PROJECT FINAL REPORT

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Name of the scientific representative of the project's co-ordinator[1]**, Title and Organisation:**

Ole Mertz, Professor, University of Copenhagen

Tel: +45 3532 2529

Fax: +45 3532 2501

E-mail: om@ign.ku.dk

Project website[2] **address:** www.i-redd.eu

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.
[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

4.1 Final report

4.1.1 Executive Summary

The negotiations under the United Nations Framework Convention on Climate Change have since 2005 included considerations of a mechanism that could ensure reduced greenhouse gas emissions (GHG) by reducing deforestation and forest degradation and by enhancing forest carbon stocks (REDD+) in developing countries. Although REDD+ is often listed as one of the most successful negotiation topics at the Conferences of the Parties (COP) – most recently reiterated at the COP20 in Lima, Peru in December 2014 – an international agreement has yet to be reached. While this lack of agreement is mainly political, on the scientific side, there is also a range of inherent obstacles for the implementation of REDD+.

The EU-FP7 funded I-REDD+ project has been addressing some of these obstacles by obtaining better understanding of how the implementation of REDD+ mechanisms:

1) may reduce emissions of greenhouse gases and maintain or enhance existing stocks of carbon in vegetation and soil of various land cover types;
2) will impact livelihoods, welfare and equity in local communities with forest-based economies;
3) can ensure equitable benefit distribution in different governance settings; and
4) can be monitored efficiently by both remote sensing and participatory approaches.

I-REDD+ focused specifically on forest degradation and worked in the uplands of Southeast Asia, more specifically in Yunnan, China, northern Laos, northern Vietnam and Kalimantan, Indonesia. The main results of I-REDD+ work show that belowground biomass has been underestimated in shifting cultivation landscapes and the new allometrics developed are needed for improved carbon accounting during land use changes in such areas. Monitoring of carbon stock changes in these dynamic landscapes is possible and cost-effective with community involvement and this could also reinforce the provision of control rights to local communities as the current governance schemes related to benefit distribution mechanisms are mainly top-down and not ceding anything but use right to the local level. Satellite based forest monitoring will be essential for REDD+ and while our results show limitations for the use of SAR for deriving historic baselines, new approaches with dense Landsat image time series are able to capture detailed forest changes in dynamic landscapes. At the national level, MODIS combined with high-resolution data is promising, even if some fine-scale information in mosaic landscapes are not captured by MODIS alone. Finally, we have demonstrated both with local case studies and more theoretical approaches that, due to the extremely high opportunity costs of other land uses and the difficulty of predicting regime shifts in land use, it will be very challenging to implement effective REDD+ in terms of actually reducing GHG emissions.

The results of I-REDD+ have already been widely disseminated, both at various consultations and conferences in the Southeast Asian partner countries and at the UNFCCC COPs 18-20 and at other international events as mentioned above. Thus, I-REDD+ results are already likely to be considered in policy-making at national level in Southeast Asia and at the international REDD+ negotiations.

4.1.2 Project context and objectives

The negotiations under the United Nations Framework Convention on Climate Change have since 2005 included considerations of a mechanism that could ensure reduced greenhouse gas emissions (GHG) from land use change in forest rich developing countries. This mechanism started with a focus on Reducing Emissions from Deforestation (RED), but it was soon realized that forest Degradation was equally important (REDD) and later again the prospects for enhancing forest carbon stocks were also included as a plus (REDD+). REDD+ was in the early stages of negotiations assumed to have a range of co-benefits such as improved livelihoods and biodiversity conservation, but it was questioned whether these benefits would in reality occur and a range of so-called safeguards were included. Thus, currently (February 2015) REDD+ is known as 'Reducing emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries'.

Although REDD+ is often listed as one of the most successful negotiation topics at the Conferences of the Parties (COP) – most recently reiterated at the COP20 in Lima, Peru in December 2014 – an international agreement has yet to be reached. There are signs of increasing political commitment as funds for a donor-driven mechanism are being made available. On the other hand, political difficulties and sceptical parties to the negotiations caused yet another postponement of the negotiations and concern that it will be difficult to reach an agreement at COP21 in Paris in 2015. On the scientific side, there are both good and bad news as technologies are increasingly improving to, for example, ensure effective monitoring of REDD+, but at the same time there is an increasing amount of scientific evidence that points to inherent difficulties in the implementation of REDD+. Some of these challenges and opportunities of REDD+ have been identified by the EU-FP7 funded I-REDD+ project, which is contributing with an interdisciplinary approach to resolving issues that are necessary for REDD+ to become successful.

The objectives of I-REDD+ were to enhance the understanding of how the implementation of a REDD+ mechanisms:

1) may reduce emissions of greenhouse gases and maintain or enhance existing stocks of carbon in vegetation and soil of various land cover types;
2) will impact livelihoods, welfare and equity in local communities with forest-based economies;
3) can ensure equitable benefit distribution in different governance settings; and
4) can be monitored efficiently by both remote sensing and participatory approaches.

Moreover, a main objective has been to inform national and international policy arenas on the impacts of proposed REDD+ policies.

Other REDD+ projects have had a strong focus on the humid tropical lowlands. In I-REDD+, we focused specifically on forest degradation in the upland forest-agriculture frontiers of Southeast Asia. Field sites were located in Xishuangbanna Prefecture of Yunnan Province, China; near the National Protected Area Nam Et Phou Loey in Huaphan Province, Laos; in Con Cuong District, Nghe An Province, Vietnam; and in Kutai Barat District, East Kalimantan, Indonesia (Figure 1.1). These sites represent gradients in terms of ecological conditions, economic development and governance structures and the specific field sites are all characterized by being dominated currently or in the very recent past by shifting cultivation. They are all experiencing land use changes but in different ways and at different pace. In the Chinese sites, much of the forest and former shifting cultivation land have already been converted to rubber plantations. Forests remain at higher altitudes and it is interesting to see what the fate of rubber plantations will be if the current low prices of rubber remain. In the Vietnamese sites, shifting cultivation has also almost ended and been replaced by forest plantations and natural forest regrowth. In the Lao sites, traditional shifting cultivation is still practiced with forests in many stages of regrowth, but cash crops such as hybrid maize are changing this system rapidly. Shifting cultivation is also still present in the Indonesian sites although strong pressure from timber, oil palm and mining companies is likely to accelerate already occurring land use changes. All sites are particularly interesting from the point of view of reducing emissions from forest degradation as remaining forests are degraded from their natural state either by timber extraction or by shifting cultivation that has created a mosaic landscape with secondary forests of many different ages.

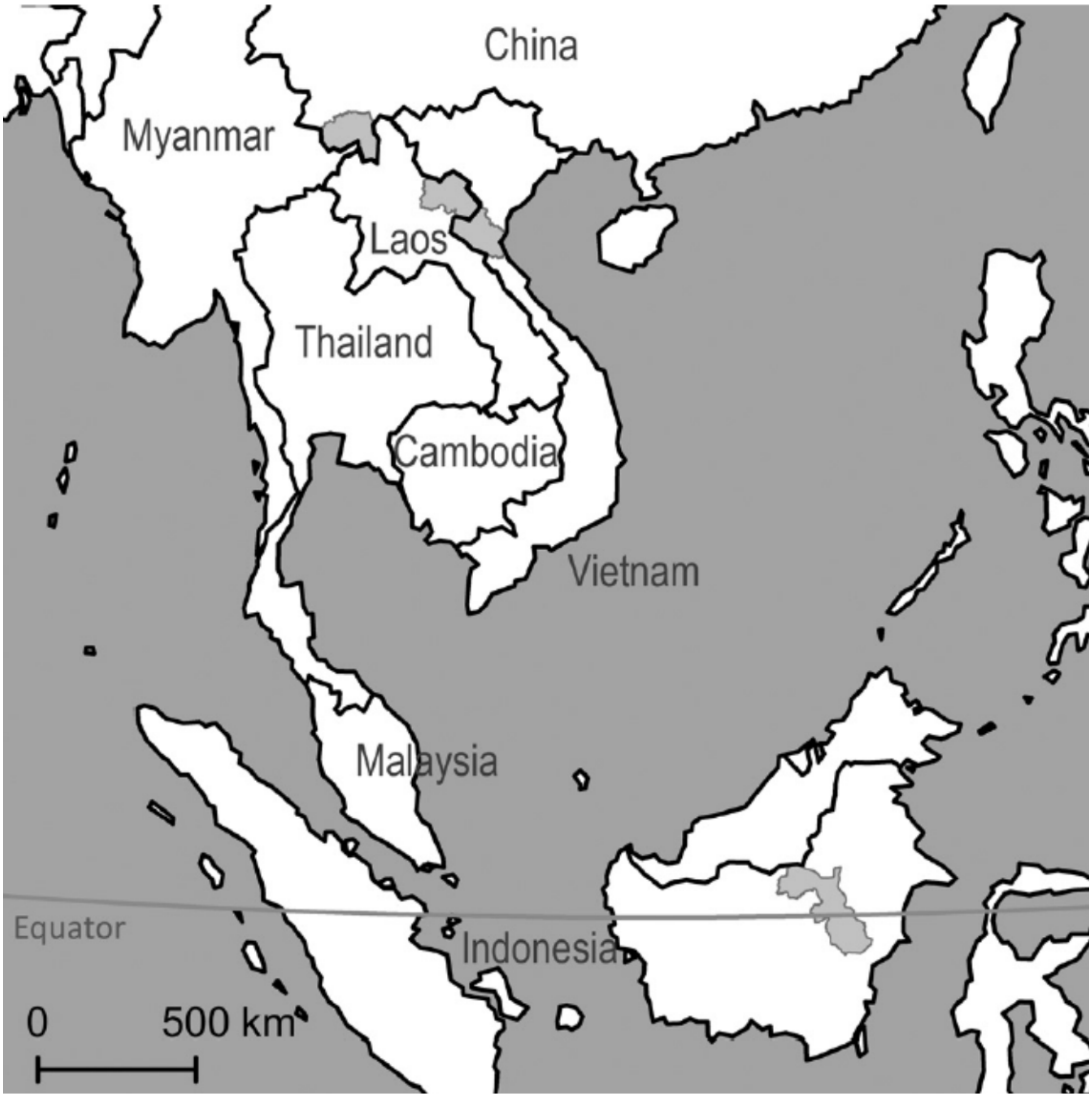

Figure 1.1: I-REDD+ field sites in Southeast Asia indicated with grey shading.

Thus, Southeast Asia represents a region where REDD+ activities will be implemented amidst complex land use systems, tenure regimes and, possibly, conflicting interests. It is also a region where forest and land use transitions are occurring at a rapid speed and there are potentially high gains to be made from REDD+ in terms of avoided emissions of GHG while local costs could also be high if payments do not compensate adequately for alternative income sources.

The specific objectives of I-REDD+ have thus been to develop and test methods for:

1. Quantifying GHG emissions and removals from the dominant forest types and agricultural systems in the study areas. These include secondary successional vegetation – e.g. grass and bushes, young open-canopy tree communities, and mature closed-canopy tree communities. The project proposed to analyse all five approved C-pools (above- and belowground C-stocks in vegetation, litter, dead wood and soil C-stocks) and fluxes of non-CO_2 GHGs in order to understand the trade-off between effort and accuracy which is crucial to the cost-effective implementation of REDD+.
2. Developing remote sensing and community based methods for monitoring of land use change and C-stocks in areas with forest and alternative land use systems.
3. Assessing potential disbursement mechanisms for REDD+ payments under different global payment scenarios and different governance and institutional structures in the case countries.
4. Assessing the benefits and costs of REDD+ for livelihoods at local levels (REDD+ rent vs. opportunity and transaction costs) as well as socio-cultural 'costs' of changing lifestyles and development pathways.
5. Developing and testing a monitoring, reporting and verification (MRV) system within five critical areas of relevance to REDD+: GHG emissions, land use change, forest resources, governance, and livelihood impacts. This objective was modified as developing and testing MRV systems were not relevant since implementation of the REDD+ projects that I-REDD+ had planned to follow in the study areas was delayed and has yet to start at the time of writing.
6. Informing the development of future REDD+ implementation policies in the light of the above, including their feasibility given the opportunities and constraints of methods and the new knowledge obtained.
7. Investigating country-specific differences and develop approaches that are appropriate in a range of different institutional, political, and socioeconomic settings.
8. Disseminating the methodological advancements and thematic insights to local, regional and national and international stakeholders through training, collaboration and publications of policy briefs, guidelines, and high-impact journal publications. The international policy arena negotiating the REDD+ mechanism is a specific target for I-REDD+ dissemination such as UNFCCC conferences of the Parties (COPs).

The main challenges related to these objectives were outlined in an overview paper that set the point of departure for the project activities (Mertz et al. 2012).

4.1.3 Main results

The work in I-REDD+ has been divided into seven work packages of which six have been producing new science and one has been responsible for management and dissemination (see Figure 1.2). The results of the project will be presented according to the six scientific work packages.

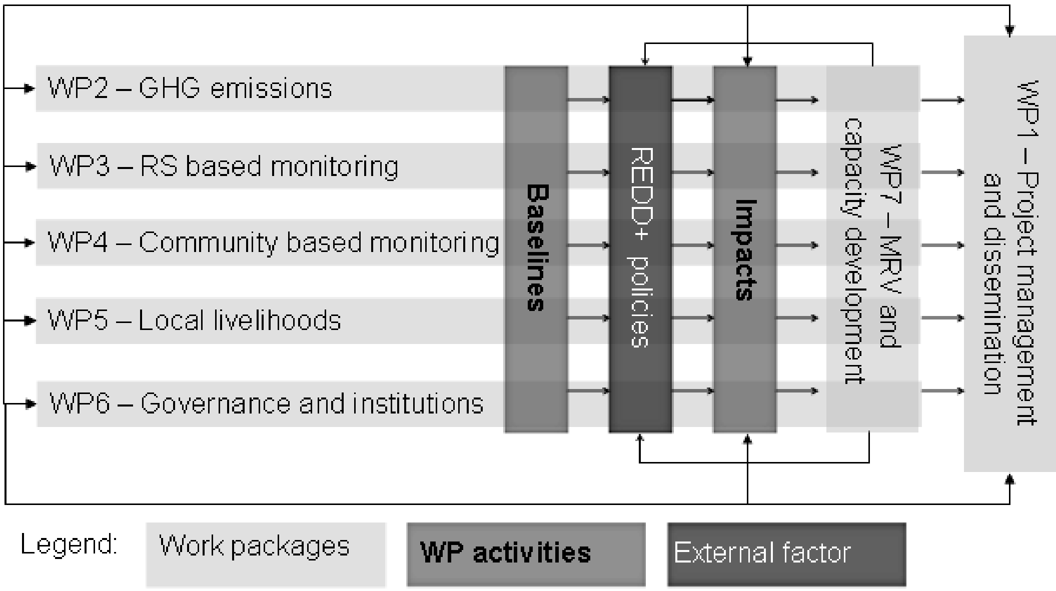

Figure 1.2: Conceptual Framework of I-REDD+ with work packages and their linkages.

4.1.3.1 GHG emissions from vegetation and soil

The specific objectives of this work were to:

1. Assess suitable proxies that may provide accurate and cost-efficient alternatives to standard methods of carbon measurement and to evaluate the potential of existing cost efficient methods of carbon determination.
2. Obtain a better knowledge of the expected reductions in GHG emissions from different types of forests which may be subject to a REDD-mechanism.
3. Develop local research capacity within measurements of GHG emissions and carbon storage.

I) Development of lacking allometric relationships including root biomass

To develop the allometric model, we measured and weighed the total biomass of 150 trees with stem diameters ranging in size from 2 to 35 cm. Sampling was carried out in December 2012 and January 2013. The measurements made were used to develop models relating stem diameter to the total biomass of tree stems, branches, leaves and roots. We compared our models to models from other single site studies carried out in upland SE Asia and generalized allometrics, and this revealed that generic tropical allometric equations may overestimate above-ground biomass and underestimate below ground biomass in swidden fallows of northern Laos (Figure 2.1). We therefore recommend the use of our allometrics, or other locally derived models if these are available, for estimating total biomass of trees in swidden fallows of upland Southeast Asia. (McNicol et al, in preparation; Rutishauser et al. 2013).

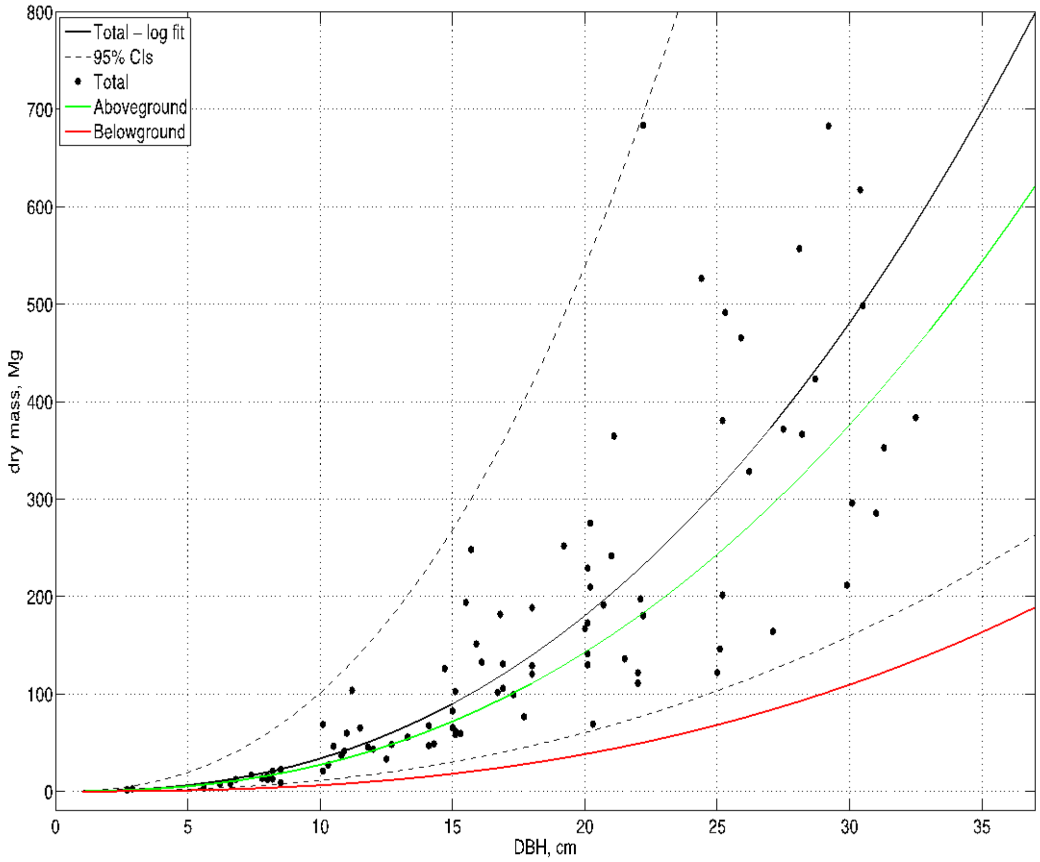

Figure 2.1: The relationships between total above- and below-ground biomass and diameter of the trees. Total biomass, from destructive samples of 100 trees in swidden fallows.

II) Validation of existing carbon stock estimates

Data set from extensive sampling of soil and vegetation in Indonesia and Laos form the basis of this study that shows a much lower influence of land use/land cover on below-ground carbon pools than above ground, and also lower than what is commonly reported in the literature (Figure 2.2). While we do not suggest that soil carbon is non-affected by land use changes, it does suggest that mild disturbances, as commonly found in shifting cultivation areas, have lower impact on soil carbon than the literature may suggest. Additional data from a rubber transect (Figure 2.3) confirm these results (Berry et al. in preparation; Hergoualc'h et al. in preparation; Bruun et al. in preparation).

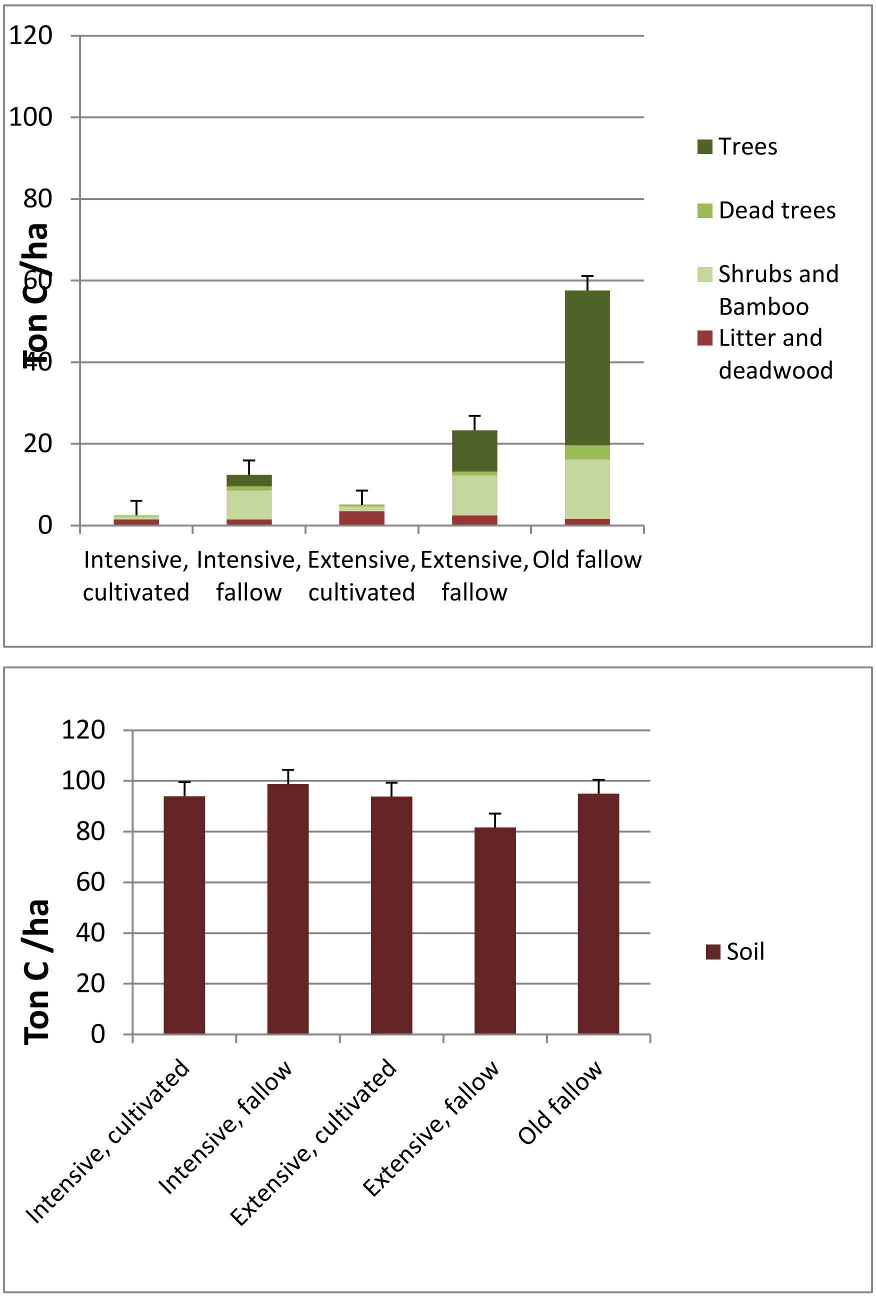

Figure 2.2: Above ground and soil organic carbon stocks in different elements of a mosaic landscape under shifting cultivation in northern Laos. The land use effect on soil organic carbon stocks is marginal and smaller than inter-plot variation within the same land use. Note that "Old fallow" is a disturbed, long fallow with low tree biomass. "Intensive" systems are cultivated on a 4-year rotation; "extensive" systems are cultivated every 7 years. "Fallow" fields were sampled just before clearing, "cultivated" were sampled during cultivation of upland rice.

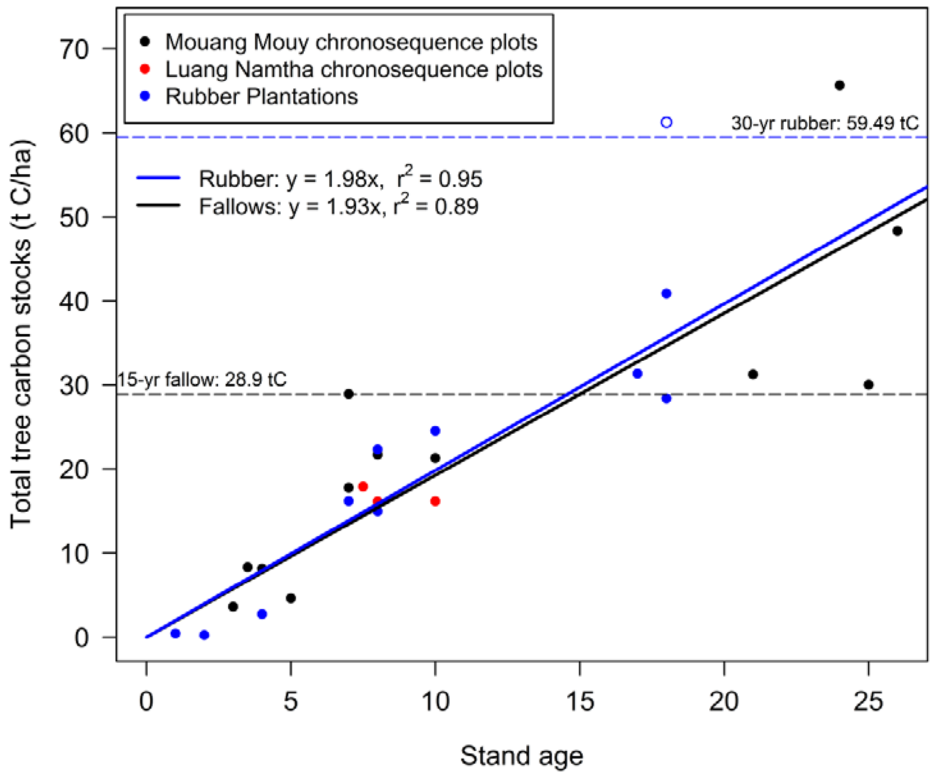

Figure 2.3: Total tree carbon stocks (above- and below-ground carbon stocks) in the rubber plantations of Luang Namtha (LN), and the swidden fallows of both Luang Namtha and Muong Muoy (MM). The recovery trajectory of fallows in LN appears to be similar to the plots in MM suggesting that these can be used to fill the fallow regrowth data gap in LN and thus calculate time-averaged C stocks. Linear models best captured the growth/recovery patterns for both the rubber plantations (1.94 tC/ha/yr-1) and swidden fallows (1.93 tC/ha/yr^{-1}), respectively, with 30-yr old rubber plantations expected to store 58.2 tC/ha, with 15-yr old fallows storing 28.9 tC/ha. Statistical outliers not included in model fitting shown as open circles. The inclusion of the two old (~25yr) fallows in the MM chronosequence which appear to be clear outliers, and are indeed classed as statistical outliers based on cooks distance, did not significantly alter the model coefficients when removed and so have been included.

III) Cost efficient techniques for assessment of carbon storage in soil and vegetation

This work required three types of contributions. Firstly, the newly developed allometrics that include below ground biomass are important for cost-efficient carbon accounting; secondly, the data on stocks and their variability yield considerable guidance to which approaches are relevant to pursue; thirdly, fundamental work on correlations between land use and various soil carbon fractions or their proxies were tested. Specifically, we investigated the permanganate oxidisable (POX) C fraction as a more labile C pool, reflecting changes in carbon stocks better than total soil carbon.

Overall, the results point towards significant challenges in quantifying both above and belowground stocks in upland mosaic landscapes. The combination of high spatial variability, with relatively small plots of homogenous land use (hence the mosaic landscapes), makes accurate assessment of carbon stocks at the plot level extremely challenging, particularly for below ground carbon stocks (Table 2.1), where soil texture, topography, previous erosion events etc. most likely play a larger role for the C stock, than for the above-ground biomass (Figure 2.4). The combined effect of high spatial variability and small plots results in inherent variation (CV values) of around 20% for above ground biomass, meaning that more accurate predictions, based on similar land use, are not possible to achieve – the variation between similar plots is simply that large (Figure 2.4).

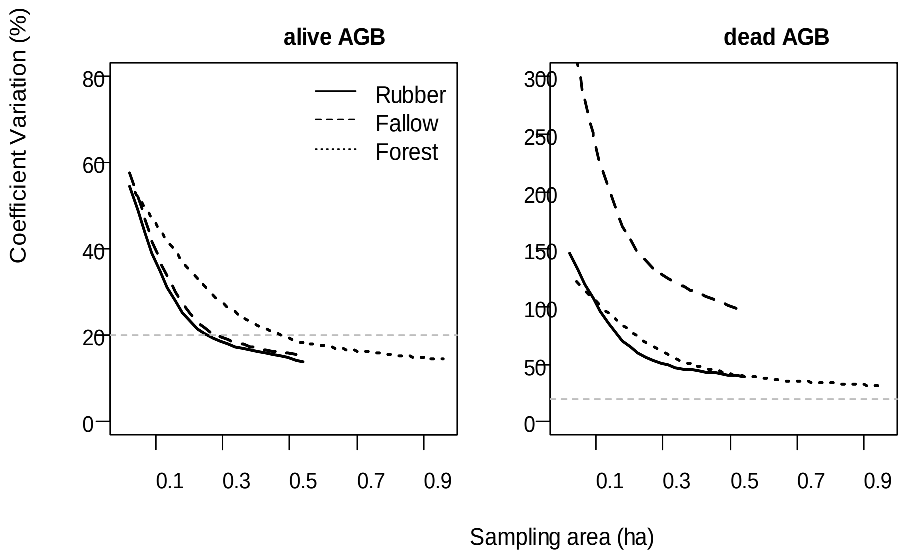

Figure 2.4: Coefficient of variation (CV) for estimates of various carbon fractions across three land uses in Kalimantan (AGB: above ground biomass).

For soil C pools in rice, fallows, forest and rubber, increasing sampling intensity from 5 samples per 3*6 meter plots to 14 samples in the same plots, did not uniformly reduce variability of the estimate (Table 2.1). In a few cases, the soil C concentration was measured to be significantly different between the two samplings, although performed at the same time in the same plots. Similarly, when converted from soil C concentrations to full-profile C stocks, estimates for forest and rice plots were significantly different between the two sampling intensities, and variation was not reduced by increasing from 5 to 14 soil cores within the plot.

Table 2.1: Total soil carbon stock (Ton per ha) across four land uses with Standard deviation and CV. For Intensive sampling (14 cores pr 18 m^2 plot), CV is highlighted in **bold** when lower than for standard sampling (5 cores pr 18 m^2 plot). T-test indicates significant difference between the 2 estimates, indicated in **red** when below 10% likelihood that the estimates are identical.

	Intensive sampling			Standard sampling			
	T C ha^{-1}	Standard deviation	CV	T C ha^{-1}	Standard deviation	CV	T test
Rubber	68,10	13,48	20	72,22	6,92	10	0.59
Fallow	61,72	11,63	19	58,37	9,14	16	0.53
Forest	77,64	12,14	16	67,88	7,35	11	**0.09**
Rice	52,23	8,07	15	60,98	8,40	14	**0.06**

For POX-C, we demonstrated that charcoal from biomass burning only has minimal impact on the values, hence the method is technically suited to use in mosaic landscapes with frequent impartial or low temperature fires, where charcoal can be expected to contribute a significant part of the soil C pool (Hepp et al, in preparation). However, the usefulness of POX-C as a labile soil C indicator, being more sensitive to land use and hence acting as a short-term indicator of longer term trends in soil carbon is still disputed. Comparison of POX-C with total C across a range of land uses generally showed good correlation between the two, suggesting that POX-C can be used as proxy for total C, i.e. can be used locally and at lower costs (Figure 2.5). However, the ambition that POX-C serves as an early and more sensitive indicator of land use induced changes in soil C stocks was not fulfilled.

Rather, the highest POX-C to soil C ratios were found in rice fields at low C content, suggesting a large contribution of fresh residues to the POX-C measurement (Hepp et al, in preparation).

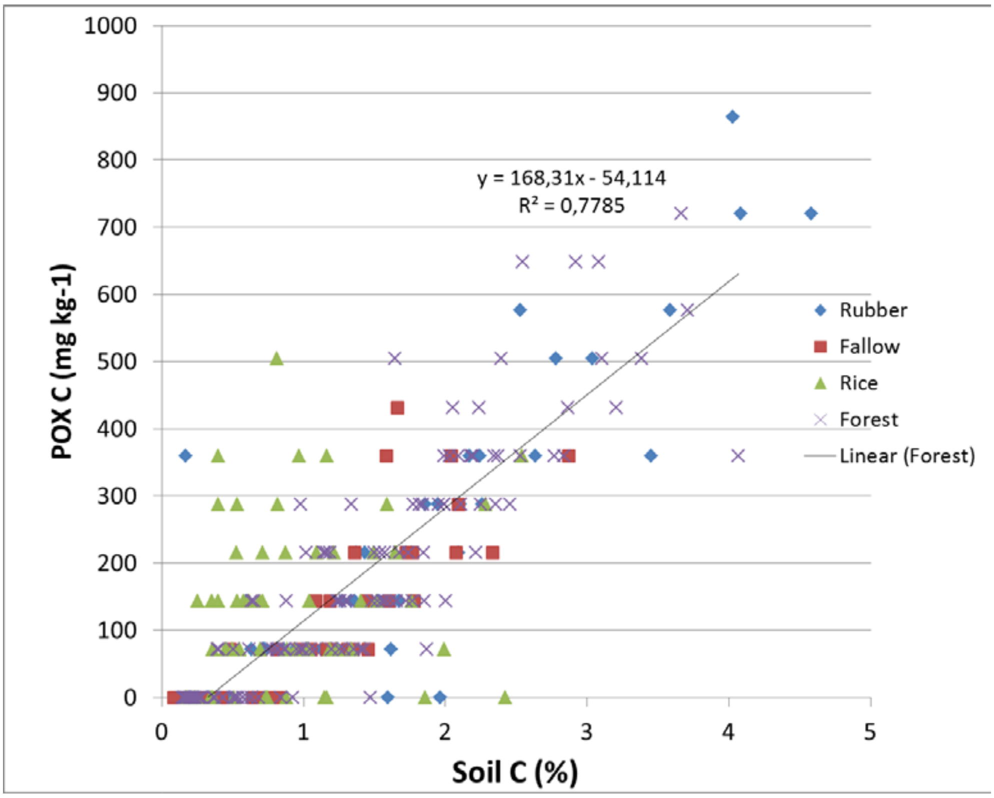

Figure 2.5: POX-C as function of soil C in four land uses in Kalimantan, Indonesia in top 20 cm soil (0-5, 5-10 and 10-20 cm layers). Linear regression for forest plots are shown in graph.

In conclusion, the results point towards significant obstacles in obtaining reliable estimates of above and below-ground C pools, and the challenge appears significantly greater in these mosaic upland systems, than in soils in general. The implications for MRV in a REDD context are the following:

- Accurate estimates on plot level will be extremely labour intensive and expensive to achieve
- Extrapolation of C density from plot to plot (with the same land use) is likely to be inaccurate
- For below-ground carbon pools, development of proxies or low-tech estimates will have limited relevance, due to the extremely high micro-variation in Carbon concentration within plots.
- Hence, carbon credits and changes in carbon density should be handled at a landscape level, average effects across a large number of plots, in order to reduce variability. Consequently, incentives should be activity based, rather than performance based, as C stock increments at the land user level will be highly variable, under similar land uses.

IV) Predictive model of the response of carbon in soil and vegetation to land use change

This work is based in intensive sample collection of above and belowground biomass as well as soil organic carbon in shifting cultivation systems in Laos (Berry et al, in preparation). Across the region there is a move towards segregation of landscapes into areas for intensive production and protected forests with the aim of reducing greenhouse gas emissions, reducing poverty and enhancing biodiversity. The carbon outcomes of these types of land use transitions are uncertain however, and the role of shifting cultivation landscapes in an international REDD+ mechanism is unclear. We developed a simple modelling approach (Figures 2.6 & 2.7) that can be applied to estimate time-averaged carbon stocks under different intensities of shifting cultivation, and apply this to scenarios of increased and reduced intensity of land use within a shifting cultivation landscape in Laos.

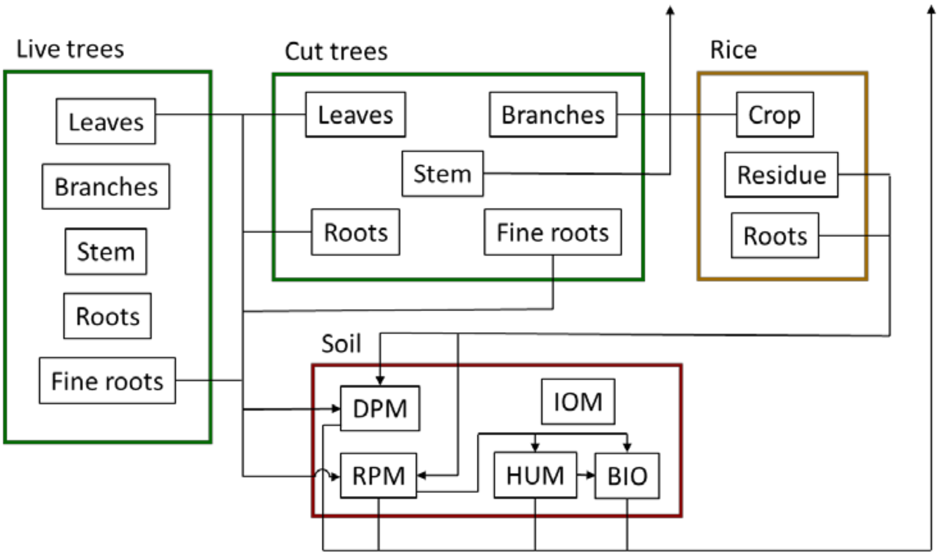

Figure 2.6: Annual carbon stocks and flows included in the modelling approach. Boxes indicate carbon stocks and arrows indicate a partial or complete flow in the year in question. Arrows that do not connect to a stock indicate a CO_2 emission. In a given year the tree component of the model is made up of either live trees or cut trees. In the soil component DPM = Decomposable plant material; RPM = Resistant plant material; HUM = Humified organic matter; BIO = Microbial biomass; and IOM = Inert organic matter.

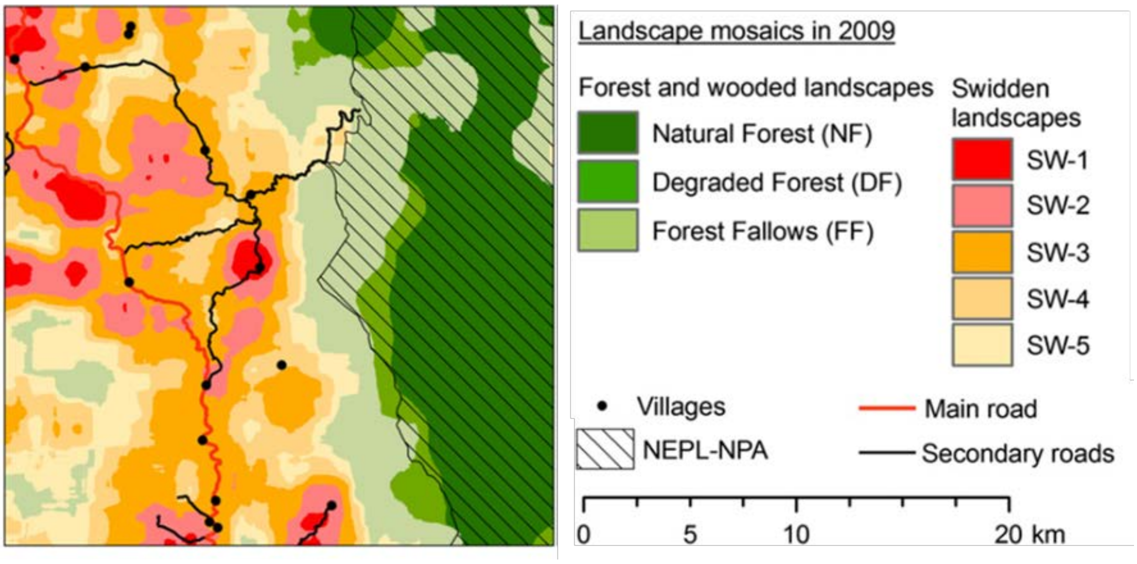

Figure 2.7: Land use intensity in the study area in 2009 described using a landscape mosaic approach (reproduced from Hett et al. 2012). Shifting cultivation landscape categories indicate intensity of cultivation, ranging from continuous (SW-1) to fallow periods longer than 15 years (SW-5). The area to the east of the study area, marked NEPL-NPA is the Nam-Et Phou Loey National Park.

The changes in carbon stocks described in our scenarios highlight the differences in time-averaged carbon stocks in tree and crop biomass under different types of management (Figure 2.8). More significantly, however, they provide one of the first attempts to describe changes in soil carbon stocks in shifting cultivation systems of upland Southeast Asia with a process-based model. Changes in soil carbon stocks are difficult to assess directly, so this type of modelling approach provides an important insight into the changes in soil carbon stocks that can be expected to result from changes in management of shifting cultivation areas. The results are as expected as increasing intensity of land use results in net carbon loss while reducing land use intensity results in net carbon uptake from the atmosphere. The quantification of these emissions and removals introduces the possibility for incorporating the carbon fluxes associated with land use change within shifting cultivation landscapes into performance-based mitigation finance mechanisms such as REDD+.

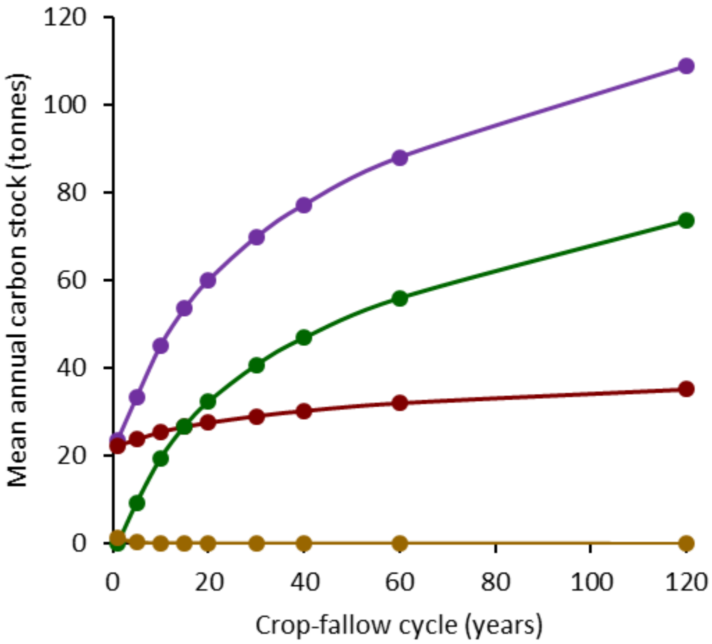

Figure 2.8: Relationships between crop-fallow cycle and 120 year average annual carbon stocks in trees (green), soil organic carbon (brown), crops (yellow), and trees, soil and crops combined (purple), derived from simulation of shifting cultivation systems with different crop-fallow cycles.

The potential for enhancement of carbon stocks within shifting cultivation landscapes is particularly relevant, and should encourage the inclusion of areas with shifting cultivation within the wider group of land use management types deemed eligible to receive support from REDD+ financing. The magnitude of increases in time-averaged carbon stocks that result from changes in management, which ranged from 8 Mg C ha^{-1} to 39 Mg C ha^{-1} for the transitions in our example landscape, may not be as great as emissions associated with clearance of undisturbed forest areas; but changes in management across the large areal extent of the shifting cultivation landscape can result in considerable emission reductions, especially in comparison to the limited area of forests that might be managed for REDD+. In our 67,600 ha study landscape there was the potential for an accumulation of 147,474 Mg C with a reduction in land use intensity, which is equivalent to a removal of more than half a million tonnes of carbon dioxide from the atmosphere. This is likely to be a conservative estimate of the mitigation benefits from reducing intensity of shifting cultivation, since our model did not account for declining soil fertility that would be likely to affect regeneration with short crop-fallow periods.

A REDD+ mechanism that incentivises less intensive use of shifting cultivation landscapes, and helps compensating for any reductions in food supply, could therefore make an important contribution to efforts to improve livelihoods, and benefit biodiversity as well as contributing to climate change mitigation. Our results highlight the opportunity for REDD+ to directly benefit communities that practice shifting cultivation, rather than providing further incentive to replace diverse multifunctional landscapes with segregated and homogenised land uses.

V) Greenhouse gas emissions from oil-palm on mineral soils in Indonesia

In addition, to the deliverables mentioned above, the WP has performed a greenhouse gas sampling scheme from oil-palm on mineral soils in Indonesia. Already early in the project phase, non-CO_2 GHG emissions from fertilised plantations were identified as a likely hotspot in the project areas. Consequently, WP2 has developed and tested a large-chamber sampling technique from oil-palm plantations across gradients of fertilisation and recycled organic material from oil-palm processing (empty fruit bunches, POME etc.). After the first sampling round, presented in the previous period report, an additional sampling cycle to investigate the role of rainfall and soil moisture content on emissions have been completed. Soil carbon stocks at different locations in smallholder and commercial plantations were also measured (Figure 2.9), demonstrating significantly higher C levels from commercial plantations, and even higher from best management practice (fertiliser, pruning and residues recycling) plantations. The data are currently being prepared for publication (Rahman et al, in preparation).

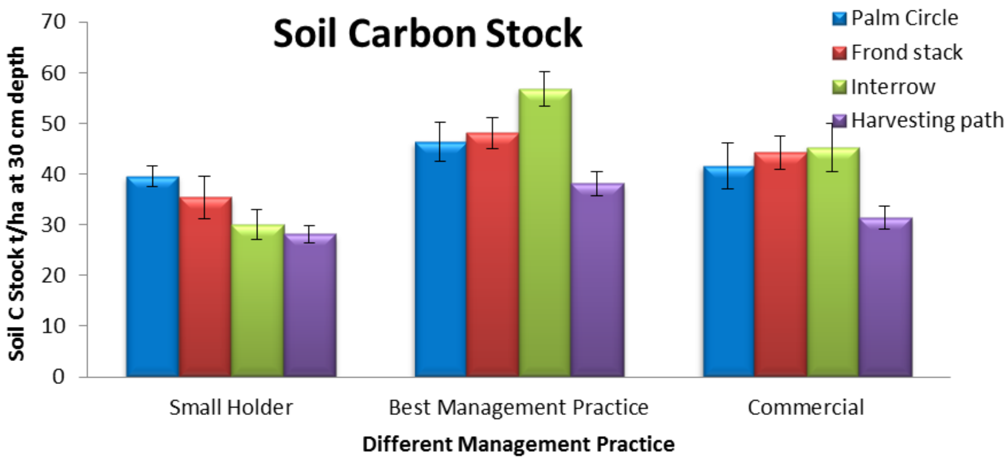

Figure 2.9: Soil carbon stocks in topsoil of oil-palm plantations on mineral soil in Indonesia, Sumatra. Smallholders are individual smallholder farmers, Commercial from large commercial plantations, and Best Management Practice from Bah Lias experimental research station. Best Management Practice indicates optimal fertilisation, pruning and residue recycling to plantations. The four pillars within each land use indicate soil sampled from different locations within the plantations.

4.1.3.2 Remote sensing based monitoring of change in land use and biomass

The specific objectives of this work were to:

1. Establish state-of-the-art and nested remote sensing approaches for REDD projects.
2. Specifically define the potential role of future hyperspectral satellite missions in forest monitoring at tier 2 level.
3. Propose an approach for ongoing monitoring of above ground carbon stocks through remote sensing tools such as combined optical and SAR satellite data.
4. Identify main patterns of deforestation present in each project area based on linking remote sensing derived results with expert knowledge.
5. Identify main patterns of forest degradation present in each project area based on linking remote sensing derived results with expert knowledge.

6. Link deforestation and degradation extracted from tier 2 conform satellite images to actual carbon density.

I) Regional scale monitoring and carbon stock estimates

This work involved several sub-tasks at each test site: a) develop and report maps and statistics of current land cover and land use, b) regional analyses of forest cover and related land-use changes, and c) integration of Landsat data and SAR data. The results are summarized below:

a) A harmonized land cover legend to enable consistent comparisons of land cover across all I-REDD+ test sites and also with other LCCS-based classifications was developed (Pflugmacher and Hostert 2012). Mapping was done using very high resolution data (RapidEye: China) and high resolution data (SPOT: Vietnam; Landsat: Laos, Indonesia). Certain critical land cover classes were difficult to map with single-year Landsat and SPOT data, including open natural forest, shrub lands and fallow lands in shifting cultivation areas (Budiman et al. 2012). At the Lao site, a new landscape-mosaics approach for mapping shifting cultivation was developed and tested (Hett et al. 2012). The approach is based on existing land cover data classified from Landsat imagery. Pixels of land cover are then classified into landscape mosaics in order to describe general land use categories at the landscape level. The classification is based on the spatial context of a pixel using the land cover information from its surrounding neighbourhood (see Figure 2.7 for an example of maps produced).

b) Due to regional differences in land-use processes and availability of remote sensing data, it was not desirable to restrict the remote sensing based land cover change analysis to a single data source and method but to utilize the best information available at each test site (Budiman et al., 2013, Hostert et al. in press, Pflugmacher et al. in preparation-a). At three test sites, we extended the historic reference period to 1995 (site in Vietnam) and 1990 (sites in Indonesia and Laos), respectively. For the sites in Indonesia and Laos, we used Landsat data with a spatial resolution of 30 x 30 m. For the sites in Vietnam and China, we used higher resolution satellite data from the SPOT (20-m) and ASTER (15-m) sensors, respectively. In Vietnam, China, and Indonesia, we estimated changes at five-year intervals, and in Laos, we used dense Landsat time series to map changes at annual intervals (Figure 3.1).

c) Mapping forest degradation with optical remote sensing data is challenging because 1) optical (multi-spectral) sensor data have a diminished sensitivity to structural variations in tropical forest and tall vegetation, and 2) because of extensive cloud cover. We therefore integrated optical data and cloud-insensitive synthetic aperture radar (SAR) at the Indonesian site, which is characterized by persistent cloud cover throughout the year, forest degradation, and a complex mix of tree-based agriculture. As data sources, we used Landsat data and C-band SAR data from Envisat ASAR, and found that combining Landsat and ASAR data into classification models improved the mapping of forest regrowth and different forest density levels indicating a promising synergy between the two sensors (Hagensieker et al., 2013). At the same time, the study showed limitations of using only C-band SAR to fill-in data gaps in optical imagery caused by clouds. Landsat data alone achieved significantly better classification accuracies than SAR data alone. Classification accuracies based on SAR data alone were acceptable at the forest/non-forest level (69% overall accuracy) but not adequate for detailed forest and land cover classifications. While C-band SAR data availability is likely to improve in the near future,

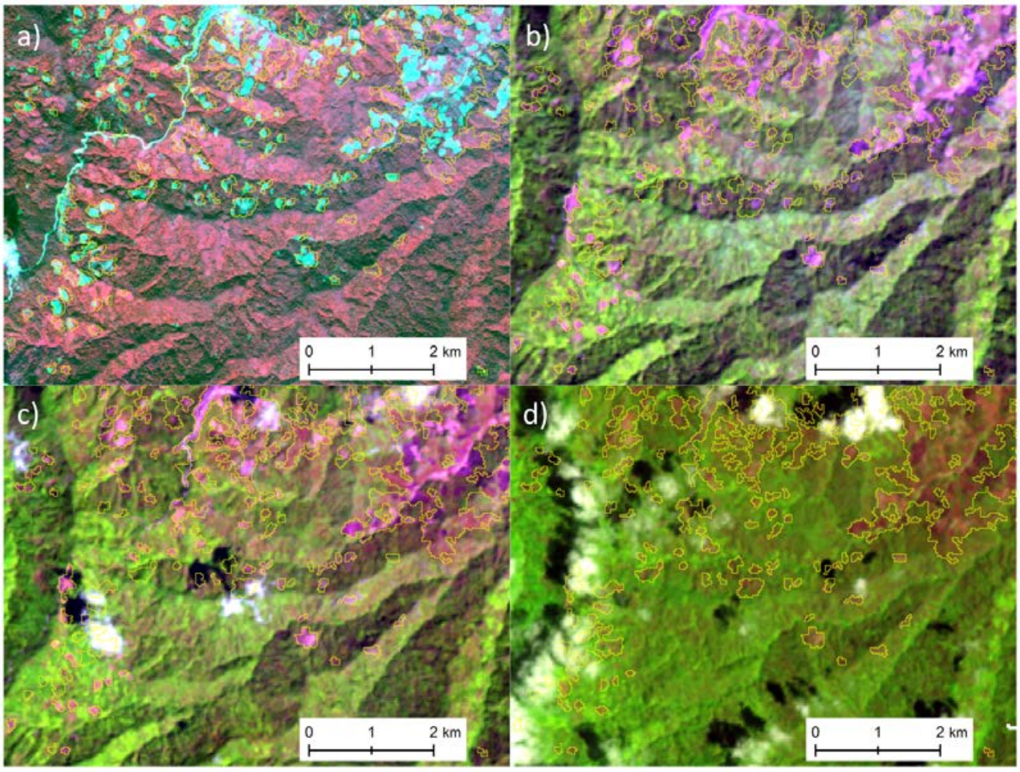

Figure 3.1: Example of detected forest clearings (yellow polygons) in Laos (Huaphan province, 2011) overlaid on false colour near-infrared RapidEye imagery acquired on December 2011, (a), Landsat imagery acquired on February 11th 2011 (b), February 27th 2011 (c) and April 30th 2011 (d).

the availability of historic satellite time series is an important requirement for operational forest monitoring. In addition, all SAR sensors are influenced by topographic effects and many remaining forested landscapes are located in mountainous areas. We examined the potential effects of terrain distortions on SAR visibility across Southeast Asia and determined the potential data coverage of Envisat ASAR and the upcoming Sentinel-1 by simulating potential SAR visibility based on sensor orbit parameters and viewing geometry. Our analysis showed that the area affected by terrain distortions varied considerably depending on the SAR acquisition mode, and that a greater area was affected by Envisat ASAR than Sentinel-1. For example, based on Envisat ASAR mode IS-2, about 25% of the forested area was affected by layover distortions, 40% if we included tree and shrub-dominated mosaics of natural and managed land covers. For Sentinel-1, layover effects decreased for similar incidence angles, i.e. 12% of forested area using IS-1. Distortion effects decreased for acquisitions using higher incidence angles (Figure 3.2). Thus layover effects have important implications for SAR-based monitoring of tropical forest in Southeast Asia.

d) Finally, we analysed the spatial and temporal patterns of carbon emissions associated with forest degradation in mosaic landscapes using forest cover and fallow age maps and a carbon bookkeeping model. We used Huaphan province in Laos as a case study and found that between 2000 and 2012 carbon stocks decreased from 953 Mg C to 901 Mg C in the province. Carbon storage throughout this period, however, showed a dynamic pattern of both carbon emissions and sequestration based on the annual time series. The estimated emissions in this period were highly variable with an inter-annual range of - 57.06 Mg C (emissions in 2004) to 30.29 Mg C (gains in 2007), with a mean and standard deviation of 4.3 (emissions) and 21.59 Mg

C ha^{-1}, respectively. Figure 3.3 shows the spatial patterns of carbon storage in forest and fallow vegetation for the year 2012 (Pflugmacher et al., in preparation-a).

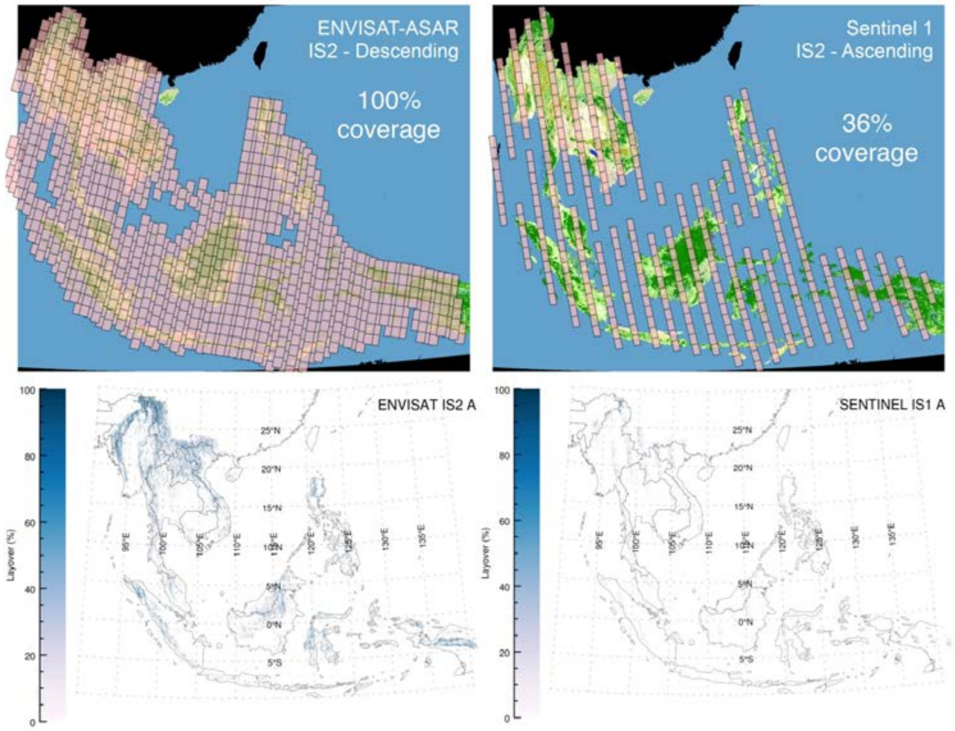

Figure 3.2: Data coverage and layover effects of Envisat ASAR and Sentinel-1 for low incidence angle swaths over Southeast Asia.

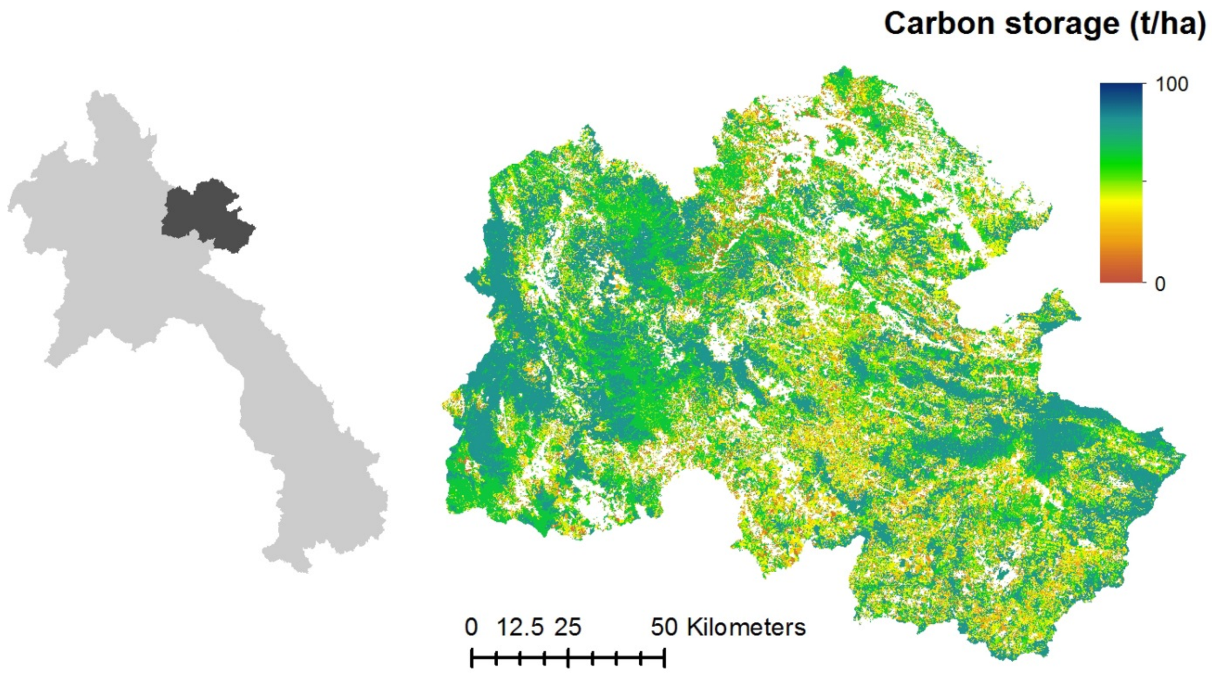

Figure 3.3: Total carbon stored in forest and fallow vegetation (aboveground and belowground biomass) for the Huaphan province in year 2012.

II) Hyperspectral remote sensing for REDD

We tested the potential of hyperspectral data to improve monitoring of forest degradation associated with shifting cultivation practices in mosaic landscapes of Southeast Asia. It was originally planned to use hyperspectral data from the EnMAP mission, but airborne campaigns of the "EnMAP" sensor were not available over the study region. Alternatively, we acquired hyperspectral data from the Hyperion sensor on board EO-1 that provides a high-resolution hyperspectral imager capable of resolving 220 spectral bands (from 0.4 to 2.5 µm) with a 30-meter spatial resolution. Young (1-4 years) and intermediate/older fallows (5-13 years) were distinguishable with moderate accuracy (76%), see Table 3.1. However, further differentiation between intermediate (5-8 years) and older fallows (9-13 years) was not possible with acceptable accuracy (Pflugmacher et al., in preparation-b). One explanation is the fast rate of vegetation succession in the first years. Once the tree canopy closes, further structural differentiation along the vertical dimension may not be easily captured by Hyperion. Forest structural properties are often more strongly associated with shortwave infrared wavelengths, but bands in this spectrum were only weakly correlated with fallow age. Hyperion's low signal to noise ratio (SNR) in this spectrum may explain part of this result. Our study highlights the importance of the SNR for monitoring forest degradation. Moreover, the variability in vegetation structure and composition increases with age, which may diminish the correlation with hyperspectral data. Although the study site was selected to minimize larger environmental and land-use gradients, the fine-scale heterogeneity characteristic for mosaic landscapes may still have had an impact on the results.

Table 3.1: Confusion matrix from random forest out-of-bag predictions for two fallow age classes (overall accuracy was 0.76). Reference age classes were derived from photo-interpreted Landsat time series. Matrix values represent 90 x 90 m samples, randomly selected from a Landsat-based forest clearing map.

	Reference age class (years)		
Map age class (years)	1-4	5-13	Commission error
1-4	96	32	0.25
5-13	23	79	0.23
Omission error	0.19	0.29	

Spectral bands in the green wavelength, the β-chlorophyll absorption maximum (~640 nm), and the near-infrared explained most of the variability in fallow age, though the absolute differences in reflectance were highest in the near-infrared (Figure 3.4). Conversely, the slightly higher reflectance in the green and orange wavelengths of young fallows suggests slightly lower chlorophyll absorption, which may be associated with vegetation composition. In addition to biochemical vegetation properties, structural properties related to the horizontal (e.g. decreased soil fraction and increased shadow fraction) and vertical distribution of vegetation elements also explain the overall decreased reflectance of older fallows (Pflugmacher et al., in preparation-b).

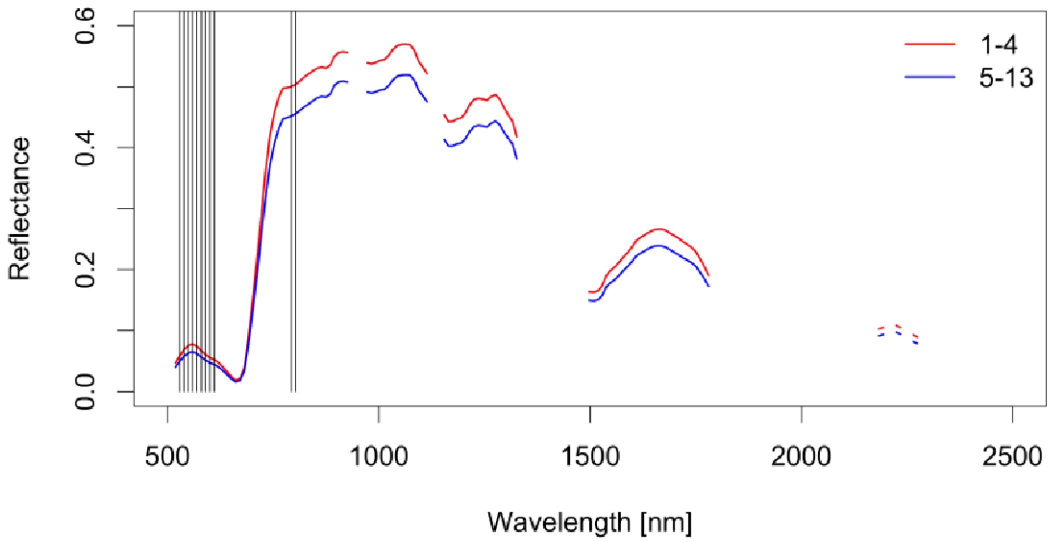

Figure 3.4: Mean spectra of young (1-4 years) and intermediate/older fallows (5-13 years) from atmospherically corrected Hyperion data. The black vertical lines represent the wavelength locations of the 15 bands explaining the majority of the variation in fallow age.

III) Wall-to-wall and national monitoring

This work focused on the development of remote sensing methods suitable for mapping deforestation at the national scale. The developed approach combines wall-to-wall, coarse-resolution data from the Moderate Resolution Imaging Spectroradiometer (MODIS) with forest cover change maps derived from high-resolution Landsat data. We used annual deforestation data developed from Landsat time series to calibrate a MODIS deforestation model - Breaks For Additive Season and Trend (BFAST). Using the advanced BFAST algorithm, we tested the sensitivity of several MODIS-derived change indicators to detect forest clearings of different sizes and in different forest types. Detection accuracies were highest for large disturbances where MODIS forest pixels (~250 x 250m) were completely disturbed (90-100% accuracy), whereas accuracies decreased substantially for MODIS pixels for which forest clearings made up only 75% and less of the MODIS pixel area (Figure 3.5). Further, the algorithm was robust across different forest types, which is an important prerequisite for large-area forest mapping (Grogan et al., in preparation).

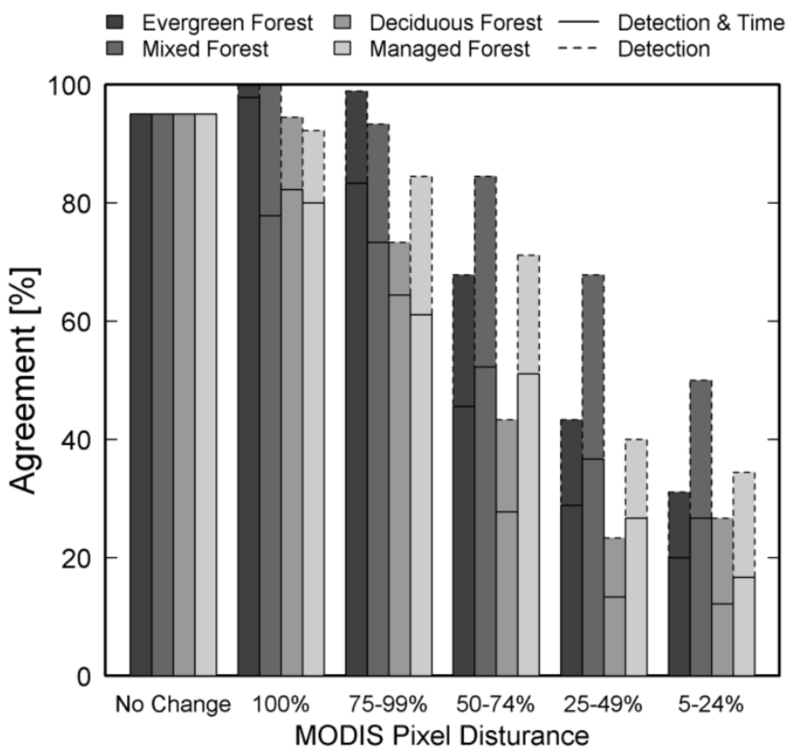

Figure 3.5: MODIS deforestation detection accuracy as a function of disturbed area proportion within MODIS pixels. The lower solid line bars represent agreement in detection and timing, while the upper dotted line bars represent additional detections without an accurate timing estimate.

The MODIS-based deforestation map captured the spatial patterns of forest changes well (Figure 3.6). However, because of the coarse-resolution bias (small clearings are missed) area estimates based on MODIS deforestation maps alone are not unbiased. To obtain statistically sound and unbiased estimates of deforestation area and associated uncertainties, we employed a model-assisted approach that combines a probability sample of Landsat deforestation data with the MODIS deforestation model (map). In this approach, the MODIS deforestation map is used as auxiliary variable to improve the precision of the change estimates derived from the Landsat samples. Our results demonstrate a high potential for combining Landsat and MODIS for an integrated national REDD+ forest monitoring system. The developed framework proposes a multistep pathway towards a national based forest monitoring system and reference emission levels, involving the combination of remote sensing data with a sample-based approach.

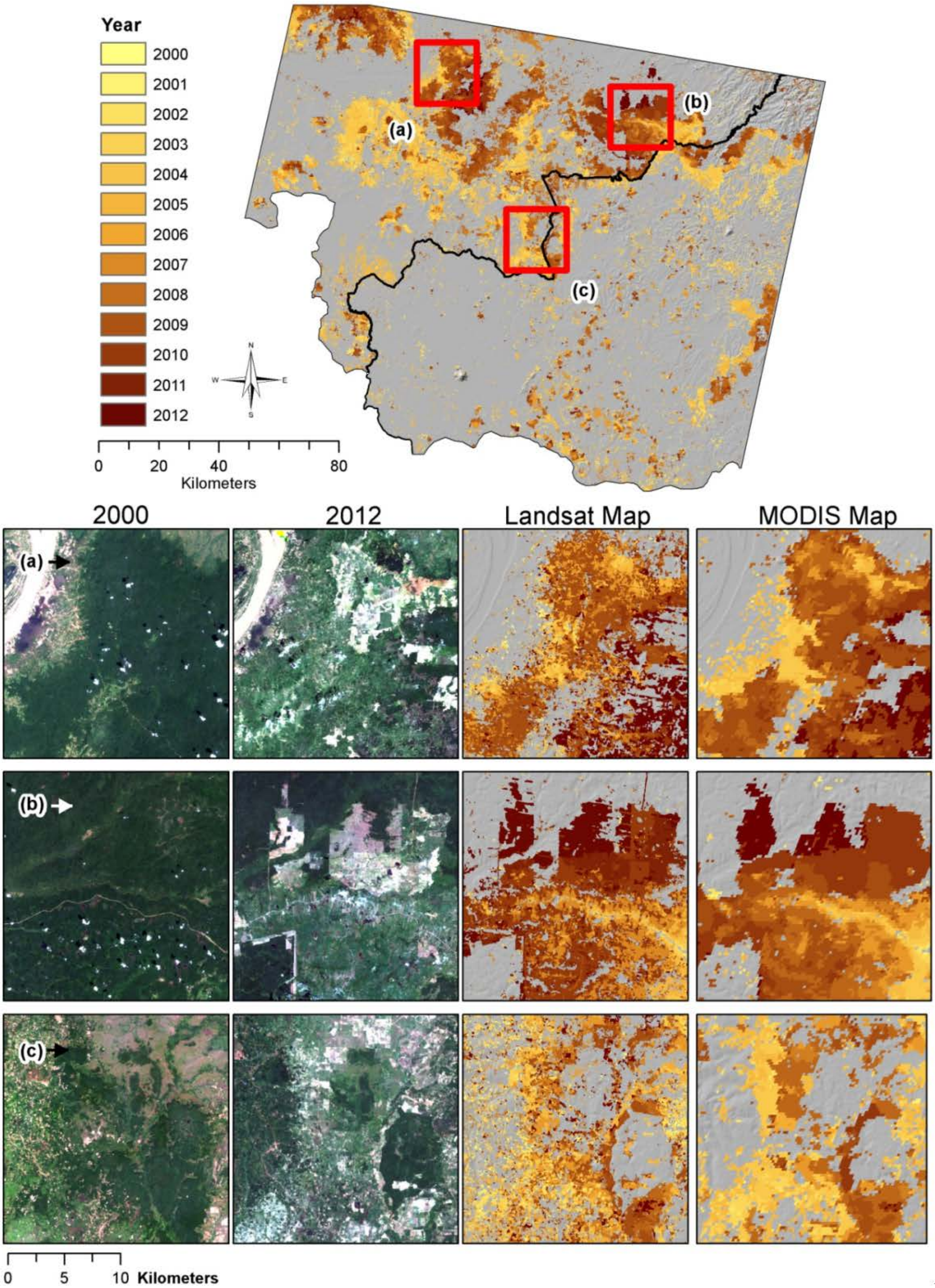

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Figure 3.6: Landsat and MODIS deforestation maps.

4.1.3.3 Community based monitoring of change in land use and biomass

The specific objectives of this work were to:
1. Combine community-based, scientist-executed and remote sensing evaluation of land use change and associated change in carbon stocks
2. Combine community-based, scientist-executed and remote sensing evaluation of forest carbon biomass.

I) Community-based mapping of land use change

Preparation of participatory maps of the current and historical land use of the forest areas adjacent to the study villages in Indonesia, Laos and China, and Vietnam has been completed in collaboration with the other working groups. All the maps have been digitized and they include the results of the measurements of above ground carbon by community monitors and the land use types identified by the villages. The results of these exercises are reported under sections 4.1.3.2, 4.1.34 and 4.1.3.6.

II) Community-based monitoring of forest carbon biomass.

Previous local forest biomass monitoring protocols have mainly relied on the use of hand-held computers, which may represent a constraint to community involvement and the broad-scale implementation of participatory REDD+ MRV as capacity is limited in some communities (Danielsen et al. 2013). Employing low-tech field approaches, such as recording of data using simple pen (or pencil) and paper, measuring with ropes marked at relevant points, and utilizing other feasible protocols for local communities, may greatly enhance the application of the approach (Danielsen submitted). Hence, we developed a simple participatory forest biomass monitoring manual that was used for community-based forest biomass monitoring in 289 permanent forest vegetation plots in the four sites in China, Laos, Vietnam and Indonesia (60-103 plots in each site; Brofeldt et al. 2014). A few days after the measurement by community members, all plots were re-measured by independent foresters. The plots represented an altitudinal gradient from lowland to montane forest, and a disturbance gradient from largely undisturbed to heavily disturbed forest. All plots are located in steep or very steep terrain.

Our data shows that community members can reliably and cost-effectively monitor forest biomass. At the same time, this can improve local ownership and forge important links between monitoring activities and local decision-making (Mascia et al. 2014; Danielsen submitted). In the past, our studies have, however, been static assessments of biomass at one point in time whereas REDD+ programs will require repeated surveys of biomass over extended time frames. During 2014, we were able to examine trends in accuracy and costs of local forest monitoring over time (Figures 4.1 and 4.2). Our analysis of repeated measurements by community members and professional foresters of the 289 plots showed, for the first time, that with repeated measurements community members' biomass measurements become increasingly accurate and costs decline. These findings provide additional support to available evidence that community members can play a strong role in monitoring forest biomass in the local implementation of REDD+ (Brofeldt et al. 2014; Danielsen et al. 2013).

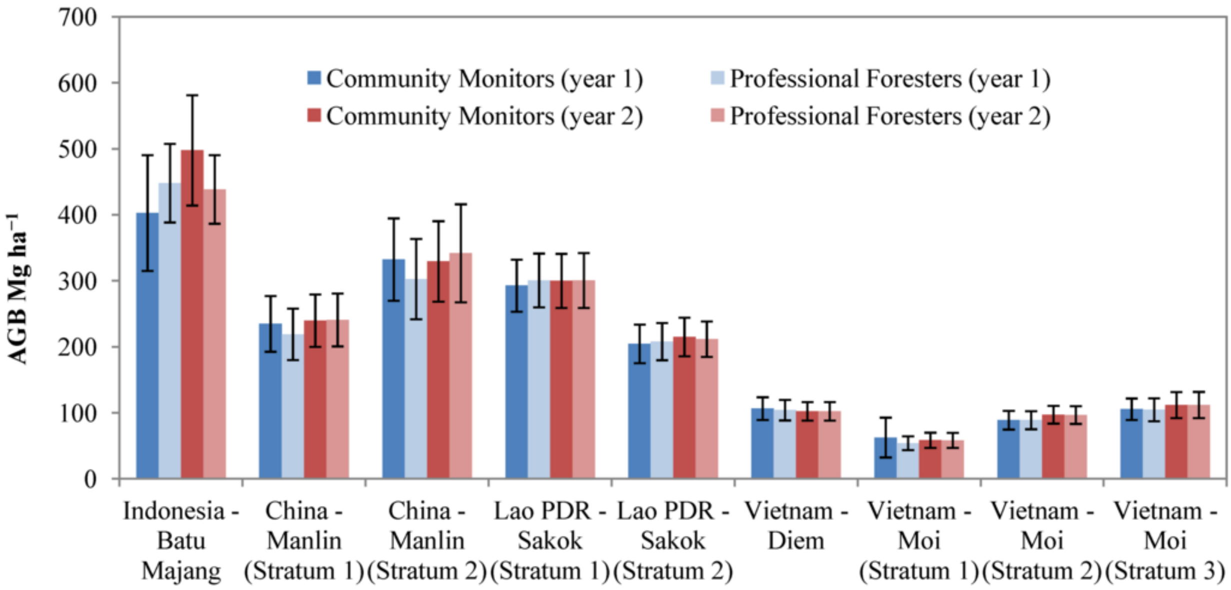


Figure 4.1: The identified above-ground woody biomass (AGB) as measured by community monitors (dark) and professional foresters (light) in the two separate monitoring rounds done from September 2011 to May 2012 (blue) and again from January 2013 to July 2013 (red); error bars represent 95% confidence limits.

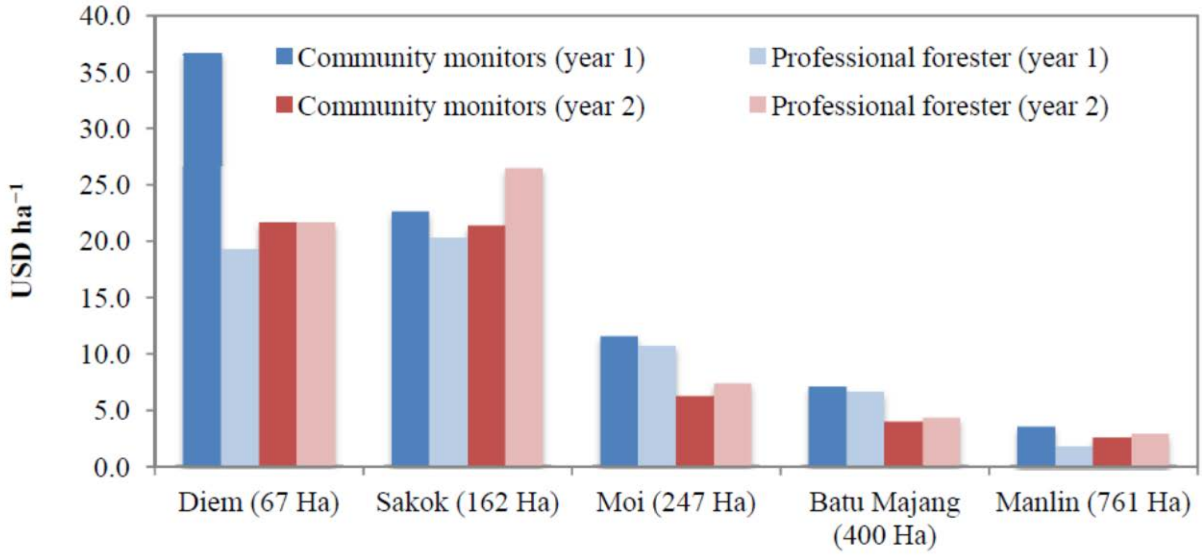


Figure 4.2: Cost USD ha−1 for community monitors and trained foresters in the monitoring year 1 and 2.

What is the relevance of these findings to REDD+ implementation? A number of countries have already selected community forest management as part of their national REDD+ readiness plans. Moreover, text in the Subsidiary Body for Scientific and Technological Advice (SBSTA) on REDD+ methodology supports “full and effective” engagement of indigenous peoples and local communities, and the contribution of their knowledge, to monitoring and reporting activities, which is recommended in the GOFC-GOLD sourcebook.

Considering concerns about the cost of monitoring for REDD+, our findings provide support for including community monitoring at local scale for national carbon monitoring. There is a need, however, to develop community MRV protocols that maximize the involvement of local people, while also meeting REDD+ forest monitoring requirements (Gardner et al. 2012). Although a literature search that we undertook showed that at least eight community carbon monitoring manuals have been developed (Brofeldt et al. 2014), these vary greatly in length and scope, reflecting a lack of agreement on methods for community monitoring of carbon. Our experience suggests that manuals should be short and need to focus on (a) effective sampling design; (b) careful establishment of sample plots; and (c) accuracy in measurements. For all these issues simplicity is important, as a simple method is easier to remember and apply consistently. However, our results and experience from the field also suggests that training remains important and re-fresher training and supervision for a day or two helps improve accuracy.

Considering firstly how central carbon monitoring is for REDD+ implementation, and secondly the concerns raised over safeguarding local and indigenous communities rights over land in the REDD+ implementation process, it seems that the potential for community monitoring to deliver accurate and cost effective monitoring should be considered seriously when planning future national REDD+ activities (Danielsen et al. 2012) as well as local REDD+ projects (Gardner et al. 2012; Danielsen et al. 2013). Our findings add to the growing consensus that local people, using participatory methods, can produce data sets that are just as accurate as those that are derived professionally (Danielsen 2014b, 2014c; Theilade in preparation; Zhao in preparation). We have also demonstrated that such data are relevant to combine with remote sensing approaches for establishing forest reference levels as reported in Ankersen et al. (2015).

Local communities will have a strong incentive to report positive trends in the forest cover and condition, so they continue to be paid, even if forests are actually declining (Danielsen et al. 2013). Periodic third party verification of the monitoring results will therefore be required, but this would need to be built into the design and costs of any REDD+ initiative, whether implemented by communities, the State, or the private sector. Independent verification could be based on random spot-checks or the use of high resolution remote sensing images. This would be unaffordable for national inventory, but would be appropriate for verification on the basis of sampling. It could be combined with statistical analysis of the community-based data to search for anomalies and growth rates that are beyond the normal or expected range (Danielsen et al. 2014b; Theilade in preparation).

If community monitoring is to have impacts on forest management beyond the local scale, then the community monitoring must be embedded within - or linked to - a national (or international) scheme that feeds the data up to the levels at which governments and international agencies operate (Danielsen et al. 2012; 2013; 2014a). We suggest that the REDD+ Readiness work by the UN-REDD program and the World Bank's Forest Carbon Partnership Facility should pay more attention to the development of appropriate community based monitoring systems, and promote policies and build capacity to allow the input of locally generated data (Brofeldt et al. 2014).

4.1.3.4 Local livelihoods and REDD+

The specific objectives of this work were to:

1. Assess opportunity costs associated with different land use systems in relation to local development contexts and expected land use transitions, thereby assessing the direct and indirect costs and benefits of REDD+,
2. Develop a participatory livelihood monitoring framework that actively involves multiple stakeholder groups.
3. In the absence of REDD+ project in the selected case areas, engage local communities in participatory simulation of a REDD+ project including land use planning and benefit sharing mechanisms.

I) Opportunity costs of REDD+

Opportunity costs are usually calculated at the sub-national level based on parameters characteristic of each land use type, especially the Net Present Value (NPV) and the estimated carbon stocks. We extended the analysis of opportunity costs to the landscape level so as to account for ecosystem goods and services associated with land use patterns and their implications in the broader context of livelihood systems. Based on participatory land use mapping, household surveys and focus group discussion about the perceived impacts of land use transitions to livelihoods and ecosystem services, we assessed REDD+ feasibility in eight villages located in the four study sites in China, Indonesia, Laos and Vietnam.

We assessed the benefits derived from REDD+ by local land users by estimating its potential contribution to their livelihood portfolios. In the absence of operational REDD+ projects in the research sites, participatory simulations were used to assess the potential impacts of REDD+ on the land uses and income levels of different household types. Historical land use changes were elicited through participatory mapping with local communities. Research sites were thus analysed as successive stages in a broad regional trajectory of land use intensification, starting from extensive, subsistence-based shifting cultivation systems and evolving towards more intensive, market-oriented land use systems. From there, several land change scenarios – including REDD+ scenarios – were defined and explored collectively. Trade-offs between forest and biodiversity conservation and economic growth were investigated, potential livelihood impacts were examined and potential ‘winners’ and ‘losers’ were identified.

The study suggests that there is little prospect for REDD+ to improve local livelihoods beyond what is achieved by on-going land use transitions in in rural Southeast Asia. Despite an apparent good potential for REDD+ projects in several of the study villages, technical problems are plentiful. Documented additionality may be difficult to achieve in cases where environmental regulations were already in place before the REDD+ era with a strong impact on reducing deforestation despite the small compensations received by local communities (e.g. Vietnam and, to a lesser extent, Laos). Moreover, forest degradation potentially accounts for much larger emissions in many of these areas than deforestation. Thus, as long as the measurement of forest degradation is still too complex for national Measurement, Reporting and Verification systems, REDD+ projects may not be relevant. Other difficulties need to be considered in China and Indonesia where the opportunity costs of rubber and oil palm will be extremely difficult for REDD+ to compete with on economic terms. Finally, in other areas where the state is managing a major part of the forest lands (e.g. Laos, Vietnam sites), there is little prospect for communities to receive a fair share of REDD+ benefits.

It is thus essential to identify windows of opportunity – both in the temporal and spatial sense – where the REDD+ potential is high, for example in areas with low opportunity costs of current land uses, dense forests and low population, but high risk of future deforestation and forest degradation (see examples of trade-off curves for different land uses in Indonesia and Laos in Figure 5.1). Such areas are rapidly disappearing in Southeast Asia and the window of opportunity is therefore closing fast (Castella et al. 2012; Castella et al. 2015).

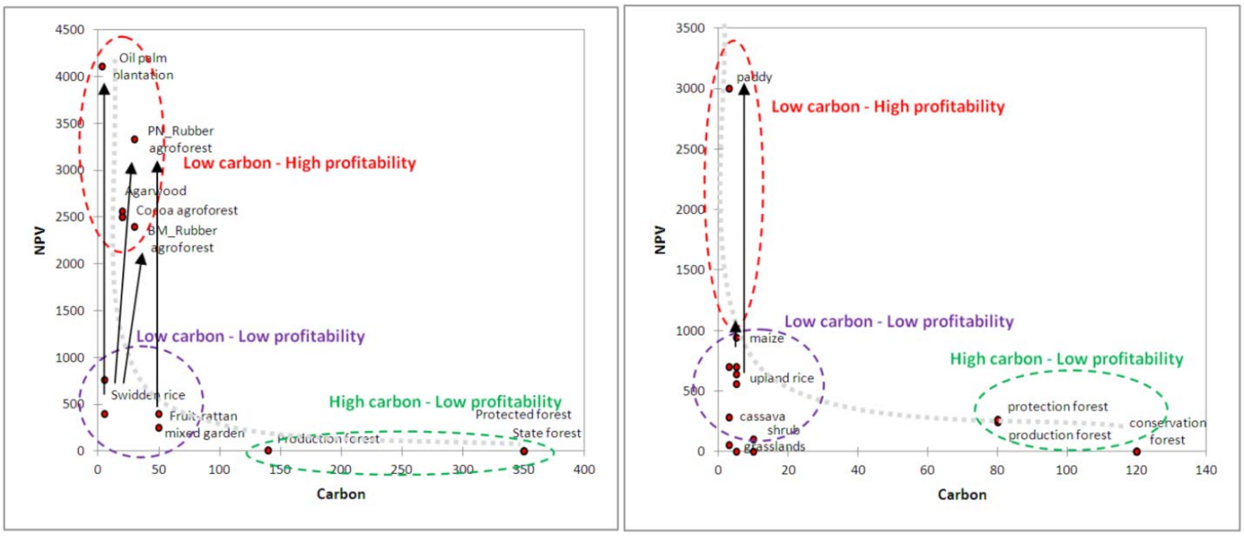


Figure 5.1: Trade off curves of different land uses, Indonesia (left) and Laos (right).

II) SMART indicators selection for participatory monitoring of livelihood changes

Participatory livelihood monitoring is a local level monitoring approach that engages different stakeholders, from the local government to the grassroots level, performing different functions with complementary mandates and skills. It recognizes the rights and knowledge of local stakeholders in monitoring their own development. Participatory livelihood monitoring is likely to be more cost-effective and sustainable than monitoring conducted solely by external technical experts and it can be regarded as one component of REDD+ Measurement Reporting Verification (MRV) systems that may be required to address several of the safeguards agreed upon at the UNFCCC REDD+ negotiations. Monitoring livelihood impacts of REDD+ can be achieved in multiple ways and we tested two different approaches. In the first approach, a combination of different data and sources was used, including national census data, secondary data from meta-analyses covering a large geographical area, and data from site-level observations. This led to the identification of a total of 30 livelihood and land use indicators that can be applicable to REDD+ livelihood monitoring. In the second approach, a simple participatory monitoring tool to be used at the village scale was developed and tested in the uplands of northern Laos. Building on local perceptions and aspirations about development and with reference to various livelihood 'capitals' (as represented in Figure 5.2), a total 37 indicators were identified. Most of the indicators used in these two trials are widely applicable in rural areas of Southeast Asia. They are defined to be easily comparable, and the required data can be collected at low cost. Finally, both the process of developing indicators and the results of the monitoring could help engage local stakeholders in planning, evaluating and adaptively managing REDD+ project activities (Castella and Lestrelin 2013).

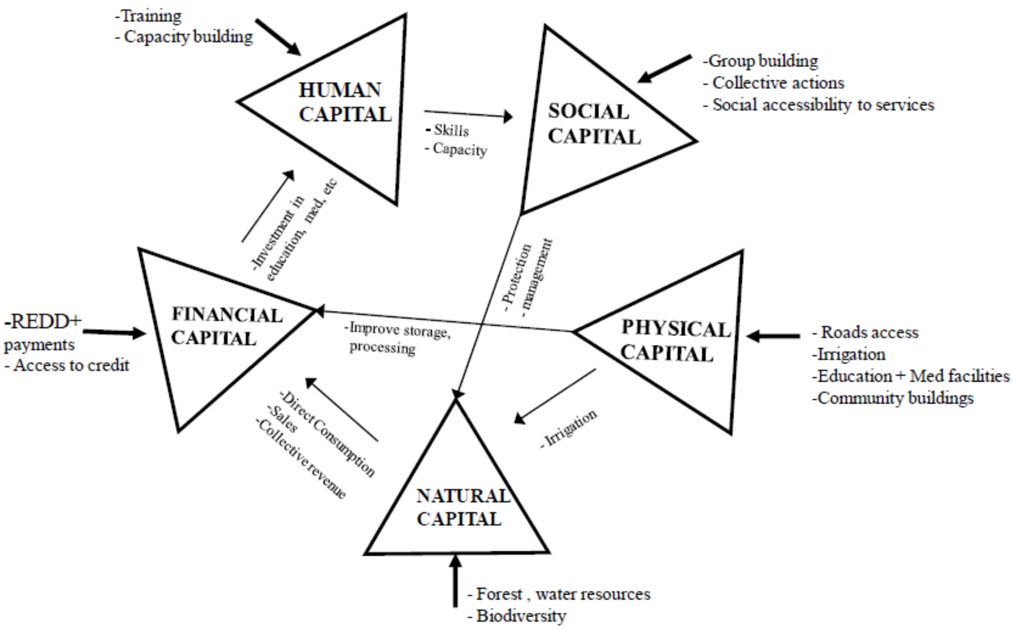


Figure 5.2: REDD+ livelihood improvement pathways

III) REDD+ policies and livelihoods

We also analysed current land use change and government policies in Laos in order to assess the feasibility of REDD+ in terms of local livelihood outcomes and concluded that while land use changes have increased rural income, they have been accompanied by considerable inequity in communities. Moreover, contradicting policies that simultaneously promote forest production and agricultural expansion have multiple outcomes. On the one hand, they reinforce State authority and claims on land leading to alienation of community lands, but on the other hand the contradicting policies also create a vacuum for entrepreneurial communities to navigate and expand their agriculture, despite efforts to develop REDD+ projects in the area (Vongvisouk et al 2014; Vongvisouk et at al., in review; Vongvisouk et at al., in preparation; Broegaard et al., in review)

Finally, a study of firewood consumption and access to firewood in Xishuangbanna prefecture, Yunnan, China, was conducted with specific focus on the differences between the resident population and migrant workers. Although there is little difference in firewood consumption, the migrant workers have limited access to the collective forest which negatively influences their living standards. The work highlights how the household registration system called *hukou* favours the resident population and creates inequity (Mertens et al, 2015).

4.1.3.5 Governance and institutions

The specific objectives of this work were to assess the potential for how REDD+ payments may work under different payment scenarios and under different governance and institutional structure.

I) Understanding existing Benefit Distribution Mechanisms (BDM)

Ten existing BDMs from the four study countries were analysed (Sikor et al. in preparation). They were not limited to REDD mechanisms but sought to cover a wide range of governance arrangements in forestry that involved BDMs such as protected area management, the exploitation of productive forest by logging companies, and community-based forest management. The ten BDMs covered a wide range of forest types, from natural forest to plantations. All were characterized by some form of community involvement, thereby reflecting a general trend in forestry but also our conscious choice to examine BDMs that provide a role for local communities. A conceptual framework, centred on four variables: actors, benefits, property rights, and outcomes, was used for the analysis (Figure 6.1). allowing us to generate a holistic understanding of different

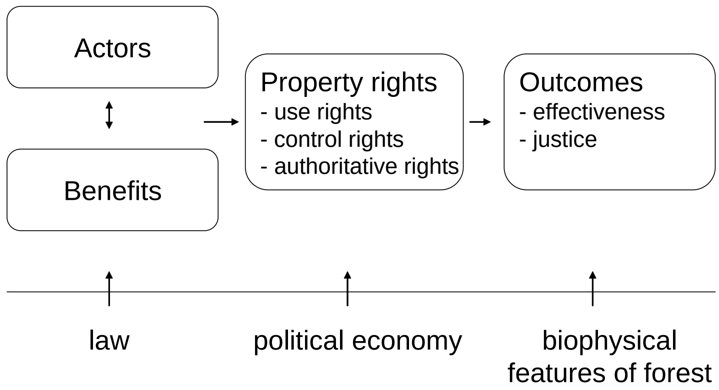


Figure 6.2: Conceptual framework for BDM analysis.

governance arrangements for BDMs.

Three different types of governance arrangements were revealed. Six of the ten can be characterized as top-down state governance, as central government agencies hold authoritative rights and their local branches exercise control rights. In two BDMs, government and INGOs share authoritative rights. In another two, government and local communities share control rights. We found it impossible to determine the overall effectiveness of the BDMs in the absence of robust empirical evidence on their ecological outcomes. However, it is apparent that the first two types – top-down state governance and authoritative rights shared between government and INGOs – rely on the presence of strong implementation capacity and availability of financial resources. BDMs in which government and local communities share control rights do not require such. We detected clear differences in the justice of the BDMs, justice viewed from villagers' perspective. BDMs are most just when they share control rights between government and local communities. They are least just where valuable natural forests are under top-down state governance. These insights possess direct implications for REDD+. The development of national REDD+ programs can employ a wide range of governance arrangements for the distribution of benefits. The governance arrangement can be expected to differ in their effectiveness, and have strong implications for the justice of REDD+ as perceived by villagers.

As a specific case of a BDM, the Sloping Land Conservation Program (SLCP) in China was studied in more detail in order to gain experiences from the world largest Payment for Ecosystem Services Program (PES). He et al. (2014) document that China has undergone a significantly forest transition from deforestation to new forestation. However, the contribution from the SLCP is debatable as the significant forest transition currently underway begun before the SLCP and they argue for a contextualized understanding of the forest transition from local dynamics. Furthermore, He (2014) documents how the outcomes of SCLP can be different from place to place, although it was implemented in a top-down approach, and he argues for the significance of local institutions in shaping the outcomes of the policy. He and Sikor (2015) offer a novel explanation of why SCLP can produce positive outcomes in some places. They reveal how villagers, local state officials, and state policy in a particular site share a primary concern for distributive justice despite significant differences in their specific notions of justice. The shared concern underlies the villagers' positive reactions to the SLCP, which among other factors, have led to the intended expansion of tree plantations and a livelihood transition. They emphasize the need to consider justice for a fuller understanding of the dynamics and outcomes of the SLCP and other PES schemes worldwide as the notions of justice applied by the involved actors may influence land use and livelihood dynamics in addition to the other factors considered in research this far. Finally, He and Long (in review) examine the effectiveness, efficiency and fairness in SLCP. They reveal the gap between policy intention and actual practice, with less marginal land involved, poor tree species selection and undifferentiated household involvement, limiting the positive outcomes regarding environmental effectiveness and social fairness. They argue that the state-led PES's bureaucratic modalities and top-down implementation lack targeting and neglect local participation and pro-poor considerations. More decentralization and local participation is necessary in policy design and implementation.

II) Global and local comparative study of potential BDMs

For this study, we used a different but complementary approach to assessing the potential for REDD+ at local level, building on the simulation methods and tools developed for ex-ante analysis of the impacts of REDD+ on carbon sequestration, livelihoods and food security and the provision of ecosystem services (see section 4.1.3.4). We engaged local-level stakeholders at eight sites in the four case-study countries in prospective work on benefit distribution scenarios and potential institutional arrangements for monitoring and transaction rights.

At local level, villagers see village-level funding as most just as this would allow them to share the transaction and exclusion rights with government and receive indirect use rights to forests. There is significant variability among their preferred local arrangements for the practical management of the fund. With regard to the use of REDD credits, a majority of the sampled villagers advocated a combination of village-level development funds, which would generally support the building and functioning of communal infrastructure, and individual payments. However, preferences for the allocation of development funds and individual payments varied from place to place. As the distribution, the land title or occupation of forest area in local community can create inequality, as found in the case studies, particularly those in Vietnam and Indonesia. Villagers prefer funding to be allocated for communal development than as individual payments, where forestland is unequally distributed. In contrast, where forestland is fairly equally distributed villagers are apt to prefer equal distribution between the communal fund and individual payments or more allocated to individual payments.

As for the right to use benefits derived from forest, those who own a lot of forestland expect to receive a large number of carbon credits and are not much interested in community redistribution mechanisms. Unequal benefit distribution is tolerated as it reflects the inequality in property distribution and the 'REDD+ efforts' of individual households who can afford to engage in the scheme. Need-based (e.g. micro-credit communal fund) or egalitarian (e.g. equal shares distributed to all households) redistribution systems are considered fair benefit distribution mechanisms without regard for pre-existing inequities in the context of communal forest tenure. Thus in the case of individual tenure it may be difficult to achieve the collective agreement on benefit distribution that would be necessary to establish workable village- or landscape-scale, low-emission land-use plans. The case studies suggest that there can be no 'one-size-fits-all' option for the design and implementation of benefit distribution mechanisms at the local level.

At the global level, this research provides a global overview and up-to-date profile of REDD+ benefit-sharing mechanisms and analyses the political-economic factors influencing their design and setting. The analysis draws primarily on a review of existing benefit distribution mechanisms use for REDD+ and natural forest management, namely fund-based approaches, market-based instruments, forest concessions, access and benefit sharing, and community forestry. We build on the results of contextual analyses in 13 countries: Bolivia, Brazil, Burkina Faso, Cameroon, Democratic Republic of Congo, Indonesia, Lao PDR, Mozambique, Nepal, Papua New Guinea, Peru, Tanzania and Vietnam. These country profiles were developed between 2009 and 2012 as part of CIFOR's Global Comparative Study on REDD+.

The study shows that state governance is centralized in many of the countries involved in REDD+ operation and implementation, whose effectiveness and justice are limited. It is common for the state to hold the control and authoritative rights. As the domination of state governance, environmental services are monitored and are not paid for based on performance, therefore market-based mechanisms may not work for basing the distribution of REDD+ benefits on performance, besides which it is largely unclear whether market-based mechanisms actually lead to improved environmental services and local livelihoods.

The analysis found that countries fund BDM in a variety of ways. Some use part of the state budget, and other affiliated with the state and independent funds for paying for conservation. However, although each country's preferred funding model may be different they all share common obstacles to the establishment and operation of the funds, largely because of organizational completion and conflicts over power and interests, because notions about how the benefits from these funds should be shared among the beneficiaries remain abstract and certain actors are underrepresented in REDD+ decisions. The analysis highlights the fact that the difference between the institutional arrangements for community forest and joint forest management needs to be distinguished, although both are often characterized by continuing state domination of the control and authoritative rights and some countries promote shared control rights in forest management. The state's domination of land tenure in most community forest arrangements allows the local community little decision-making power: villages may gain use rights, but not control rights. On the other hand, the joint forest management performed in positive role of partnerships that generate additional benefits for local communities.

We found that forest concessions are common practice in BDMs in all of the studied countries except Tanzania. Having the government decide the uniform rules governing the share of forest revenues makes scaling-up quite efficient. However, it was observed that this is associated with significant injustices due to weak governance accountability and transparency. In sum, there is a general understanding that villagers should benefit from REDD+ action. However, the use rights to REDD+ benefits (commonly termed 'carbon rights') are generally not defined and there is often conflict between customary and statutory tenure rights.

III) Developing Recommendations for REDD+ BDM in China, Indonesia, Laos and Vietnam

Consultation workshops were held in each of the four project countries in order to 1) call for feedback on the analysis of existing BDMs and potential REDD+ projects; 2) discuss potential BDMs for the country; and 3) come up with recommendations about improving BDMs in the forest sector. The country workshops convened a wide range of participants and experts from different organizations including activists, government officials at different levels and representatives of NGOs, international organizations, national research institutes and universities.

The empirical findings suggest that contextualized and decentralized benefit distribution mechanisms to improve REDD+ would benefit from meaningful local participation. We put forward specific recommendations for the improvement of REDD's effectiveness and justice in four areas: governance (i.e. control and authoritative rights); the fund mechanism (i.e. transaction rights); forest tenure (i.e. use rights) and capacity-building needs. Effective and just BDMs require not only innovative payment schemes but also, and more importantly, sound institutional arrangements to ensure their proper implementation. This research has found that institutional arrangements, including management and control rights, are an important element of benefit distribution that eventually determine who can benefit and how. Understanding the governance structure, i.e. the management rights, control rights and authority rights held by the stakeholders, can help to promote institutional reform for the improvement of BDMs. It is widely agreed that local communities need to have a strong role in decisions about setting up BDMs, which will therefore make it possible to develop a wide range of BDMs that is suitable to local context. Local communities should not only enjoy use rights but also participate in the exercise of control rights, in managing decisions and in the governance of funds. Sharing the authoritative and control rights among the stakeholders affects the environmental and social outcome in term of effectiveness and justice in BDMs. Central governments and the international community should therefore push for decentralized and diversified BDMs and REDD governance to enable meaningful local decision-making and participation.

A "one-size-fits-all" approach does not work for REDD+ and BDMs, which cover a wide range of cultural and social contexts. In particular it is very difficult to implement a single national BDM system. National government can develop a generic BDM system but each district or local government must adapt its technical implementation.

IV) Four policy briefs for the four case countries

Based on these findings and recommendations from stakeholders, policy briefs were developed for each country. Each policy brief was first developed in English and sent to local partners for review and comments before being finalized. To reach the broad audience and scale-up the impact of the project, the policy briefs were also translated into the national languages.

The policy briefs outline the key findings from research in the specific country context and point out policy implications for each country. In China, it was suggested to strengthen the sharing of rights over decision-making and involvement of multiple stakeholders, particularly in governance. In Indonesia, the policy brief highlights the significance of improving land tenure security, which requires further development of the legal framework for ensuring meaningful recognition of customary rights and safeguarding the exercise of customary forest rights by local people. In Laos, it was suggested that the government encourages the involvement of third parties, as it can improve the effectiveness of REDD+ governance and third-party involvement is most effective at the project level in design, implementation and monitoring. In Vietnam, the key recommendation to the government is to continue investing in community forest management, as it has distinct advantages and is less costly than the use of labour contracts, incorporates more checks and balances than companies and co-management, distributes forest benefits in a more equitable manner, and accords local people an active role in REDD+.

V) Forest tenure and justice case studies

Two additional case studies on topics relevant to the governance of REDD+ were also carried out. Indonesia, policy options for effective REDD+ implementation to consider the security of forest tenure were analysed by Saito-Jensen et al. (in press). They argue for the necessity of forest tenure reform, in particular the recognition of customary forest tenure through communal titles, which is more advantageous than the transfer of individual titles to households. They also conclude that companies are unlikely to take up compensation payments to stop large-scale activities that cause deforestation and forest degradation due to the high opportunity cost. REDD+ finance may be more effectively used to reward small-scale dispersed activities that enhance carbon stocks, such as those already happening under Indonesia's community nursery program.

In a case study in Vietnam, Sikor and Cam (in review) argue that villagers involved in a REDD+ pilot project end up protecting rocks which barely have a tree on them. The apparent paradox indicates how actual practices differ from general ideas about REDD+ due to ongoing conflict over forest, and how contestations over the meaning of justice are a core element in negotiations over REDD+. They explore these politics of justice by examining how the actors involved in the REDD+ pilot project negotiate the particular subjects, dimensions, and authority of justice considered relevant, and show how politics of justice are implicit to ostensibly technical decisions in project implementation. They argue that contestations over the meaning of justice are an important element in the practices and processes constituting REDD+ at global, national and local levels, challenging uniform definitions of what forest justice is about, and how forests ought to be managed.

4.1.3.6 Monitoring, reporting and verification (MRV) and capacity development

The specific objectives of this work were to

1. Identify the main causes of deforestation and forest degradation for each case study site
2. Predict future forest and land use transition pathways
3. Establish development-adjusted historical and crediting baselines levels for each site
4. Analyse the efficiency, effectiveness, equity, and co-benefits of various Measuring, Reporting and Verification (MRV) systems.
5. Provide research based guidance to developing MRV systems.

I) Regime shifts and forest reference levels

REDD+, as a performance-based scheme, relies on the establishment of Forest Reference Levels (FRL) to estimate carbon credits that should be paid to participating countries. FRLs are used as a benchmark for comparing the achievements of a participating country in emission reductions compared to the business-as-usual (BAU) development. The establishment of the FRL is therefore a cornerstone of REDD+ as it determines payments for attained emission reductions. Current guidelines from the UNFCCC require the FRL to be expressed in tons of carbon dioxide equivalents per year and be transparent, complete, consistent and accurate to ensure integrity, additionality and permanence of REDD+. The FRL is typically derived by measuring and estimating emissions for a reference period and projecting this trend into the future for the REDD+ commitment period. REDD+ credits are then paid with the aim of reducing emissions below the BAU pathway. The definition of the FRL is crucial in shaping incentives for countries to reduce emissions. Too ambitious FRLs result in unreachable targets while too low FRLs may result in emission reductions in the absence of intervention.

We demonstrated with the case studies in I-REDD+ that the prediction of future forest-related carbon fluxes is marred with uncertainties. These uncertainties in BAU developments are particularly large in dynamic settings, such as in the mosaic landscapes of Southeast Asia. This was shown in Con Cuong, Vietnam, by Ankersen et al. (2015) who assessed Landsat-based land-cover changes to calculate changes in forest cover for 1973, 1989, 1998, 2000 and 2011 (Figure 7.1) and associated carbon stocks. It was also demonstrated in northern Laos on both provincial and district levels with land cover series and carbon stocks changes based on the analysis of time series of Landsat images from 2000 to 2012 (Mertz et al, in preparation), see Figure 7.2. Both studies established BAU scenarios based on observed carbon stock changes using linear extrapolation and compared FRLs based on these scenarios with actual changes in forest-carbon stocks. The case studies demonstrate that due to the nature of non-linearity of land-system changes, historic pathways simply are not likely to repeat in the future. In other words, land systems, as coupled human-environmental systems, are complex systems that exhibit high complexity in both space and time. This conclusion poses serious challenges to the current approaches and assumptions in baseline setting under the REDD+.

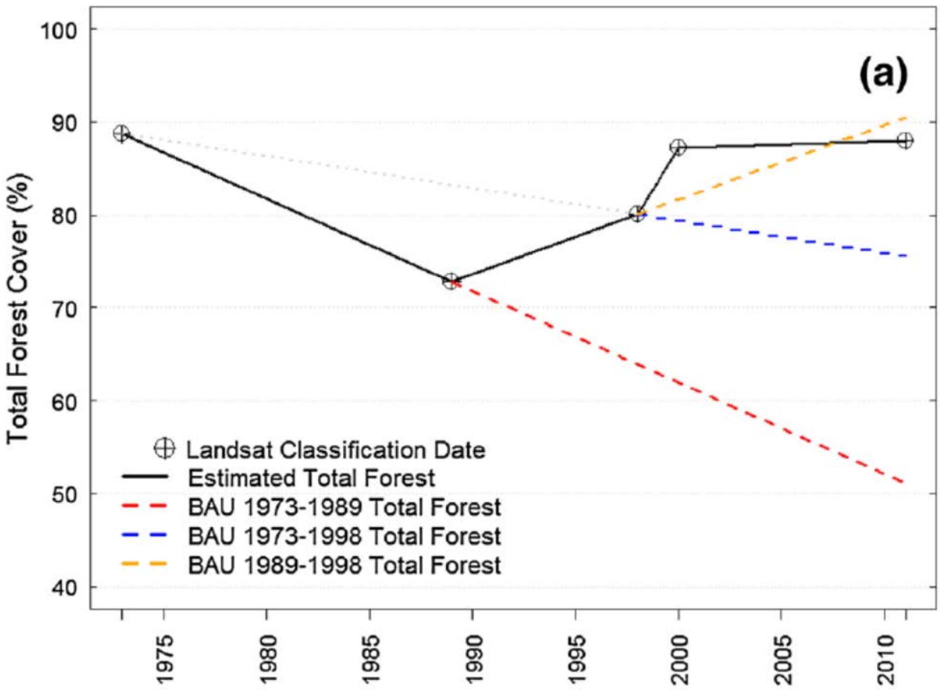


Figure 7.1: Business-as-usual scenarios (BAU) of total forest proportions in Moi Village and the actual development of forest cover (solid black line) based on Landsat classifications in five years. As an example, the red dashed line shows the BAU based on a reference emission period from 1973 to 1989, indicating that a REDD+ project started in 1989 would have led to payment of carbon credits without achieving additionality – deforestation was not only stopped but considerable reforestation occurred after 1989 without a REDD+ project.

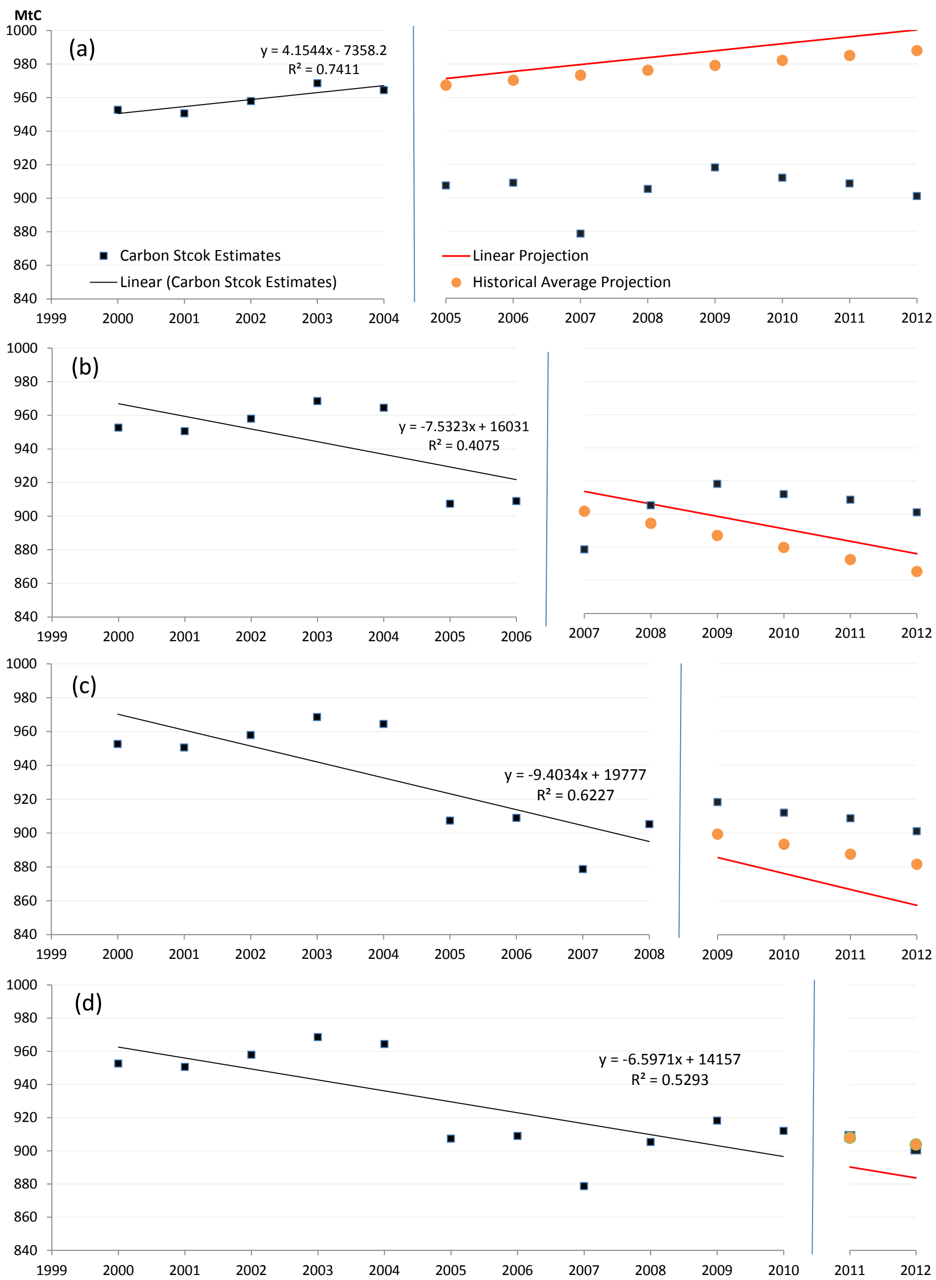


Figure 7.2: Retrospective business-as-usual (BAU) scenarios for Huaphan Province, Laos, using 4 reference time periods, 2000-2004 (a), 2000-2006 (b), 2000-2008 (c), and 2000-2010 (d). BAU scenarios are projected into each hypothetical monitoring period using 2 methods; linear regression (red line), and the historical average of the first and last observation point in reference period (orange circles). Actual estimated carbon stocks (MtC) are presented from 2000-2012 (dark grey squares).

In response to these case study results, we investigated in more detail the complexity of land-use system dynamics in the study sites. To better understand the causes of rapid, surprising changes of land systems, we used qualitative comparisons of the I-REDD+ sites based on the triangulated information from participatory land-use maps, cause-effect networks, and land-use transition curves. The land-use transition curves, by providing continuous, long-term land-use data, allowed us to determine whether historic land-use changes were linear or nonlinear, if they occurred gradually or abruptly, in which year rapid change occurred, and what proximate and underlying drivers contributed to the sudden changes (Müller et al. 2014).

The results of this analysis are shown in Figure 7.3. The sudden systemic shifts and leapfrogging, that we defined as regime shifts of land systems, were evident in some of the study sites. Land systems in all four sites were dominated by largely subsistence-based shifting cultivation in the early 1980s but land-system change later embarked on distinctly different pathways with different agricultural production strategies and divergent outcomes in terms of livelihoods and ecosystem services.

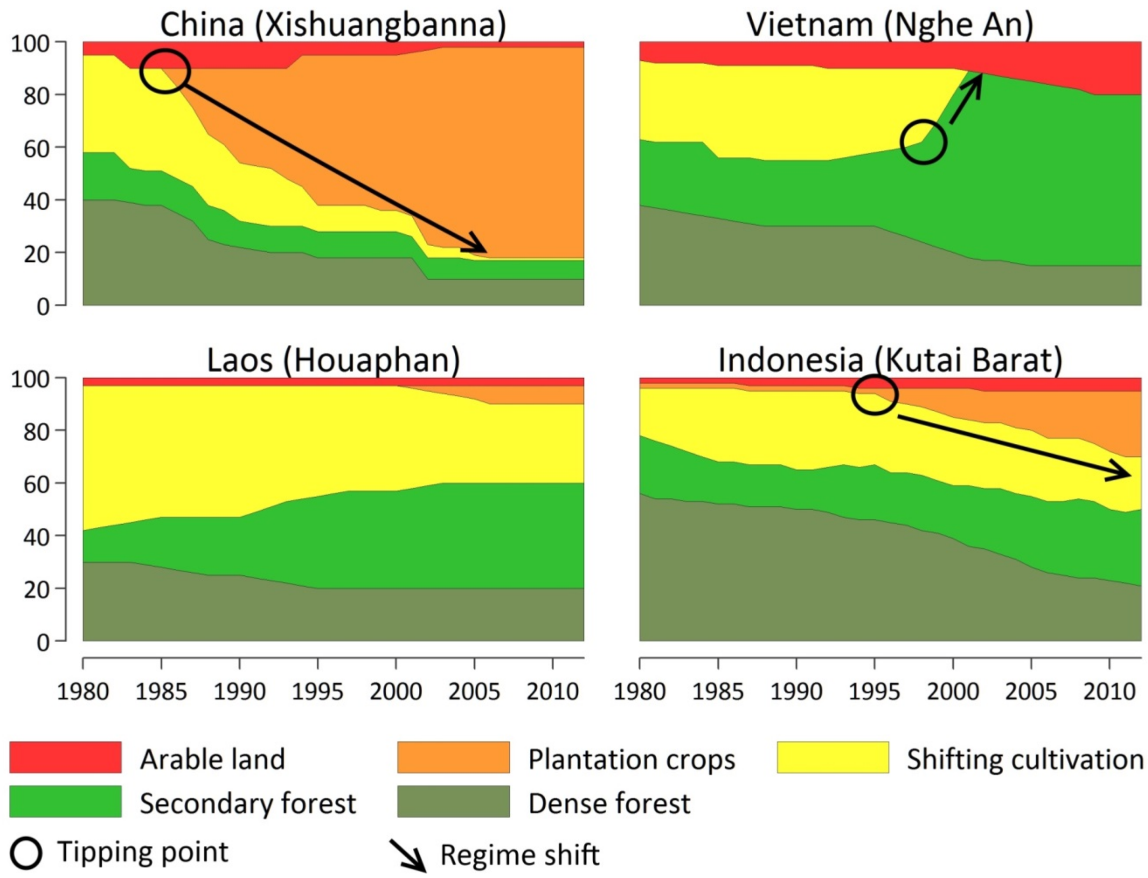
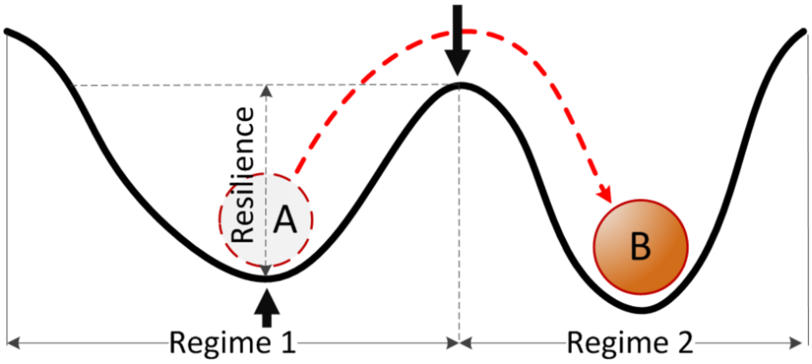


Figure 7.3: Land-use transitions from 1980-2012 in the four study sites (Müller et al. 2014). Shares of land-use types (y-axis) were aggregated for all communities within each study site.

We then constructed a conceptual model to describe the regime shifts in land systems, and applied it to explain the land-system change in the study sites. Regime shifts best exemplify the non-linear nature of land-system change. A land-system regime, defined a relative stable system featuring particular land-use composition, livelihood, and ecosystem services, may remain steady and resilient to external shocks. However, when one or more thresholds in underlying drivers are crossed, or if exogenous changes accumulate until a previously unknown threshold is crossed, land system can suddenly shift to a new state (Figure 7.4). During the transitional period between two regimes, feedback and interactions within the land system are reconstructed and reorganized. As a result, land systems may undergo abrupt, unexpected change that is persistent and difficult to reverse, akin to regime shifts in ecosystems.



Regime shifts in land systems (Müller et al. 2014). The balls represent the state of a land system. It can shift from one regime (a stable state confined by a valley) to an alternative regime (another valley), as illustrated by the ball shifting from A to B. The depth of a valley characterizes the resilience of the land-system regime to change. The resilience can be reduced by drivers that push up the valley (upward-pointing arrow) or by improvements in enabling conditions that reduce the height of the hill (downward-pointing arrow). Reduced resilience increases the attractiveness of alternative regimes and may thus facilitate regime shifts.

By applying the regime-shift theory, we categorize the land systems in the study sites into different regimes based on our qualitative knowledge and quantitative data for all sites. Comparisons over time and across sites reveal shifts in land-system regimes to alternative stable states and various causal mechanisms leading to the observed shifts (Figure 7.5). The land system in the Lao sites remains largely in the tradition of shifting cultivation despite considerable pressure from the introduction of cash crops, mainly hybrid maize. In China and Vietnam, the land systems quickly shifted to alternative regimes such as the capital-intensive and market-oriented rubber plantation in China and the permanent cropping in Vietnam. In contrast to the sites in mainland Southeast Asia, the Indonesian sites are not in an equilibrium state; instead, they seem to transition from a subsistence-oriented regime to a market-oriented regime, mainly characterized by expanding oil palm plantations.

One way to better predict these regime shifts would be to fully understand the dynamics of the drivers that affect land-use changes. However, change in the relative importance of different drivers is very difficult to anticipate. For example, the development of global market prices on rubber and palm oil can fundamentally alter local opportunity costs of land use, which in turn jeopardizes the permanency of emission reduction of REDD+. National polices, such as the logging ban in China and shifting cultivation ban in Vietnam may also substantially alter local and-use responses in ways that are difficult to foresee. Moreover, previously unknown thresholds in drivers may be transgressed, setting off abrupt and unexpected responses of land users. Hence, the observed changes in the study sites and the difficulty in projecting a business as usual scenario into the future illustrate how difficult it will be to obtain additionality in REDD+ activities.

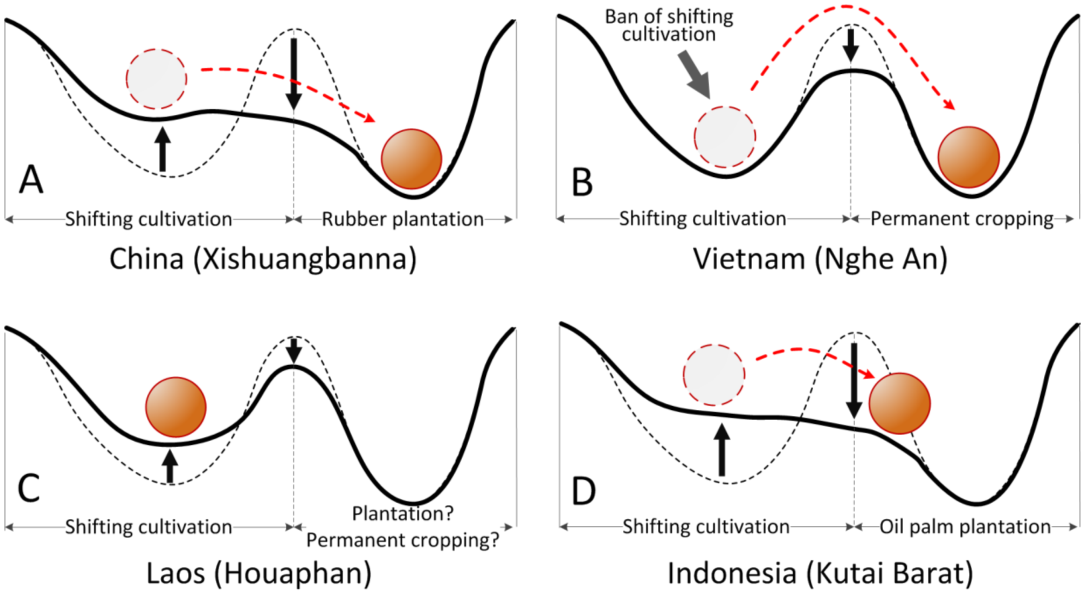


Figure 7.5: Regime shifts in land system change (Müller et al. 2014). Ball-and-valley diagrams of land-system regimes and observed regime shifts. Light grey balls and red balls characterize the state of land systems in 1980 and 2012, respectively. Upward-pointing arrows designate pressure from underlying drivers (e.g., population growth and rising commodity prices) and downward-pointing arrows designate improvements in enabling conditions (e.g., road upgrading or establishment of processing facility). The grey arrow in B symbolizes the external policy shock in Vietnam.

In order to provide a way forward for increasing the understanding of the dynamics of regime shifts in land systems, we designed a stylized system dynamics (SD) model to depict processes and mechanisms. The SD model of regime shifts shows, for example, how fluctuation of commodity prices leads to wide diffusion of a particular crop (e.g., rubber), often fuelled by policy support and/or improvements of infrastructure (Figure 7.6). Land-use regime shifts are conceptualized as a diffusion process driven by underlying drivers of change and, at the same time, constrained by socio-economic factors (e.g., availability of labour, capital, technology, and infrastructure). In the model, land-use regime shifts are caused by a reinforcing feedback, that is, a new land-use strategy (noted as LU2 in Figure 7.6), firstly adopted by investors from outside. Innovators among the farmers may trigger a snow-balling adoption among their peers due to the increasing returns to scale and economies of agglomeration. The model shows how a gradual change of certain variables that drive change, for example, the increase in commodity price for land use type 2 (e.g., rubber), may eventually trigger a quick and large-scale switch from land use type 1 (e.g., maize) to type 2. This “winner takes all” phenomenon is consistent with the well-known S-shaped adoption curve. It also corresponds very well to what we observed on the ground, e.g., the rapid expansion and dominance of the rubber plantations in Xishuangbanna, China. The model is hence a good learning tool and useful for supporting policy-making though the examination of the behaviour of key variables over time and under different scenario conditions. In that way, the SD model enhances our understanding of the presence of regime shifts in land systems and supports proactive decision making to prevent undesirable and promote desirable regime shifts of land systems.

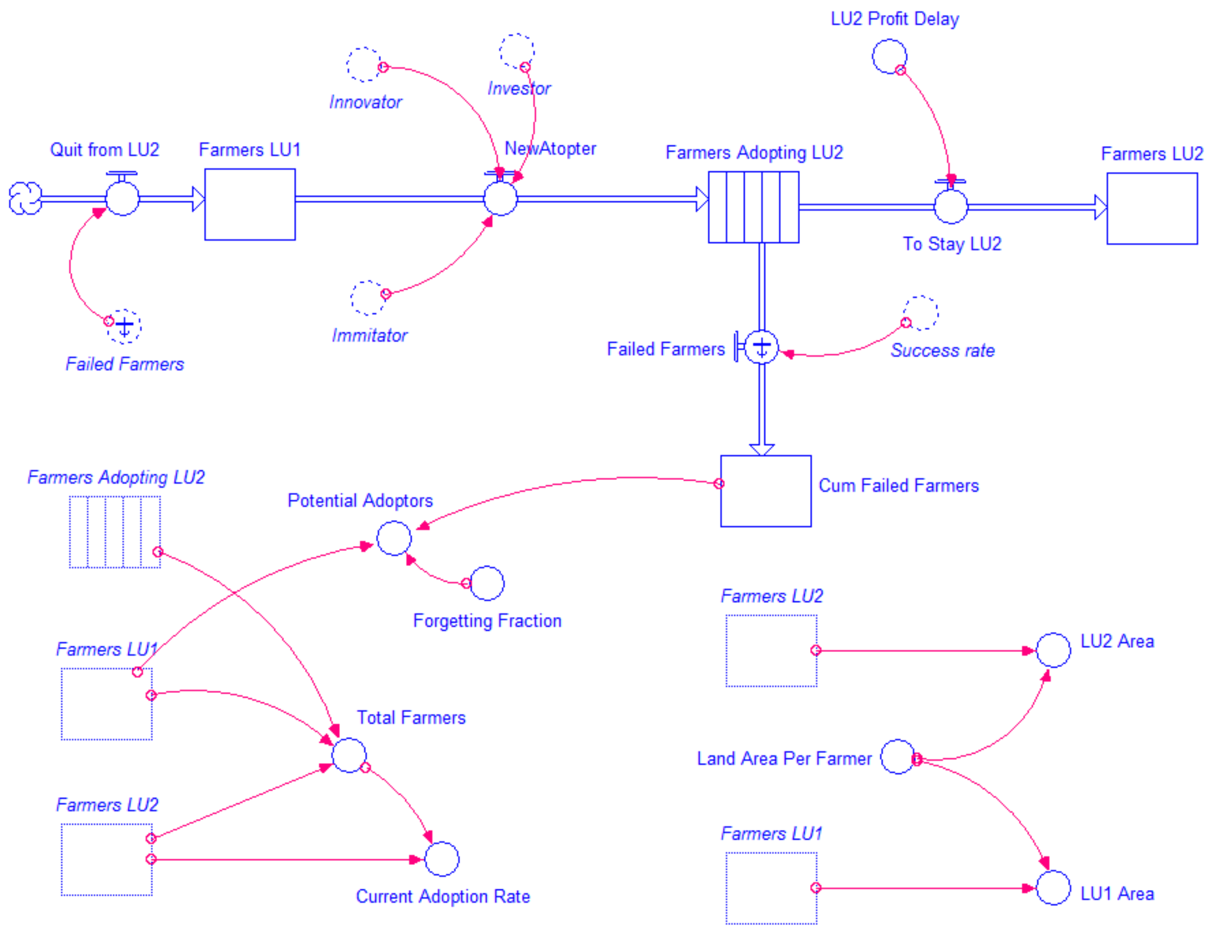


Figure 7.6: A stylized system dynamic model of land-system regime shifts (Sun & Müller 2014).

II) Achieving effective, efficient and equitable (3E+) REDD+

A comparative case study to evaluate the prospects of REDD+ in terms of effective, efficient and equitable (3E+) outcomes was conducted to obtain a holistic understanding of how REDD+ implementation may take shape in Southeast Asia and beyond. The study is based on the empirical research from the four study sites (Laos, Vietnam, Indonesia and China) reported above as well as the perception of REDD+ effectiveness, efficiency and equity of local stakeholders, NGOs, consultants, researchers and officials, who are involved in REDD+ implementation (Pasgaard et al. in preparation). We examined the opportunities and challenges to reach such 3E+ outcomes and specifically analysed the potentially desired qualities for the selection of REDD+ locations e.g. in relation to opportunity costs, forest area size, local willingness and equity perceptions, and political commitment. We also studied how the specific desired qualities vary according to the sub-objectives of the individual proposed REDD+ projects, the selection and development of which are often in the hands of external agencies.

Our findings suggested that desirable preconditions for making REDD+ successful at both national level and for localized interventions are generally agreed upon. These include a high degree of dense forests, low population density, low level of losses from foregone opportunities, high biodiversity benefits, high poverty reduction potential and commitment to engage in REDD+. However, so far locations for REDD+ pilot activities have typically been selected on the basis of specific interests of the external implementing agencies and other powerful players – with or without the potential to reach the intended climatic, ecological and/or social objectives in REDD+. This is likely to remain an issue if national REDD+ has an important sub-national/nested component. Greater attention towards the identified desirable qualities, such as the proportionality between deforestation drivers and mitigation measures, the various equity dimensions and perceptions among intended REDD+ stakeholders, and a novel typology of property rights, together offer a more feasible and meaningful approach towards assessing feasibility of REDD+ projects.

III) Guidance for REDD+ MRV

All results of the I-REDD+ project were finally placed in a context of how they may contribute to the development of monitoring systems aimed at measuring, reporting and verifying (MRV). This work concludes that there is no such thing as a "one-size-fits-all" option for the design and implementation of REDD+ mechanisms at the local level, if the objectives of REDD+ action goes beyond a mere reduction of emissions. This is particularly true for the complex landscapes that dominated in the study sites but also across most of Southeast Asia. Community-level approaches provide a number of potential advantages that can support emission reductions and co-benefits in these highly variable settings. Monitoring carbon stocks is promising at local level and can feed into regional assessments as validation and verification data but can also be sufficiently accurate and most cost-effective in local project-level interventions. The assessments of carbon at local level could also be accompanied by livelihoods monitoring systems to assess the multiple impacts of REDD+ implementation on the ground and avoid unexpected consequences on local populations. Participatory planning of resource use can facilitate the engagement of local people in negotiating context-sensitive REDD+ mechanisms and lead to locally appropriate actions that account for the substantial differences across sites observed in natural setting, culture, history, livelihoods and formal and informal institutional settings. Consequently, sufficient time and resources are needed towards local consultations and consensus building prior to developing REDD+ mechanisms.

The establishment of MRV systems remains still one of the largest challenges in REDD+ and we argue that, as currently proposed, MRV systems will fail to provide the incentives needed to arrive at zero net deforestation and to reduce carbon emissions. We particularly take issue with the "R" in REDD+ as we believe the baseline situation of emission in a BAU scenario are impossibly to establish in a way that they are "complete and accurate", as requested by the UNFCCC. Land systems in general and particularly in many of the dynamic tropical and subtropical regions often changed unexpectedly in response to, e.g., previously unexpected developments of global drivers, unexpected impacts of national policies or unforeseeable natural disasters. Compensation of land users based on unknown future emission pathways is therefore prone to failure. Yet, there are more unresolved issues beyond securing additionality that are difficult to tackle in national or subnational REDD+ MRV, such as securing permanence in emission reductions and avoiding displacement of land use that we have not addressed in our research.

We propose to concentrate forces on identifying locally adapted and flexible policy measures that support win-win outcomes towards sustainable land use. These include, e.g., many of the classic measures of rural development such as agricultural extension, including extension in resource management and sustainable forestry; support to farmers for improving agricultural productivity and investment into low-cost, land-saving technologies with high returns on labour; zoning and enforcement of land-use restrictions in forest landscapes with high nature values, including compensation of local population. This is of course not an exclusive list but provide some options that may yield better win-win outcomes and are less controversial than REDD+, as currently proposed. Yet, implementation of these and other measures are urgent because land-use emission continue to be high and the loss of biodiversity is unabated in the highly dynamics landscapes of Southeast Asia.

4.1.3.7 Publications from I-REDD+

The publications listed below include all types of published material as well as articles and books that are in in review, have been submitted or are in preparation. A few deliverables are also listed if they are referred to specifically in the text above. There is considerable material that has still not been published, especially the work on carbon stock assessment (WP2) and remote sensing (WP3) as this work was completed quite late in the project.

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Berry NJ, Bruun TB, de Neergaard A, Ryan CM. (in preparation). Climate change mitigation potential in shifting cultivation landscapes of upland Southeast Asia.

Bourgoin J, Castella JC, Hett C, Lestrelin G, Heinimann A. (2013). Engaging local communities in low emissions land use planning: a case study in Laos. Ecology and Society 18 (2): 9. http://www.ecologyandsociety.org/vol18/iss2/art9/

Broegaard RB, Vongvisouk T, Mertz O. (In review). Contradictory land use plans and policies in Laos: Hope for tenure security and threats of exclusion. In review in Journal of Peasant Studies.

Brofeldt S, Theilade I, Burgess ND, Danielsen F, Poulsen MK, Adrian T, Bang TN, Budiman A, Jensen J, Jensen AE, Kurniawan Y, Lægaard SBL, Mingxu Z, van Noordwijk M, Rahayu S, Rutishauser E, Schmidt-Vogt D, Warta Z, Widayati A. (2014). Community Monitoring of Carbon Stocks for REDD+: Does Accuracy and Cost Change over Time? Forests 5(8): 1834-1854. http://dx.doi.org/10.3390/f5081834

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Castella JC, Lestrelin G, Vongvisouk T, Nguyen DT, Janudianto, Li Q, Mertz O. (2015). Assessing livelihoods impact pathways of REDD+. Deliverable 5.3, I-REDD+ Project, Copenhagen.

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4.1.4 Impact and dissemination

The I-REDD+ research project originally responded to a call text that asked for research to "Improve and facilitate harmonisation of monitoring, accounting and verification aspects related to REDD/LULUCF in view of a post-2012 agreement. Identify and assess the effectiveness of relevant mitigation policies, at international level and contribute to the implementation of a post-2012 international agreement on climate change". As it is well known, neither a post-2012 international agreement on climate change nor any sub-agreement on REDD/LULUCF have been reached in the UNFCCC negotiations. Nonetheless, I-REDD+ has worked intensively to influence the negotiations of these agreements as well as their preparations for their implementation at local level in the I-REDD+ target countries of Indonesia, Laos, Vietnam and China.

4.1.4.1 Impact

I-REDD+ has considerably advanced the state of the art in science for the understanding of opportunities and challenges for REDD+ implementation. Some of these have already been published and include the demonstration of how local communities can cost-effectively and with high accuracy measure carbon stocks in forests (published in Ecology and Society and Forests); how benefit distribution mechanisms need to include more decentralization and local participation to be successful and just (published in Land Use Policy and Earthscan book); and that regime shifts in land systems represent a serious obstacle to obtaining additionality and permanence in REDD+ (published in Global Environmental Change and Environmental Management). In addition, several important results are in preparation for publication, including a discovery that belowground carbon stocks are underestimated in forest fallows that have been under shifting cultivation; development of new remote sensing based methods for carbon accounting in landscapes with shifting cultivation and degraded forests; and how the opportunity costs of land uses such as rubber, oil palm and maize are so high that REDD+ is unlikely to be feasible in many areas.

Impacts on policy processes and society in general are more difficult to measure at this early stage but through dialogue with both international REDD+ negotiators and staff responsible for REDD+ at national and local level in the four countries in Southeast Asia, it is clear that I-REDD+ has provided valuable inputs. For example, the results that demonstrate the weaknesses in how forest reference levels are translated into business-as-usual scenarios have been recognized as an important stumbling block for effective REDD+, and negotiators are calling for this issue to be addressed and not just ignored as a technical issue that can be resolved. It will be detrimental to an agreed REDD+ mechanism if ten years down the line it is realized that the additional emission reductions achieved were much lower than what was paid for – or the opposite case where REDD+ projects were never established because historical deforestation was too low, but subsequent regime shifts caused rapid decline in forests deemed ineligible for REDD+.

The results related to how communities can cost-effectively and accurately measure carbon stocks in their forests received considerable media attention, including broadcasts by BBC News, Mongabay and numerous other media. This, along with results that illustrate that benefit distribution mechanisms do not work without local participation, brought considerable attention to this issue and helped strengthen the agenda of the proponents who see the UNFCCC safeguards as central for a future REDD+ agreement. Community involvement in monitoring can be an important way of engaging stakeholders in the REDD+ implementation and thereby also make it more likely to succeed. Few REDD+ eligible governments, however, see community monitoring as being feasible in national monitoring systems, but even though REDD+ will be a national mechanism, it will always have sub-national implications that will involve forest users to some extent. Hence, I-REDD+ has made a considerable effort strengthen the positions at international, national and local level that see community involvement in REDD+ as essential.

The results related to how belowground carbon stocks in forest fallows are underestimated are yet to make a significant impact as they are under publication, but as these landscapes cover vast areas of the tropics, they are likely to have significant impact on distribution of emissions between different land use types. This will affect policies on how REDD+ deals with these landscapes and they may be considerably more valuable for climate change mitigation than previously thought. In addition, the remote sensing techniques developed specifically for monitoring these landscapes will be able to integrate these new carbon stock results to adjust larger scale carbon accounting estimates. Thus, the combination of better carbon stock assessment and more detailed remote sensing based forest monitoring will be highly useful for national forest and carbon monitoring systems.

At the national level, I-REDD+ has through a range of efforts led by the project partners in Indonesia, Laos, Vietnam and China brought these concerns to the REDD+ agenda, such as in REDD+ offices or task forces at national and local level. Especially at local level, and particularly in Laos, I-REDD+ has contributed to capacity building of local staff that have been made aware of the complex nature of REDD+ through the research activities. This has also taken place at community level, especially through the participatory land use planning (PLUP) exercises carried out in each of the eight villages targeted for I-REDD+ research. This made communities highly aware of what REDD+ may or may not do and provided them with a better background for decision-making if they become involved in actual REDD+ activities.

Overall, the I-REDD+ project has documented a number of weaknesses that need to be accounted for in future REDD+ projects and programmes. These findings may not be a contribution to making REDD+ implementation easier or reaching an international agreement more likely, but they help to avoid fundamental mistakes that may jeopardize successes in emission mitigation from land-use change. International negotiations may reach agreement on technical and political issues, but these will not be useful if fundamental elements of the REDD+ system are ignored.

4.1.4.2 Dissemination activities

The I-REDD+ project produced at an early stage a dissemination plan that outlined all dissemination activities apart from scientific publication that is presented under results. These activities targeted international, national and local levels of policy as well as the broader public internationally and in the partner countries in Southeast Asia. The activities have been as follows:

I) Project website

The I-REDD+ project website **www.i-redd.eu** has been continuously updated and expanded and the public site contains all necessary information about the project activities, field sites, project partners and participants as well as project events. Moreover, all publications of I-REDD+ are presented on the public site with direct links to the electronic versions of the papers where available. The internal part of the site is being consistently used for uploading project documents such deliverables, policy briefs, and other publications, including draft papers. The website will be kept online and continuously updated for at least 1-2 years as new publications of I-REDD+ work emerge.

A separate website was developed for the final conference entitled Carbon-Land-Property (http://carbonlandproperty.dk/, see more information below) to convey all relevant information related to the conference participants and the public.

Tracking of website visits was not done, but there has been considerable feed-back stating that both websites have been good resources for finding material about the projects, its activities and about REDD+ in general.

II) Policy briefs

Four general policy briefs have been produced by I-REDD+, all of which were finalized prior to and distributed at the UNFCCC Conference of the Parties in 2011, 2012, 2013 and 2014. The policy briefs are entitled:

1. I-REDD+ Policy Brief no. 1 (2011). The forgotten D: challenges of addressing forest degradation in REDD+.
2. I-REDD+ Policy Brief no. 2 (2012). Understanding, measuring and governing changes in forest carbon stocks in complex landscapes.
3. I-REDD+ Policy Brief no. 3 (2013). Opportunities for REDD+ in degraded forests and complex landscapes.
4. I-REDD+ Policy Brief no. 4. (2014). Lessons for REDD+ from complex mosaic landscapes.

The briefs were moreover sent directly to the European Union REDD+ negotiators and distributed to wide range of other international and national events where REDD+ issues were discussed. The fourth policy brief was moreover translated into Lao and distributed to a wide range of stakeholders in Laos.

In addition, a number of other policy briefs were produced for specific activities in I-REDD+. The work on benefit distribution mechanisms was presented in four country specific policy briefs that were all translated into national languages. These briefs have been widely distributed in the four target countries and were presented at national consultations on REDD+ and benefit sharing. The governance group has moreover produced two policy briefs entitled 'REDD+: Justice effects of technical design' and 'REDD+ Safeguards for Vietnam: Key Issues and the Way Forward'.

The work on community based forest monitoring also resulted in a policy brief entitled 'Policy brief on cost-effective methods for monitoring forest biomass and land-use change' that was distributed as part of policy brief series at University of Copenhagen. Finally, a brief entitled 'Local Mitigation Actions Supporting the Low Emission Development Plan in Kutai Barat District, Indonesia' was produced in both English and Indonesian for local dissemination (Johana et al. 2013).

III) I-REDD+ conferences

Two international conferences were organized by I-REDD+. The 'Conference on science based measurement, reporting and verification (MRV) systems for REDD+ in Southeast Asia' was aimed at regional policy-makers in Southeast Asia and held on 9th November 2012 in Hanoi, Vietnam. The focus of the conference was on how science can contribute to developing Measurement, verification and reporting (MRV) systems. The conference had 60 participants.

The main I-REDD+ event was the international conference 'Carbon-Land-Property' which was held at University of Copenhagen on 1-4th July 2014. Keynote speakers included leading researchers on REDD+: Prof. Arun Agrawal, University of Michigan, USA; Prof. Arild Angelsen, University of Life

Sciences, Norway; Dr. Christine Padoch, Director of Livelihoods Programme, Centre for International Forestry Research (CIFOR); Dr. Esteve Corbera, Autonomous University of Barcelona, Spain; Dr. Frédéric Achard, Joint Research Centre; Dr. Sandra Brown, Winrock Foundation, USA; Prof. Nancy Peluso, University of California Berkeley. Moreover, the conference was opened by Head of Department and president of the IUFRO Niels Elers Koch and Dr. Anastasios Kentarchos, representing the European Commission (DG Research). While the conference was mainly a scientific event, presentations by REDD+ negotiators from the European Commission (Dr. Michael Bucki) and the Danish Government (Dr. Peter Iversen) ensured the link to important policy arenas. A total of 120 participants from all over the World attended the conference. See more on http://carbonlandproperty.dk/.

IV) Side-events at UNFCCC COPs 2012-2014 and other conferences

I-REDD+ organized two side-events at EU Pavilion of the UNFCCC COPs. At COP18 in Doha, November 2012, a side-event entitled 'Is the window of opportunity for REDD+ closing?' was organized jointly with the REDD-ALERT project and I-REDD+ had two presentations. At COP19 in Warsaw, I-REDD+ organized a full side-event entitled 'Opportunities for REDD+ in degraded and complex landscapes' with four presentations. At COP20 in Lima in December 2014, the final outcomes of I-REDD+ was presented at a side-event in EU Pavilion entitled 'LULUCF & REDD+: Forest Potential for Climate Change Mitigation in the Post-Kyoto Framework'. This event was organized by the Swedish University of Agriculture and I-REDD+ was invited to present. All events had a good audience of 40-60 participants, including negotiators, who engaged in discussions of the work presented. The policy briefs mentioned above were all presented and distributed at the COPs.

In addition to the I-REDD+ conferences and COPs, I-REDD+ work has been presented at wide range of international, national and local events aimed at scientific, policy and broader audiences. In total, the project has been presented with more than 130 different types of dissemination efforts.

V) Dissemination in Southeast Asian countries

Dissemination of I-REDD+ results in the countries selected for case studies in Southeast Asia has been another high priority of I-REDD+, both to ensure that decisions on REDD+ are taken on an informed basis and to contribute to capacity building on REDD+. As mentioned above, four policy briefs on the governance work were translated into national languages and several other activities were carried out in each country:

In China, an I-REDD+ Dissemination Workshop was organized by Kunming Institute of Botany in Jinghong, Yunnan, in September 2014 and had 53 participants from government, research, business, and NGOs. The main aim was to present I-REDD+ results and to discuss how payment for environmental services can be improved in the Chinese context.

In Indonesia, an event was organized by WWF-Indonesia and ICRAF in Balikpapan, East Kalimantan, entitled 'First district-scale green economy plan in Indonesia launched in Kutai Barat'. I-REDD+ results were presented, including the brief mentioned above on local mitigation actions (Johana et al. 2013), and the event was also accompanied by a range of other policy briefs addressing different REDD+ relevant issues:

- Develop REDD+ Readiness Through Participatory Land Use Mapping and Planning in Indonesia: Case of Kutai Barat (in Indonesian)
- Creating Community Forest in Indonesia: Case of Kutai Barat, East Kalimantan

- Participatory Land Use Planning, Case of Batu Majang Village, East Kalimantan, Indonesia (in Indonesian)
- Community Conservation Area in Kutai Barat, East Kalimantan, Indonesia (in Indonesian)

In Laos, the fourth general I-REDD+ policy briefs was translated into Lao and disseminated in various policy arenas in the country that deal with REDD+. In addition, I-REDD+ results were presented to the Research Forum for Development held by National University of Laos and the National Agricultural and Forestry Research Institute on 17-18 December 2014. These activities were organized by National University of Laos. As a post-project activity, a national dissemination workshop is planned on 10th March in Huaphan Province where most I-REDD+ work have taken place.

In Vietnam, the I-REDD+ paper on effective, efficient and equitable REDD+ was translated to Vietnamese and distributed at various REDD+ policy events. Moreover, a book based on I-REDD+ results and destined for teaching at university level on REDD+ has been written. The book is currently in the process of being published. These activities were organized by Center for Agricultural Research and Ecological Studies, Vietnam National University of Agriculture.

Collaboration with other projects and institutions

Agreements were made with two REDD+ implementing organizations, the German funded CliPAD project in Laos and the international NGO SNV that works regionally. The purpose of the agreements was for I-REDD+ to follow activities regarding implementation of REDD+ on the ground and for the organizations to get access to data from I-REDD+. Unfortunately, the CliPAD Project has so far been unable to implement their REDD+ activities in Laos and SNV implementation in Vietnam did not start before I-REDD+ field research was completed. Therefore, it was not possible to assess the impacts of any actual REDD+ implementation before the project ended. This has not been crucial for obtaining results as the I-REDD+ research was designed for this fairly likely risk-scenario to occur.

Contact with the other EU FP7 funded project on REDD+, REDD-ALERT, was established in 2011 and I-REDD+ ideas and plans were presented at the third annual REDD-ALERT project meeting in Dalat, Vietnam, September 2011. Contact with the REDD-ALERT coordinator has been maintained since this meeting, including the joint side-event at COP18 in Doha.

Existing agreements are still in force and I-REDD+ works in close collaboration with a range of new research projects. These include e.g. 'Property and Citizenship in Developing Societies' that co-funded the July 2014 conference with funds from the Danish Research Council for Independent Research, the 'Ecosystem Services and Well-Being' project funded by the ESPA mechanism of the United Kingdom Natural Environment Research Council, and the Global Land Project under FutureEarth, which has endorsed I-REDD+ as one of its core activities.