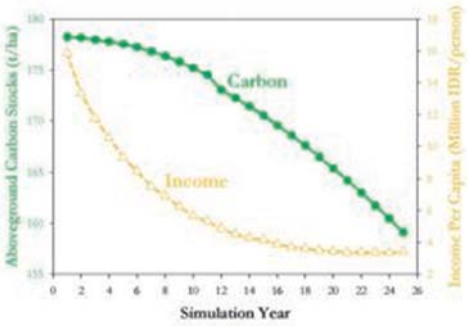
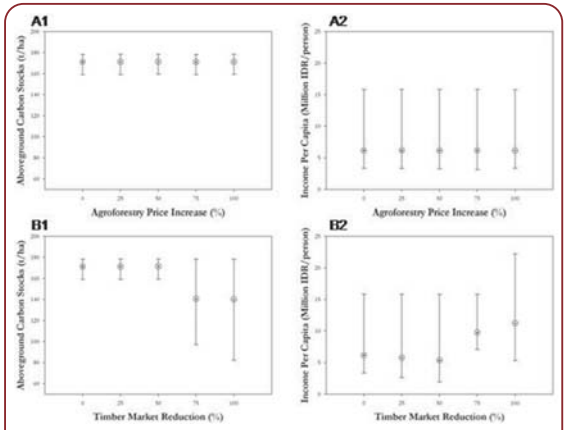
increase in profitability of agroforestry options is needed before this practice cab be an 'alternative to illegal logging' and compete with the attractiveness of logging.

Simulation result. Efforts to improve agroforestry profitability through better market development did not correspond with adoption of agroforestry, when natural capital for logging activities provided better payoffs. Thus both income per capita and carbon stocks remained similar to current trend (A1 and A2). Reducing timber market by 25 50% from current setting (full capacity) reduced income without changing existing carbon stocks. When timber market reduction was increased by 75 100%, people adopted agriculture and agroforestry to compensate income lost from logging. Thus reduced existing carbon stocks but creating better income level.



Simulated carbon stocks and income in Nunukan based on survey data.



Simulation result

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RAPID CARBON STOCK APPRAISAL (RaCSA):

a rapid but integrated way to assess landscape carbon stocks

Trees in Multi-Use Landscape in Southeast Asia (TUL-SEA)
A negotiation support toolbox for Integrated Natural Resource Management

Carbon storage in trees and soil as ecosystem service under threat

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC Fourth Assessment Report, 2007).

About 20% of the emissions of carbondioxide (CO_2) and other greenhouse gasses that cause this global climate change are due to land use change in the tropics. While most policies have so far focused on the fossil fuel use that causes the bulk of the CO_2 emissions, the land use change component can no longer be ignored. Global mechanisms for providing economic incentives for maintaining and restoring C-stocks are taking shape. The UN Framework Convention on Climate Change (UNFCCC) regulates the Clean Development Mechanism (CDM) that includes, under specific rules, afforestation and reforestation activities. Currently under discussion is a similar approach to reducing emissions from deforestation and degradation in developing countries (REDD). Voluntary market mechanisms, not part of the commitments to emission reduction that UNFCCC countries have pledged, target various combinations of landscape level restoration and protection of tree cover and carbon stocks.

Environmental service rewards for **carbon storage** need to deal with three important criteria:
Realistic - interventions need to be based on knowledge of carbon (C) stocks and greenhouse gas (GHG) fluxes; they also need to align with the tradeoffs between economic benefits from land use change and the consequences for emissions ('abatement costs');
Voluntary - the mechanisms need to respect existing property and land use rights (compare the RATA or rapid tenure claim appraisal tool) and follow principles of Free and Prior Informed Consent (FPIC); agreements require a shared understanding of the issues and options to deal with them
Conditional - the economic incentives will be 'performance based' and thus require systems of monitoring changes in the landscape; linked to that is that rewards will be based on 'additionality' (changes relative to what would have occurred anyway) and address 'leakage' (negative effects elsewhere of C stock conservation within a 'project' area).

Objectives of Rapid Carbon Stocks Assessment (RaCSA)

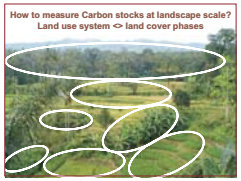
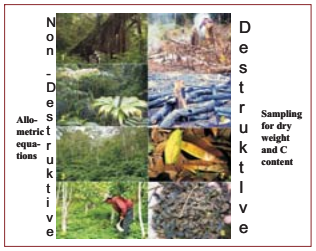
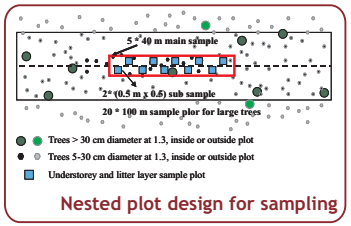
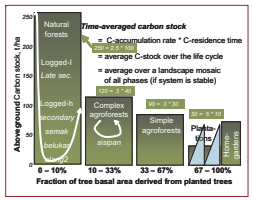
The RACSA appraisal tool is designed to provide a basic level of locally relevant knowledge to assist in such discussions between relevant stakeholders. It introduces a scientifically sound methodological framework of accounting carbon sinks, while focusing on activities that can improve local livelihoods and alleviate rural poverty.

The purpose of RaCSA is to provide a cost effective and time-bound (within 6 months) appraisal that

- ***provides*** reliable data on C stocks in a defined landscape, its historical changes and the impact of ongoing land use change on projected emissions, with or without specific interventions to increase or retain C stocks
- ***identifies*** the primary issues in the local tradeoff between C stocks and livelihoods and the opportunities to achieve more sustainable development pathways
- ***enhances*** shared understanding between stakeholders as step towards FPIC in contracts to increase or retain C stocks

Steps in RaCSA

Table 1. Activities conducted under RaCSA approach and their relevant outputs

Steps	Activities	Objectives
1	Initial appraisal of landscape (compare PALA), focussed on dynamics of tree cover 	To define the unit of assessment (integrated livelihood/landscape unit), its gradients in tree and forest cover, mineral and peat soils, legend of land use/land cover types, major 'issues' in the current debate
2	Explore Local Ecological Knowledge (LEK) and economics of local tree/forest management combined with a rapid household socio-economic survey	To document livelihood strategies of the farmers pertaining to land use practices and key drivers of change in the landscape
3	Plot-level C data in representative land cover units and; integrating from plot to time-averaged C stock of land use types; an updated version of the ASB C-stock protocol provides the tree and soil level data 	•To assess the performance of existing land use systems as carbon sinks and/or preserving carbon stocks.  Nested plot design for sampling
4	Combining remote sensing imagery and ground-truthing data within a sufficiently sensitive 'legend' to provide spatial analysis of land cover change 	•To estimate carbon stocks of the main land use practices at plot level as well as their integration at landscape level
5	Explore Public/Policy Ecological Knowledge (PEK) of tree/forest management and existing spatial planning rules	To explore the opportunities to use or adjust existing policy frameworks to enhance C storage in the landscape
6	Scenario studies of changes in C stocks and welfare through modelling land use and carbon stock dynamics in the landscape 	To appraise landscape carbon stocks dynamics in relation to 'drivers' of change, as a basis for selecting interventions that an enhance peoples welfare and at the same time maintain/increase carbon stocks.

The results need to be communicated in a simplified format that focuses on the main tradeoffs and decisions that can be made within the landscape. The primary data on C stocks can contribute to national databases and be subsequently used for national scale reporting. The ground-truthing and spatial analysis can similarly contribute to future analysis of the dynamics in larger areas, while the trade-off data and scenario models can be used for direct comparisons with other landscapes.

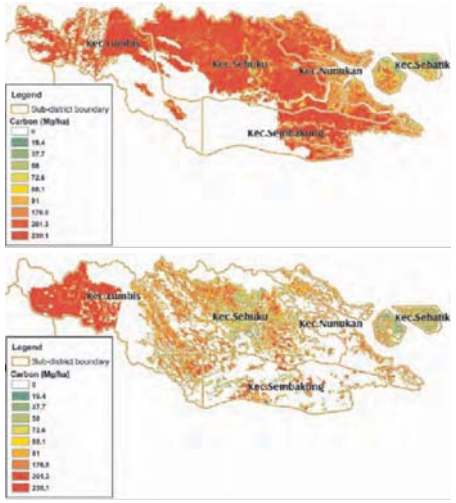
Example of application in Nunukan District, East Kalimantan, Indonesia

The RaCSA approach was applied in Kabupaten Nunukan, East Kalimantan to monitor carbon stocks in the area, where forest conversion, illegal logging and fire are causing substantial carbon emissions. In the area, community based forest management, such as agroforestry and low external input sustainable agriculture are seen as options that could provide sustainable livelihood for local farmers as well as increase/maintain carbon sequestration. This agriculture activity competes with logging as the most profitable activity.

Based from a household survey, there are 3 main tree-based systems in the area: smallholder plantation of oil palm and pepper, Jakaw (an upland rice fallow rotation systems) and a fruit-based systems where farmers plant fruit trees in logged-over-forest between remnant trees of low-commercial values. These systems are estimated to store the following carbon stocks.

Table 2. Mean aboveground carbon stocks of land use systems sampled in Nunukan

Land Use Systems	Carbon stock (Mg ha^{-1})
Primary forest	230
Logged-over-forest aged 0-10 years	207
Logged-over-forest aged 11-30 years	213
Logged-over-forest aged 31-50 years	184
Jakaw aged 0-10 years	19
Jakaw aged more than 10 years	58
Agroforestry aged 0-10 years	38
Agroforestry aged 11-30 years	73
Imperata	4
Upland Rice	5



Distribution of land cover derived carbon density in Eastern Nunukan, 1996 (top) and 2003 (bottom)

Landscape carbon stocks assessment estimated that the carbon density in 1996 was 210 Mg ha^{-1}, while in 2003 was 166 Mg ha^{-1}. Within the period, primary forest was converted to other land cover at the rate of 3.9% year^{-1}. The estimated rate of carbon sequestration for jakaw systems is 3.7 Mg ha^{-1} year^{-1} and agroforestry systems is 2 Mg ha^{-1} year^{-1}.

Modeling exercise suggests that both income and landscape level carbon stocks in Nunukan is decreasing, as non sustainable logging remains the most profitable land use options (Figure above). Efforts to improve agroforestry profitability by increasing its yield and improving its market (increasing the price) did not substantively change its adoptability on the landscape, producing similar trade off patterns as current setting (Figure below). Thus the current recommendation for policy in Nunukan setting is agroforestry and community based natural resource management (CBNRM) should work hand in hand to simultaneously achieve global and local benefits. A substantial