent relationship. As with any spatial correlation, there are 'chicken and egg' issues about its interpretation. There are two options.

1. Forest plots differ in carbon stocks and guard posts are built in the denser forest types.
2. Guard posts actually help to protect the forest and decreasing forest carbon stock with distance indicates the effectiveness of guard posts.

The fact that figures close to the river and inland are similar may support interpretation B, as does circumstantial evidence of historical patterns.

If we take this line, we can estimate the total amount of forest carbon protected per guard post as the integral over a circle with a radius of, say, 4 km (endpoint of the data and probably where the guard posts have zero influence) with the carbon stock function (declining from 47 t C/ha at a rate of 7.1 t C/ha per km), minus the carbon stock of the same circle at (47 – 4 + 7.1 =) 18.5 t C/ha. The net effect is 650 t C that is protected per guard post.

The annual cost of maintaining a guard post is estimated at USD 9000 per camp (employing three staff at a monthly salary of Rp 2.5 million). This suggests a net cost per tonne of carbon protected of USD 13.80 per year. If expressed as tonnes of CO_2 emissions avoided, the cost is USD 3.77 per year.

Conclusions

- Buffer zone of the reserve is dominated by peat land 0–450 cm deep, with average 134 cm
- Belowground carbon stock in buffer zone of the reserve at 134 cm peat depth is 84 t/ha of carbon
- Aboveground carbon stock in buffer zone of the reserve is categorized low (77 t/ha of carbon in high density LOF) compared to logged-over forest in East Kalimantan (184 t/ha of carbon)
- Protecting this area at current levels will increase aboveground carbon stock 1.3 t/ha of carbon per year
- Guard posts help to protect the forest
- *Jelutung* contributes 4% to total biomass in buffer zone of the reserve

Recommendations

Protecting buffer zone and planting *jelutung* will increase carbon stock, conserve biodiversity and generate income for the local community.

Component E: Scenarios of land-cover change at landscape level

Ni'matul Khasanah, Rahmat Mulia, Meine van Noordwijk and M Thoha Zulkarnain

Introduction

The Lamandau River Wildlife Reserve and its buffer zone were previously 'production forests' with logging rights assigned to a private forest concession. *Ramin* and *ulin* (*Eusideroxylon zwageri*) were the major timber trees extracted from this area. This logging activity ceased in 2003, leaving a pretty much depleted landscape. Currently, the dominant land-cover type of the buffer zone is logged-over forest that can be classified as secondary forest (low, medium or high density) with small patches of pandanus, *nypa*, rubber agroforestry (old, young), shrub and grassland (Component C of this study provided detail on this). The logging activities and land-cover changes have had a significant influence on carbon storage.

The overall objectives of this scenario study, as part of the feasibility study carried out in the buffer zone of the reserve, were threefold.

1. To estimate the (aboveground[15]) carbon emission and sequestration rate of the buffer zone and its surrounding landscape.
2. To assess plausible future landscape mosaics of the reserve, buffer zone and their neighbouring area and the consequences of such scenarios for economic and ecological performance indicators in the landscape, calibrating the FALLOW model simulation.
3. To estimate carbon emission and sequestration rate of the buffer zone and its surrounding area over a 30-year simulation period.

Material and method

The primary study area for the feasibility study was the buffer zone (east of the reserve), which covers about 23 600 ha. However, for the simulation of the future landscape mosaic of

[15] Throughout this scenario study we focus on changes in aboveground carbon stocks, as changes in belowground carbon stocks will primarily depend on drainage, fire and intensive fertilization; depending on management details, oil palm conversion could potentially cause substantively larger emissions than here presented if the peat soils were be drained.

the the reserve, the simulated area covers two districts (Kotawaringin Lama and Arut Selatan) of about 350 000 ha. The purpose was to assess possible land-cover changes outside the reserve and its buffer zone, if the two areas were protected or not from any logging or agricultural activities. This wider area can help understand the issues of leakage and additionality.

Carbon emission and sequestration rate from land-cover changes

The carbon emission and sequestration rate from land-cover conversion were estimated by the following method.

1. Using the actual trajectories of land-cover change derived from satellite images from the periods 1990s, 2000s and 2005 (Component D of this study).
2. Estimating time-averaged (aboveground) carbon stock of each of the existing land-cover types (Component C of this study; some adjustment of categories was needed, as shown in Table 27).
3. Up-scaling changes of carbon stock to the whole area based on area changes and time-averaged carbon stock of each land-cover type:

$$\Delta C = (\Sigma_{ij} A_{ij} \times [\Delta C_{ij}]) / T$$

Where:

ΔC: is the total annual carbon emission at the landscape

A_{ij}: is changes in the area of land-cover type $_i$ to land-cover type $_j$

ΔC_{ij}: is the difference of time-averaged (aboveground) carbon stock of land-cover type $_i$ to land cover $_j$

T: is the length of study period.

FALLOW model and simulation

The FALLOW (Forest, Agroforest, Low-value Land Or Waste? (Suyamto et al 2009)) simulation model was used for exploration of landscape dynamics over a 30-year period. The model (Figure 32) simulates land-cover change in a rural area, based on farmer decisions, that includes both tactical aspects (labour allocation) and strategic aspects (land allocation), choosing between different livelihood options. Farmers' decisions on the strategic and tactical time-scales are based on actual track records within that landscape, external information and farmer learning styles. The choices have consequences for household economics (measured as potential non-food or secondary consumption expenditure) and ecological performance (aboveground biomass) of the simulated area. In the default, no direct linkage is provided between carbon stocks in the landscape and farmer income.

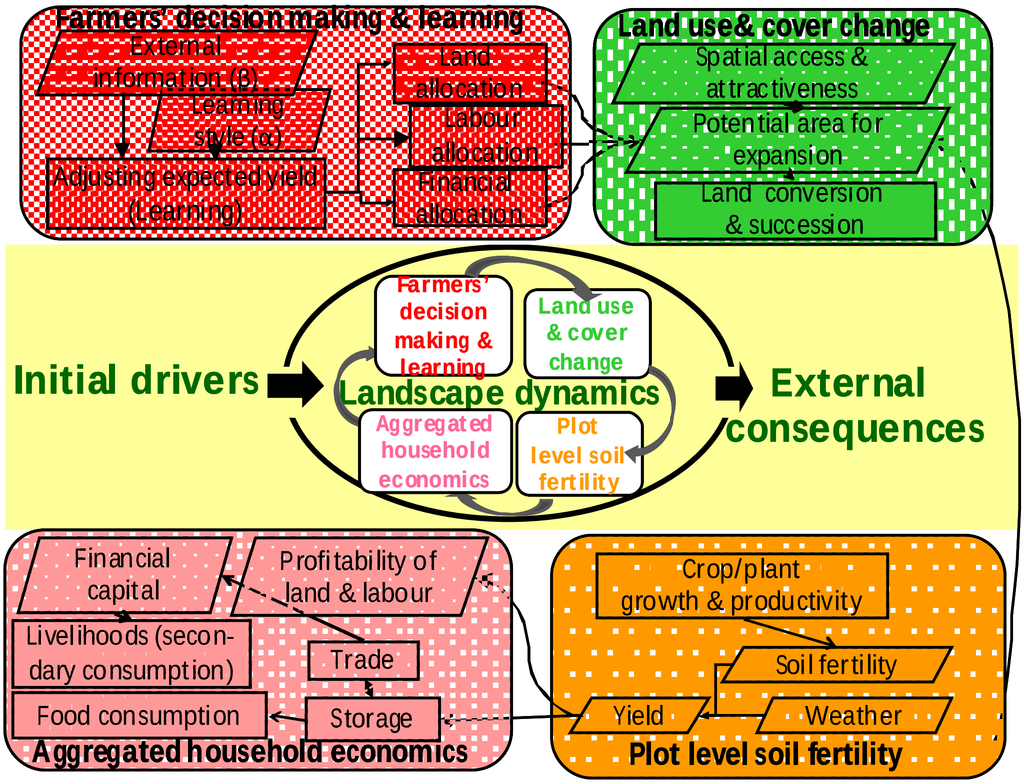


Figure 32. Components of the FALLOW model used for scenario studies (Lusiana et al 2010)

The model runs in annual time steps and uses a number of classes of land cover. For this study, the following land-cover classes (**Table 26)** were used: swamp, mangrove, and four succession stages of forest (pioneer, young secondary, old secondary and primary forest). The four stages are essentially distinguished based on biomass level and their NTFP yield.

Table 26. Land-cover class assignment for the FALLOW model application

Land-cover class of FALLOW model	Land-cover class of image analysis
Settlement	Settlement, settlement on peat
Pioneer forest	Cleared land, cleared land on peat, grass, grass on peat, shrub, shrub on peat, logged over forest (low density), logged-over mangrove
Young secondary forest	Logged over forest (high density), logged-over swamp forest on peat
Old secondary forest	Undisturbed mangrove
Primary forest	Undisturbed forest, undisturbed swamp forest on peat
Crop	Crop land, crop land on peat
Rubber post	Estate, estate on peat
Agroforest post	Agroforest, agroforest on peat
Timber late	Timber plantation, timber plantation on peat

Plant growth in the plantations is also modelled according to four successive stages: pioneer, early, late and post. The four stages are assigned with their own aboveground biomass and yield level. Van Noordwijk (2002) and Suyamto et al (2009) provide a more detailed explanation of the model's concept, assumptions and application.

Suyamto et al (2008) list all parameters needed as input of the FALLOW model. They are classified into inputs in the form of maps, constants and/or time series. For the simulations here, however, due to lack of data some parameter values measured on Sumatra instead of Central Kalimantan were used. Table 28 lists the main input parameters and their corresponding values as used in the scenario simulations.

Based on the observations made during a feasibility study in the reserve and buffer zone, the following scenarios for the landscape (that is, Kotawaringin Lama and Arut Selatan) were explored.

1. **Baseline (current condition)**
   Five commodities are of a primary concern for farmers in the area: rubber (plantation), timber (*Gmelina arborea*), agroforest (with rubber as dominant commodity), rice as agriculture and *jelutung* as non-timber forest product. Since logging is practically prohibited everywhere inside the simulation area, we simulated no logging activity in the baseline situation.
2. ***Jelutung***
   As a possible scenario for increasing both economical and ecological performance of the landscape, options to promote *jelutung* trees in young secondary forest were assumed, extending *jelutung* production beyond the old secondary forest, as in the baseline. The yield is assumed to be the same as in the old secondary forest, that is, 0.99 t ha^{-1}. We assumed that young *jelutung* trees are introduced in the young secondary plots at year 0 and all trees need 10 years growth before tapping. Technical feasibility of these assumptions will depend on a concerted effort to clarify use rights and plant the trees.
3. **Logging**
   In this scenario, logging was made a de facto possible in all forestry plots except the forest reserve (that is, the reserve and its buffer zone). This scenario represents the abolishment of current illegal logging control and is included to test the short-term economic benefits foregone by current forest protection policies.
4. **Oil Palm A**
   Oil palm was introduced as an alternative commodity for farmers in the simulated area, outside the reserve and its buffer zone. This assumes forms of 'smallholder oil palm' that requires financial investment as well as knowledge that tend to be concentrated in larger have started to emerge in Sumatra but are relatively scarce in Kalimantan as yet. It scale plantations.

5. **Oil Palm B**
   Here oil palm plantations are able to establish inside the reserve and its buffer zone.

In all simulations, settlement and infrastructure (for example, roads) were assumed static during the 30 years and the buffer zone and reserve were protected. Maps of the year 2005 were used as initial maps. Economic level in terms of secondary consumption and ecological level in terms of aboveground biomass were measured as output of model simulation.

Table 27. Aboveground time-averaged carbon stock of each land-cover type in relation to the legend used for the land-cover maps

Land over types (image analysis)	**Time-averaged carbon stock assignment (Mg ha^{-1})**	**Land-cover types (Lamandau field study)**	**Time-averaged carbon stock (Mg ha^{-1})**
Agroforest	77.1	Rubber mixed system	77.1
Agroforest on peat	77.1	Rubber mixed system	77.1
Cleared land	1.07	Grassland	1.07
Cleared land on peat	1.07	Grassland	1.07
Crop land	0.53	Shrub	0.53
Crop land on peat	0.53	Shrub	0.53
Estate	40.0	Oil palm	40.0[1]
Estate on peat	40.0	Oil palm	40.0[1]
Grass	1.07	Grassland	1.07
Grass on peat	1.07	Grassland	1.07
Logged-over forest (high density)	70.9	Secondary forest (high density)	70.9
Logged over forest (low density)	21.3	Secondary forest (low density)	21.3
Undisturbed mangrove	175	Undisturbed mangrove	175[1]
Logged over mangrove	28.4	*Nypa*	28.4
Undisturbed swamp forest on peat	200	Undisturbed swamp forest	200[1]
Logged over swamp forest on peat	45.9	Secondary forest (high density)	21.3
		Secondary forest (medium density)	45.3
		Secondary forest (low density)	70.9
Settlement	4.14	Settlement	4.14[1]
Settlement on peat	4.14	Settlement	4.14[1]
Shrub	0.53	Shrub	0.53
Shrub on peat	0.53	Shrub	0.53
Timber plantation	42.0	*Gmelina*	42.0[1]
Timber plantation on peat	42.0	*Gmelina*	42.0[1]
Undisturbed forest	**300**	**Undisturbed forest**	**300[1]**

1) ICRAF database

Table 28. List of input parameters that vary between scenarios

Parameter	Baseline	*Jelutung*	Logging	Oil Palm
Yield (tonne ha^{-1})				
Pioneer forest (ntfp)	0	0	0	0
Young secondary (ntfp)	0	0.99	0	0
Old secondary (ntfp)	0.99	0.99	0.99	0.99
Primary forest (ntfp)	0	0	0	0
Pioneer forest (logging, m^3 ha^{-1})	0	0	0	0
Young secondary (logging, m^3 ha^{-1})	0	0	71.1	0
Old secondary (logging, m^3 ha^{-1})	0	0	213.1	0
Primary forest (logging, m^3 ha^{-1})	0	0	304.4	0
Rubber pioneer	0	0	0	0
Rubber early	1.7	1.7	1.7	1.7
Rubber late	2.5	2.5	2.5	2.5
Rubber post	1.7	1.7	1.7	1.7
Timber pioneer	0	0	0	0
Timber early	45.32	45.32	45.32	45.32
Timber late	64.21	64.21	64.21	64.21
Timber post	83.1	83.1	83.1	83.1
Agroforest pioneer	0	0	0	0
Agroforest early	1.6	1.6	1.6	1.6
Agroforest late	2.4	2.4	2.4	2.4
Agroforest post	1.6	1.6	1.6	1.6
Oil Palm pioneer	0	0	0	0
Oil Palm early	0	0	0	32.6
Oil Palm late	0	0	0	40.7
Oil Palm post	0	0	0	48.4
Crop	2	2	2	2
Return to labour (Rp pd^{-1})				
Jelutung	73 530	73 530	73 530	73 530
Logging	0	0	963 504	0
Crop	25 110	25 110	25 110	25 110
Rubber	77 400	77 400	77 400	77 400
Timber	46 807	46 807	46 807	46 807
Agroforest	77 400	77 400	77 400	77 400
Oil Palm				167 880
Return to land (Rp ha-1)				
Jelutung	2 490 000	2 490 000	2 490 000	2 490 000
Logging	0	0	132 000 000	0
Crop	6 220 000	6 220 000	6 220 000	6 220 000
Rubber	7 875 000	7 875 000	7 875 000	7 875 000
Timber	6 412 500	6 412 500	6 412 500	6 412 500
Agroforest	7 875 000	7 875 000	7 875 000	7 875 000
Oil Palm	0	0	0	5 625 000

Results and discussion

Carbon emission and sequestration rate from land-cover changes

Land-cover changes

In the 1990 to 2000 period when logging activities and timber extraction by local community and private forest concession companies reached their historical peak, 19% of undisturbed swamp forest on peat was degraded into logged-over swamp forest on peat and undisturbed forest was degraded into logged-over forest (high density) (10%) and shrub (3%). Conversion of undisturbed forest into estate (4%) and agroforest (4%) also occurred (see Figure 18 of Component D). These drastic changes occurred in the northern part of the two subdistricts. The buffer zone of the reserve had been logged before and its rate of further degradation during the 1990s was fairly low. About 64 % and 19% of the land-cover type remained as logged-over swamp forest on peat and undisturbed swamp forest on peat; only 5% and 2% of undisturbed swamp forest on peat were degraded into logged-over swamp forest on peat and shrub on peat (**Table 31**).

From 2000 to 2005, when logging activities and timber extraction ceased, only some further forest conversion took place in the buffer zone or in its direct surroundings. In the buffer zone, 67% and 16% of the land remained as logged-over swamp forest on peat and undisturbed swamp forest on peat; only 3% and 2% of undisturbed swamp forest on peat were degraded into logged-over swamp forest on peat and into shrub on peat (Table 30). In the northern part of the two subdistricts, more land was converted to estate plantation (see Figure 18 of Component D).

Table 29. Change matrix (% of total area) for the buffer zone in the period 1990–2000

1990	2000								
	Crop land	Grass on peat	Logged- over swamp forest on peat	Settlement	Shrub	Shrub on peat	Undisturbed swamp forest on peat	Water body	Grand Total
Logged-over swamp forest on peat		1.01	64.29	0.18		2.97			68.45
Settlement				1.31					1.31
Shrub						0.01			0.01
Shrub on peat		1.50				0.74			2.23
Undisturbed mangrove						0.06			0.06
Undisturbed swamp forest on peat	0.00	0.40	5.39		0.01	2.60	19.20		27.60
Water body								0.35	0.35
Grand Total	0.00	2.90	69.68	1.48	0.01	6.37	19.20	0.35	100

Table 30. Change matrix (% of total area) for the buffer zone in the period 2000–2005

2000	2005										
	Cleared land on peat	Crop land	Crop land on peat	Grass on peat	Logged-over swamp forest on peat	Settlement	Shrub	Shrub on peat	Undisturbed swamp forest on peat	Water body	Grand Total
Crop land		0.00									0.00
Grass on peat	0.00			2.25				0.65			2.91
Logged-over swamp forest on peat	0.47				66.96	0.01	0.03	2.15			69.61
Settlement						1.49					1.49
Shrub							0.01				0.01
Shrub on peat	0.24		0.20			0.04	0.07	5.82			6.37
Undisturbed swamp forest on peat					3.39		0.05		15.82		19.26
Water body										0.35	0.35
Grand Total	0.71	0.00	0.20	2.25	70.35	1.54	0.17	8.61	15.82	0.35	100

Carbon emission and sequestration from land-cover conversion

Table 31 presents the results of up-scaling carbon emission and sequestration from land-cover conversion per year per unit area of buffer zone, using the data in Table 27. In general, carbon emission of the buffer zone is significantly higher than carbon sequestration, but it is low compared to the rest of the area of the two subdistricts. From 1990 to 2000, the conversion of undisturbed swamp forest on peat to logged-over swamp forest on peat and shrub on peat (about 5% and 2% of the area, respectively) appeared to be the highest source of emission (3.04 Mg CO_2-eq ha^{-1} yr^{-1} and 1.90 Mg CO_2-eq yr^{-1}, respectively). For the 2000–2005 period, the rate of emission decreased by 20%. But conversion of undisturbed swamp forest (3% to logged-over swamp forest and 2% to shrub, respectively) was still the largest source of emission (3.82 Mg CO_2-eq ha^{-1} yr^{-1} and 0.71 Mg CO_2-eq ha^{-1} yr^{-1}, respectively).

Table 31. Carbon emission and sequestration of buffer zone

Location	Year	Net emission	Emission	Sequestration
		(Mg CO_2-eq ha^{-1} yr^{-1})		
Buffer zone	1990–2000	5.97	5.97	0.003
	2000–2005	4.78	4.78	0.002
Non-buffer zone[1)]	1990–2000	44.71	45.92	1.21
	2000–2005	8.63	11.60	2.97

1) *For the rest of the area in the two subdistricts including LRWR, the main source of emission is conversion of undisturbed forest into others type of land cover/use in the northern part of the area*

Simulation of land-cover changes

The slightly different land-cover classification system used for the FALLOW model scenarios led to a different representation of the past emissions: these were estimated to have been 7.30 and 5.86 (**Table 32**), rather than 5.97 and 4.78 (**Table 31**) Mg CO_2-eq yr^{-1}, respectively.

The baseline (Business As Usual or BAU) scenario, with full protection of remaining forest, predicted that the gross emissions would come to a halt in the 2005–2035 period and that the gross sequestration of 2.5 Mg CO_2-eq yr^{-1} would be approximately the net sequestration rate. The other scenarios are expressed by difference to this BAU, based on 'additionality'.

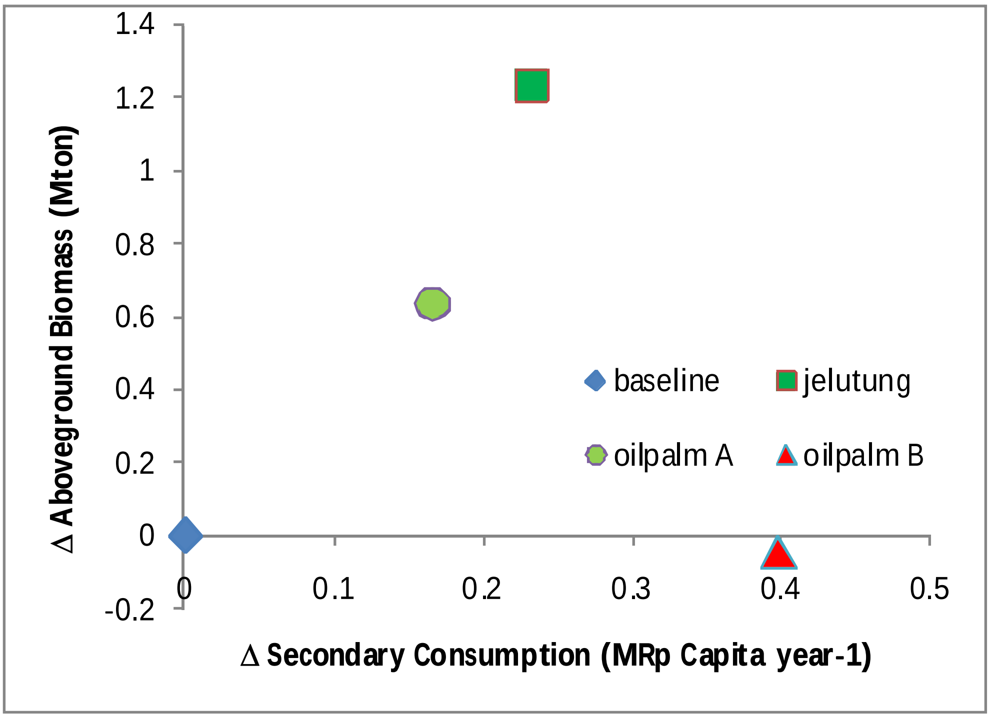
Averaged over 30 years, the *jelutung* scenario is expected to increase aboveground biomass around 1.2 Mt over the landscape, compared to the baseline (Figure 33). This is achieved largely through 'carbon stock saving', because fewer plots were converted for other livelihood options. The secondary consumption in this scenario is also expected to increase relative to BAU, by around 0.3 MRp $capita^{-1}$ $year^{-1}$ (Figure 33) owing to sales of NTFP to the market.

Introducing oil palm plantations as one of the livelihood options attracts farmers to clear plots in the area and this increases the economic level around 0.17 MRp $capita^{-1}$ $year^{-1}$ compared to baseline (Figure 33). Interestingly, the model also predicts a net increase in landscape-level carbon stock because fewer plots were opened for other livelihood options.

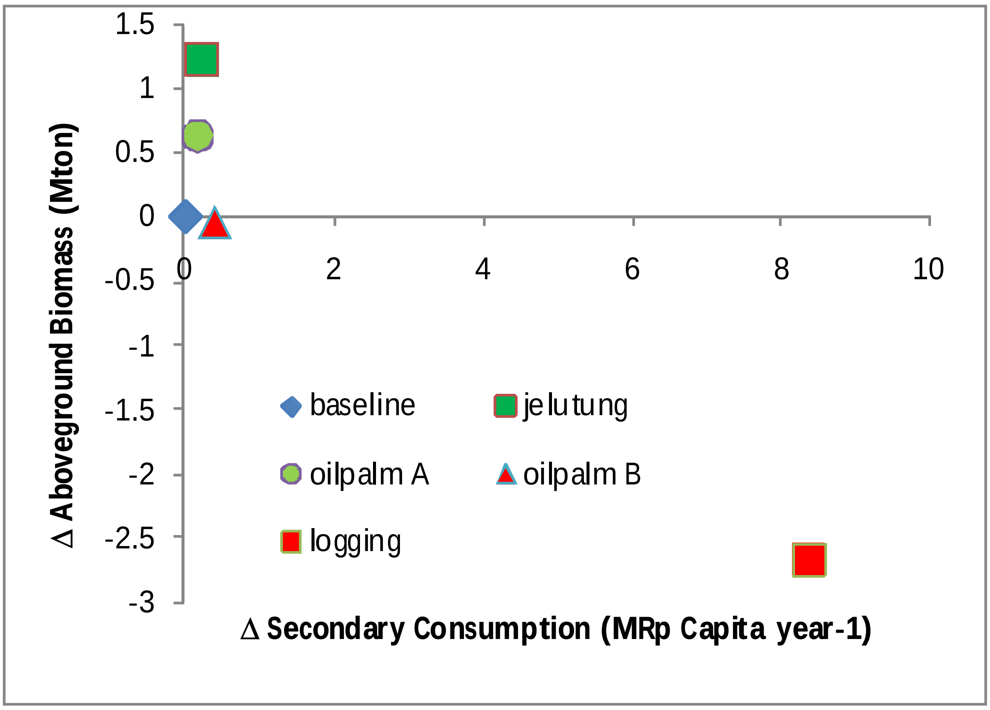
However, the 'green' scenario with Oil Palm A was turned into 'red' with Oil Palm B (Figure 33A). Despite the increase of economic level by 0.4 MRp $capita^{-1}$ $year^{-1}$ compared to the baseline (around doubled compared to Oil Palm A), the biomass value was less than the baseline because of the massive opening of the reserve and its buffer zone considered as forest reserve in other scenarios. High risk of fire spreading in the dry period potentially occurred in the massive opening area of peat. Forest fire was occurred a couple years ago in the middle part of buffer zone.

Due to a high price for logs, the secondary consumption level with logging scenario is highly superior to other scenarios (Figure 33B): illegal logging remains a very attractive option from a short-term local livelihood perspective. However, this increase was accompanied by a great decrease related to aboveground biomass because all forest plots (except the reserve and its buffer zone as forest reserve) were open for logging activities.

Figure 34 describes the final land-cover mosaic in the landscape related to the five scenarios. It can be noticed that the 'red' landscape occurs with the logging scenario and the reserve and its buffer zone mostly converted to oil palm plantation with Oil Palm B scenario.



A



B

Figure 33. Economic and ecological levels compared to the baseline scenario predicted by the FALLOW model with five three scenarios: baseline, *jelutung*, Oil Palm A, B and logging. The simulation was carried out for 30 years. Mton = Mega ton, MRp = million rupiah

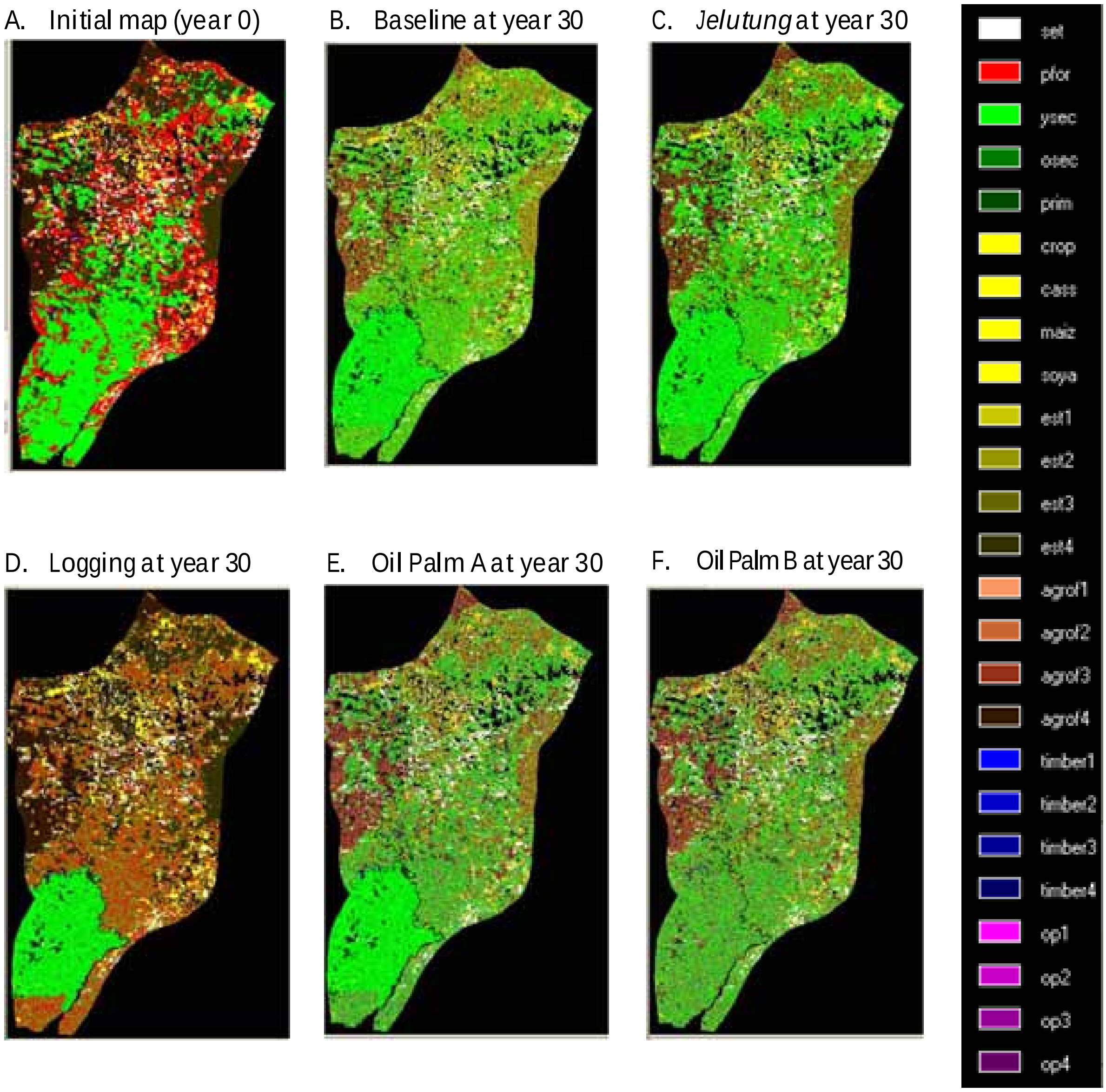


Figure 34. Final land-cover mosaics in two districts (Kotawaringin Lama and Arut Selatan) of Central Kalimantan estimated by the FALLOW model. The green area in the lower part of the map is the Lamandau River Wildlife Reserve and its buffer zone. Pfor = pioneer forest, ysec = young secondary forest, osec = old secondary forest, prim = primary forest, est = rubber plantation, agrofor = agroforestry (rubber dominated), timber = timber plantation (Gmelina arborea trees), op = oil palm

Carbon emission and sequestration rate of buffer zone after 30 years of simulation

Table 32 presents results of the simulation of various scenarios, showing the carbon emission and sequestration results for the buffer zone and its surroundings over a 30-year period. The results are based on land-cover type simplification while running the FALLOW model.

Compared to the emission rate presented in **Table 31**, simplification of land-cover type results in slightly different amounts of emission rates but produce the same trend for 1990–2000 and 2000–2005. Protecting the buffer zone significantly raised the sequestration rate in this area in any of the scenarios. In contrast, permitting oil palm inside the buffer zone significantly reduced the sequestration rate. Promoting *jelutung* trees significantly increases the sequestration rate, not only in the buffer zone, but also outside.

Table 32. Carbon emission and sequestration of the buffer zone and its surroundings under different scenarios

Location	Year	Net emission	Emission	Sequestration
		(Mg CO_2-eq ha^{-1} yr^{-1})		
Buffer zone: measured LU dynamic	1990–2000	7.30	7.30	0.00
	2000–2005	5.86	5.86	0.00
Buffer zone	2005–2035 (baseline)	-2.49	0.02	2.51
	2005–2035 (*jelutung*)	-2.58	0.01	2.59
	2005–2035 (logging)	-2.52	0.03	2.55
	2005–2035 (oil palm A)	-2.54	0.02	2.55
	2005–2035 (oil palm B)	0.54	2.09	1.55
Non-buffer zone[1)]	2005–2035 (baseline)	0.36	2.02	1.64
	2005–2035 (*jelutung*)	-0.89	1.20	2.09
	2005–2035 (logging)	0.84	1.50	0.66
	2005–2035 (oil palm A)	-0.005	1.75	1.76
	2005–2035 (oil palm B)	0.15	1.84	1.69

1) The rest of the area in the two subdistricts, not including LRWR

Conclusions

Based on the land-cover changes and carbon emission calculations, we conclude that the recent rate of land conversion and emission within the buffer zone has been much lower than that in the surrounding area. From 2000 to 2005, when the logging activities and timber extraction ceased, the rate of emission saw a 20% decrease. Avoiding further changes to undisturbed swamp forest can contribute to significantly reducing the emission rate. The high emission rate in the surrounding area points to the significant risks of 'leakage': activities to protect the carbon stock in the buffer zone can contribute to an increase of emissions elsewhere, unless labour is absorbed in the area, alongside carbon stock protection. The logical links between use of the buffer zone and the surrounding landscape need to be explored to interpret such patterns. The FALLOW model, even though its calibration to local conditions leaves much to be improved, suggests two quite different approaches.

1. Support for *jelutung* as NTFP in the buffer zone can be expected to absorb labour and provide returns to labour above the average for the landscape as a whole.

2. Promotion of oil palm on degraded, non-peat soils outside the buffer zone can absorb labour and reduce the pressure on relatively carbon-rich land-cover types.

The first of these two approaches is likely to be considered in a REDD+ project design for the buffer zone, the second requires a wider context of spatial planning, but may be at least as effective. Combinations of these approaches are feasible, but require a more detailed focus. The focus of the feasibility study on the buffer zone will need to be complemented by a broader understanding of the surrounding landscape in order to fully access additionality and leakage issues for a spatially targeted REDD+ pilot design.

Synthesis and options for REDD$^+$ design

Plans are underway to develop a proposal for a REDD+ pilot project for the buffer zone of the Lamandau River Wildlife Reserve. The overall aim would be to demonstrate how REDD+ projects can contribute to helping forest-dependent communities move out of poverty, conserve tropical forests and ensure real reductions in greenhouse emissions associated with land use, land-cover change and deforestation. This REDD+ feasibility study looked at the key aspects of reducing carbon emission and supporting sustainable livelihoods.

Socio-economics

The socio-economic study showed some farmer-dependent communities for whom access into the reserve and the buffer zone is critical for their livelihood. Local people have a tendency to migrate, change occupations and benefit from emerging opportunities. While logging provided the highest benefit (income) to the local people, its restriction meant people had to move to other jobs. *Jelutung* extraction, fishing and salvaging submerged timber are key economic activities. However, the overall dependency on forest resources around the reserve seems to have declined significantly over the last decade. For those people who rely heavily on the buffer zone and the reserve area, other livelihood options are still limited. The interest in farming activities is low as people prefer sources of quick income such as fishing, off-farm labour and oil palm work. Frequent flooding and sea water intrusion also make farming risky. Diversification of crops and planting of *jelutung* trees can be a good alternative since *jelutung* is well adapted to peat land. A program to increase *jelutung* trees inside and outside the buffer zone may also help the *jelutung* tappers who are normally landless. There are some local claims over land inside the buffer zone, but it appears people have accepted the land as a protected area. However, further clarification of the tenure status will be required for implementation of a REDD+ pilot project.

Carbon stock assessment

The carbon stock assessment indicates that the forests in the buffer zone contain rather low amounts of carbon compared to other forest systems. The area is dominated by peat of up to 4.5 m depth (average 1.3 m) and contain 841 t/ha of carbon. The aboveground carbon stock in the buffer zone is relatively small (77 t/ha of carbon in high density, logged-over forests. Compare this with a reported 230 t/ha of carbon in natural forest in East Kalimantan). With the current protection of the reserve and buffer zone, the carbon stock is increasing by 1.3 t/ha of carbon per year. Additional planting of trees, with locally useful trees such as *jelutung*, can increase the carbon sequestration rate. There is convincing evidence that guard posts are useful in reducing further degradation of forest resources. *Jelutung* is an economically important tree and its stock in the wild is rapidly decreasing. At present, the species contributes 4% to total biomass. There is potential to increase the stock of *jelutung* (by enrichment planting) in the buffer zone that can enhance both carbon stock and the income of forest-dependent people in the area.

Land use and land-use change scenarios

The land use and land-use change data indicate no significant change in land-cover types; and recovery in logged-over forests is gradually taking place. Any major change, such as establishment of oil palm plantations, may lead to large emissions of carbon. Scenario testing showed that additional *jelutung* can provide a better ecological and economic situation while oil palm plantation is the lowest carbon stock scenario.

Additionality

The protection of the reserve and the buffer zone since 2005 has significant positive impact on forest restoration, biodiversity conservation and carbon storage. It is unlikely that any REDD+ project will bring significantly more benefits to carbon stock and the carbon sequestration rate. Additional planting of tree species, especially in open and degraded areas may be beneficial. Compared to areas close to guard posts, further away areas seem to be suffering from additional degradation. Additional controls and guard posts may also have some positive influence.

Leakage and permanence

There are still some, but not a large number, of forest-dependent people for who access to forest is very important. For these people, tapping *jelutung*, fishing in the rivers and accessing the forests are important. However, these activities do not deplete carbon in any significant way. Illegal logging takes place, but not at a large level. However, if protection of forests is relaxed, there is a good possibility of increased logging as this is still seen as a good way to make quick money.

Options for REDD$^+$ design

Three 'flavours' (or paradigms) of the concept of Payments for Environmental Services (PES) have recently been distinguished (van Noordwijk and Leimona 2010). They have their counterparts in the REDD$^+$ efforts.

CES, COS and CIS deal in different ways with some of the major challenges in implementing REDD$^+$:

- Baseline or 'reference emission level': what emission level is accepted as 'business as usual'?
- Trust and threat: fairness and efficiency, can perverse incentives be avoided?
- Additionality of emission reduction: will REDD$^+$ lead to net global emission reduction?

- Control of leakage: how to deal with the spatial and temporal scaling of emission drivers?
- Trust in $REDD^+$ service providers

CES, COS and CIS: three flavours of $REDD^+$ as form of 'payment for environmental services' as piloted in Indonesia.

CES-$REDD^+$: current efforts by Australia, Germany and others to prepare sub-national REDD for emerging 'carbon markets' are running into a range of difficulties in '***C***ommo-ditizing ***E***nviron-mental ***S***ervices' (CES). CES requires clarity on non-contested ownership and non-overlapping land-use rights, as well as legality of threats to the environmental services, compatible with a strict additionality interpretation. It also requires a cost-effective certification system for divisible units of emission reduction.

COS-$REDD^+$: the proposals at national level to buy out concession holders (e.g. HGU swaps for oil palm on non-converted peatland to low carbon-stock lands) would '***C***ompensate for ***O***pportunities ***S***kipped' (COS). COS also requires clear land ownership and legality of threats to the environmental services, but can operate at a lower level of 'conditionality' as long as the government as provider of public funds achieves overall effectiveness goals.

CIS-$REDD^+$: the NAMA/LAAMA articulation of reference emission levels with '***C***o-***I***nvestment in ***S***tewardship' (CIS) achieving the goals and opportunities for additional emission reduction based on voluntary agreements. CIS can operate in situations where tenure security needs to be enhanced and can operate forms of risk and benefit sharing. It can lead to articualtion of locally appropriate adaptation and mitigation (LAAMA) actions that nest in nationally appropriate mitigation action (NAMA) plans, that are not restricted to forests per se.

Table 34 compares current understanding of the CES, COS and CIS concepts to $REDD^+$ (this is work in progress) and Table 35 summarises our findings for Lamandau in a $REDD^+$ value chain concept.

Table 34. Differences between CES, COS and COS paradigms in approaching spme of the key challenges of REDD + design

Challenge to REDD+	CES: C_{RED}'s as basis for internationa l ER off-set markets	COS: National offsets for opportunity cost	CIS: Co-investment in low emission devel-opment
Baseline or 'reference emission level' (REL)	REL is the primary bargaining target, by selective use of 'objective' arguments	Focus on voluntary or mandatory reduction of activities with high emissions per unit economic benefit	The NAMA/LAAMA commitment provides a (nested) REL, linked to the 'name' and desired 'image'
Trust and threat to ES	Increasing perceived threat (higher reference emission levels) enhances 'efficiency' for buyers and sellers and thus attracts investment; clarity of land/carbon rights is presumed and 'voluntary' action at 'right price'	Issue of land-use change (carbon emission) rights is crucial (no compensation for illegal threat); FPIC important for 'mandatory' schemes at fixed (non-negotiable) price	Building trust by sharing risk and responsibility is key; community scale control of illegal/ semi-legal threats are feasible
Control of leakage	All sub-national CES-REDD+ schemes need to be embedded in national responsibility for leakage, paid for by a risk-sharing tax (retribution)	The design of the scheme must be com-prehensive and include the main leakage risks	Leakage control must focus on the nesting of sub-national REL's + performance incen-tives at intermediate scales
Additionality of emission reduction	Off-sets are emission neutral, ER additionality depends on acceptance of deeper cuts by 'buyers'	National efforts can be supported by international fund, additional to off-set market	International investment can be linked to performance-based next steps

Table 35. Overview of issues that a full REDD+ design may need to address

<table>
<tr><td>Efficiency: short-term emission reduction</td><td>Sustainable livelihoods: long-term emission prevention</td></tr>
<tr><td>Threat to aboveground carbon stocks: stocks of 80 t C/ha can support emissions of 15 t CO2e/ha/yr for 15 years, with emission rate of 5%/year</td><td>Community involvement through joint management contracts for the buffer zone may be linked to carbon-stock protection</td></tr>
<tr><td>Threat to belowground carbon stocks: stocks of 800 t C/ha can support emissions of 35 t CO2e/ha/yr for 80 years upon drainage for oil palm and in absence of fire control</td><td>Promotion of jelutung regeneration and management by local claimants of tree tenure can provide high carbon-stock livelihoods</td></tr>
<tr><td>Control efforts: Current voluntarily supported control efforts have lead to ** low emissions</td><td>Stimulation of oil palm and rubber production outside biodiverse and carbon-rich parts of the landscape</td></tr>
<tr><td>Trust enhancement: More synergy is possible between community and government-based control</td><td>In coastal zone, options for synergy with climate change adaptation</td></tr>
<tr><td colspan="2">Emission and carbon stock monitoring
Priority data for reducing uncertainty in carbon stock estimates: focus on spatial distribution of peat depth; further plots in logged-over and agroforest can improve precision. Remote sensing interpretation has low uncertainty. Involvement of local stakeholders in tree monitoring may help in building local ownership.</td></tr>
<tr><td colspan="2">Additionality: reference emission level
An otherwise desirable increase in the official protection status of the buffer zone, as well as national expressions of intent to stop further conversion of peatlands to oil palm and pulpwood plantations, may reduce the perceived additionality of actual protection.</td></tr>
<tr><td colspan="2">Leakage control
The people currently using the buffer zone are mobile within the district and emission displacement is feasible if access to the buffer zone were to be restricted. Guided development of rubber and oil palm outside carbon- and biodiversity-rich areas may help to reduce pressure and could be part of overall development and district-level land-use planning.</td></tr>
<tr><td colspan="2">Carbon rights and registry
Local claims on traditional land-use rights are not very strong, but the tradition of jelutung management and tree tenure needs further study. The relationship between the reserve, buffer zone, NGOs and local government as potential proponents of a REDD^{+} pilot needs further discussion.</td></tr>
<tr><td colspan="2">Sharing of benefits and monitoring of implementation
Current government guidelines for sharing of net REDD^{+} incentives influence the perceived benefits of various tenure arrangements for the area. Providing sufficient benefits for a community-based management contract may be the key to low-cost implementation.</td></tr>
<tr><td colspan="2">Validation and auditing
The data of this feasibility study may need further replication in full project design stage.</td></tr>
<tr><td colspan="2">Salesmanship and investment
Current NGO-supported protection efforts cannot be supported purely on the basis of REDD^{+} goal attainment; the biodiversity value of LRWR as primary reason for interest in conservation of the area requires biodiversity-based co-funding of any REDD^{+} pilot effort.
Options for a co-investment CIS-REDD^{+} approach are stronger than those for a market-based CES-REDD^{+} or a government compensation scheme (COS-REDD^{+}).</td></tr>
</table>

Overall conclusions

The buffer zone of LRWR has an interesting and very dynamic history of intensive pressure, opportunistic and flexible communities and initiatives that are effectively protecting the wildlife reserve and the buffer zone. At present the biggest threat seems to be not from the forest-dependent people or the communities around the protected area, but from possible large-scale oil palm plantations. The idea has been discussed in the past and is still on the table.

Regarding the feasibility of a REDD+ project in the buffer zone, the potential benefits certainly exist, but such projects are unlikely to significantly improve carbon stock in the forests. A REDD+ project for the sole purpose of reducing carbon emissions may not be economically justifiable unless additional co-benefits of biodiversity conservation and livelihood improvement of the forest-dependent people as well as other communities living around the area are considered.

The study concludes that a REDD+ project may be feasible for the reserve's buffer zone if the following points are taken into account.

1. Logging, land clearing and burning inside protected areas can be strictly controlled (increased carbon accumulation).

2. *Jelutung* and other valuable trees (for example, Lagerstroemia species) in and outside the forests can be promoted (planting and protection for use) in order to help sustain livelihoods.

3. Local people are allowed to continue to fish, tap *jelutung* (in a controlled manner) inside the buffer zone (to avoid leakage and help sustain livelihoods).

4. Tenure status can be secured, preferably under community control (to reduce threat of conversion to oil palm plantation).

5. Tree-use rights can be enhanced separately from land rights.

6. Climate change adaptation elements at the coast are included.

7. National and international rules (NAMA-GAMA) allow for the multifunctionality and additionality conundrum.

8. Various sectors of the forestry and agriculture agencies can agree on local action leading to the national aim of reducing carbon emissions (LAMA-NAMA links).

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The buffer zone of the Lamandau River Wildlife Reserve is part of a landscape with an average human population density of 40 km-2 (three times the average for Central Kalimantan province). The buffer zone is used for fishing and small-scale extractive activities and is one of the main production areas of jelutung (Dyera costulata) trees in Indonesia. Jelutung are managed through a locally recognized tree-tenure system. Nearly a fifth of the people in four surrounding villages reported involvement in activities inside the buffer zone, dominantly (82%) as jelutung tappers. The majority of jelutung tappers, however, are landless people from other sub districts. The average aboveground carbon stock of the current vegetation is 84 t/ha plus 840 t/ha belowground in the peat soil. Current threat levels to this carbon stock are modest but the existing forest classification allows conversion to oil palm or fastwood plantations; companies interested in oil palm conversion have made applications to local government.