What Can a Clean Development Mechanism Do to Enhance Trees in the Landscape? Experience with Rubber, Coffee and Timber-based Agroforestry Systems in Indonesia

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Abstract

Terrestrial carbon storage is one of a broader array of environmental services and lessons that can be shared between the mechanisms developed or under development for watershed functions, biodiversity, carbon storage and landscape beauty. In many situations a "bundling" of services will be needed to provide sufficient incentives for smallholders to avoid conversion to low-ES land use types. The Clean Development Mechanism (CDM) is often considered to be intended for project-scale investment, with the reforestation CDMs focussed on fast growing trees. In fact, the mechanism can also be used by local government units to use an array of incentives to stimulate their farmers to convert the landscape to a more tree-based land use pattern, as long as a sufficient part of the landscape makes the transition from non-forest (less than 30% crown cover with Indonesia's operational forest definition) to forest (more than 30% crown cover of trees potentially growing to more than 5 m tall, at a 0.5 ha scale). A number of constraints to more tree-based land use can be identified and efforts to remove the key constraints at local scale can qualify under the Clean Development Mechanism, as long as there is a measurable increase in overall carbon stock. As a delivery mechanism, the reduction of taxes and of transaction costs for land use agreements (HKM) may be more effective for farmers than direct payments. The paper discusses the land use patterns in three benchmark sites of the Alternatives to Slash and Burn (ASB) program in Indonesia, with rubber and coffee-based land use systems.

Introduction

Rewards and payments for terrestrial carbon storage is part of a broader issue: rewards for environmental services provided by land use (Table 1). Based on the CGIAR's commitment to poverty reduction and meeting the Millenium Development Goals, we are specifically interested in the use of such reward and payment mechanisms in the context of smallholder farmers—with carbon stocks, biodiversity, watershed functions and landscape beauty as four categories of environmental service (ES) functions. In the context of the RUPES project (Rewarding Upland Poor for the Environmental Services they provide), a typology of environmental services was developed (van Noordwijk 2005) that leads to the distinction of 12 prototypes of situations where the upland-lowland relationship is focused on a specific environmental service function (Table 2). For each of these situations we need to understand the perspective of the ES providers/sellers, the ES users/buyers and the intermediaries who try to broker between the two parties.

Although avoiding degradation may be easier and less costly than restoring a degraded situation, the politics of attribution make it difficult to design effective reward systems. The international debate on CDM has demonstrated that investment for rehabilitation (reforestation) is easier to generate than for avoided deforestation or for avoided loss from peat soils.

Table 1. Environmental services relating to carbon stocks among 25 environmental services in 5 main categories (Van Noordwijk 2005).

Biodiversity functions (B)		**7 services**
Watershed functions (W)		**5 services**
Carbon stocks (C) 4 services:		
C1	Protecting natural forest area, peat soils and other carbon storage areas	
C2	Protecting above- and/or belowground carbon stocks in areas used for (agro)forestry and/or agriculture	
C3	Restoration, increase in tree cover (in a 'sustainable harvest' regime the time-averaged C stock of a land use system does not depend on the growth rate, but on maximum stock at time of harvest)	
C4	Accumulating wood and other products derived from recent plant production in, for example, the form of houses, furniture, paper, organic waste dumps.	
Productivity and direct profitability (P)		**4 services**
Human health & landscape beauty (H)		**5 services**

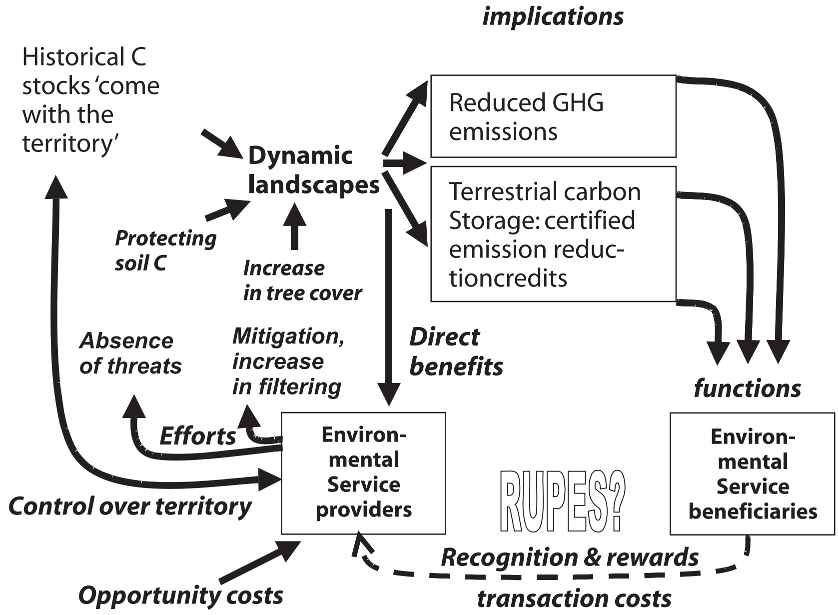

Figure 1. Key relationships in landscapes where local guardians and stewards are rewarded for the carbon storage services they provide (Van Noordwijk 2005).

It has been suggested that oxygen supply is an additional environmental services provided through trees. As there is no global shortage of oxygen, this is not a service that is likely to merit rewards (Box 1)

Box 1. Oxygen supply a forest function?

The counterpart process of carbon sequestration is the release of oxygen to the atmosphere. Decomposition of the sequestered carbon will tend to re-use the same amount of oxygen as was produced. Popular accounts of forest functions and benefits of having trees around, tend to include production of oxygen as a service that should be included in valuing trees and forests. People can't live without oxygen, so any increase in oxygen supply should be welcome.

Counter arguments are:

- With over 20% of the atmosphere consisting of O_2 there is no shortage of oxygen, except in locations with poor atmospheric contact (in water, in wet soils, in closed air spaces), so only local supply within locations with shortages are relevant, not additions to the global atmosphere,
- A doubling of atmospheric CO_2 concentration due to the oxidation of stored carbon (biomass or fossil fuels) will be linked to a change the atmospheric O_2 concentration of only 0.03%, which is negligible.

Table 2. Twelve prototype situations for ES rewards in upland agricultural systems (Van Noordwijk 2005).

Environmental service	Providers/ sellers	Users / buyers	Main issue
1. Total water yield for hydroelectricity via storage lake (W_{cons}_1)	Impacts on total water yield small; reservoir sedimentation issue may dominate the debate; option for sediment traps and landscape filters	Consumer satisfaction depends on continued functioning; high project investment costs, little subsequent management flexibility	Intercepting sediment flows rather than avoiding them is generally easier to accomplish; sediment flows out of well-managed upper catchments may still be high because of geological and geomorphological processes
2. Regular water supply for hydroelectricity via run-off-the- river (W_{cons}_2)	A change from soil quick flow (saturated forest soils) to overland flow will have some effect on buffering of river flows and hydroelectric operation time		Interventions influencing the speed of drainage (linked to paths, roads and drains) have the most direct effect on buffering at larger scales
3. Drinking water provision (surface or groundwater) (W_{cons}_3)	Intensive agriculture and horticulture will cause rapid pollution of surface flows and slow but persistent pollution of groundwater flows with nitrogen and pesticides; people residing around streams cause pollution E.coli and diseases	Willingness to pay for drinking water depends on quality assurance from medical perspective, as well as taste	Slow response of groundwater flows to changes in the pollutant status make 'regulation' a more effective solution than results based markets
4. Flood prevention (W_{cons}_4)	Land use effects strongest for flow buffering of small-to-medium sized events, with saturation dominating the large events	Relevance of upland land use depends on location ('floodplains') and engineering solutions (dykes, storage reservoirs)	Risk avoidance for the rare category of large events
5. Landslide prevention (W_{cons}_5)	Mortality of deep-rooted trees ('anchors') causes temporary increase in landslide risk	Relevance depends strongly on location in the flow paths	Deep landslides are little affected by land cover
6. General watershed rehabilitation and erosion control (W_{reh})	Promoting tree cover and permanence of litter layer protecting the soil is a good precaution	"Holistic" perception of watershed functions survives despite the lack of clear impacts on specifics	Communication gap with scientists who try to enhance clarity

Table 2. *Continued*

Environmental service	Providers/ sellers	Users / buyers	Main issue
7. Biodiversity bufferzones around protected area (B_{cons}—1)	Use value of buffer zones depend on hunting restrictions, presence of human-life threatening species	Flagship species still dominate the public perception of value	Push and pull factors in human land use; livelihoods operate at larger scales than most conservation plans acknowledge
8. Biodiversity landscape corridor (B_{cons}—2)	Still new concept in agriculture/forest land use mosaics in the tropics; use value of patches in the "stepping stones" similar to the buffer zone case	Relevance depends on dispersion properties of the species of main interest; sometimes higher connectivity not desirable; relevance increases with climate change concerns	Ex-ante impact assessment of effectiveness is still difficult
9. C restocking degraded landscapes (C_{reh})	Options for profitable tree restocking primarily depend on policy reform	Demand is for Certified Emission Reduction (CER) rather than carbon	Additionality issues in CDM; high transaction cost
10. C protecting soil and tree stocks (C_{cons})	Road construction (accessibility) is main determinant of opportunity costs for non-conversion		Not recognized as part of CDM
11. Guaranteeing production landscapes meet environmental standards (Ecolabel)	Where the eco-label process starts from the consumer side, there can be a substantial gap in communication and trust, leading to high transaction costs	Consumers with high sense of personal responsibility; gradually replaced by the introduction of standards and the raising of baselines of "acceptable" behavior	Relevance of global standards in the face of variation in local conditions; transparency of the standards and compliance monitoring; transaction costs
12. Providing guided access to landscapes of (Ecotourism)	The local and international appreciation for landscape beauty depends on culture and time (fashion); rewards are for roles as guide and provider of accommodation, food, transport and handicrafts; gender aspects of provider roles may be prominent	The appreciation of landscape beauty and cultural traditions does not reduce the need to provide security and comfort to potential tourists	Global ecotourism is a highly volatile market where security and political concerns can interfere

In this contribution to the debate we will focus on the Clean Development Mechanism and its possible application in Indonesia, building on the experience in three benchmark sites of the Alternatives to Slash and Burn (ASB) program where a number of international and national centers cooperate.

Clean Development Mechanism: A project or programmatic approach?

Much of the language and concepts surrounding CDM (Clean Development Mechanism) applications is in terms of *projects*: activities with a specific spatial and temporal timeframe, management entity, investment mechanism and expectation of end-of-project benefits. Yet, in rural development projects have obtained a negative connotation: they tend to be dominated by their initial design rather than by learning along the way; private benefits of the various actors do not depend on improvement in the overall performance of the system; private benefits do depend on maintaining positive news and goods to the higher hierarchical levels; projects tend to distort markets with temporary subsidies that cannot be maintained once the project is over, leading to the collapse of most of the apparent project successes.

The Clean Development Mechanisms should be about removal of (generic) constraints to development, allowing bottom-up processes and self-organizing structures to contribute to household benefits (improving the Human Development Index, reaching Millenium Development Goals) as well as provision of services to local and external stakeholders. Increased services to external stakeholders in the form of enhanced storage of CO_2 from the atmosphere is the basis for financial transfers in the carbon market, which in fact, may be more correctly labelled as a certificates of emission reduction (CER) market. Most of the economic value is in the certification rather than in the carbon storage per se, and that is reflected in a situation where about half of the financial value will go to the intermediaries (project developers, evaluators, certifiers).

A cynic might conclude that this allocation of the financial benefits to consultants and government agencies is logical given the primary decision-makers on CDM. However, the low level of trust between the various stakeholders in the international negotiations has lead to rules and conditions that are in danger of defying the purpose: enhancing net carbon storage in terrestrial systems (from a generally negative baseline in most tropical countries), to "buy time" for the development of life styles and technologies that are less dependent on fossil fuel use and greenhouse gas emissions. The rules for additionality may be perverted to "if it makes sense you should have done it any way" and thus favor projects that don't make sense. The rules for leakage may be perverted to the reduction of the freedom of (poor) economic actors outside of the domain of beneficiaries of the project. The permanence issue will tie local partners into long-term commitments that they may not fully understand or are able to judge. The link between carbon storage and land ownership may lead to a skewed distribution of development benefits where the local rich benefit and local landless or smallholders see little benefit or are negatively affected.

Within the Annex I countries of the Kyoto Potocol a substantially different regime applies. The primary performance criterion is the net impact on the national account of greenhouse gas emissions. Definition of "forest" does not matter, as all land cover classes are taken into account at their mean carbon stock densities. Protecting existing carbon stocks is at least as important as enhancing terrestrial C sequestration, while additionality and leakage are of no concern to the international community and monitors of compliance to the agreements. Permanence is also embedded in the annual reporting commitment of the national entity. It is thus in the best interest of the countries to stimulate terrestrial carbon sequestration by generic incentives such as tax cuts rather than at project level with complex disbursement schedules. The government can evaluate the effectiveness of its rules by national scale monitoring, which it is committed to do anyway, leading to low transaction costs attributed to the C sequestration activities *per se*.

What can we learn from the difference between Annex I and non-Annex I countries? First of all that in the long run the global climate change issue will be best served if all countries undertake commitments and report at national scale. For developing countries these commitments should be to limit their growth in emissions to specified levels rather than reduce emissions. Such a change, however, will take a substantial improvement in global level social capital that primarily depends on improvements in global processes regarding trade, security and social benefit flows, rather than that it can be negotiated for the climate issue alone.

Secondly, the current CDM rules allow for a much closer approach to the way Annex I countries can stimulate terrestrial C storage than may have been realized so far. Any effective enhancement in tree cover in areas that lost forest cover before 1990 is fair game, as long as the results meet the "forest" definition (Indonesia selected a 30% canopy cover rule at scales > 0.25 ha, with trees > 5 m at maturity) and are tractable. Additionality can be argued on the basis of removal of current obstacles (policies, lack of fire control) rather than starting non-economical land use activities. Leakage issues are easier to deal with if entities such as districts that encompass overall livelihood systems rather than specific reforestation areas are the target. Benefits to the farmers and land users can be primarily in the form of removal of policy obstacles, rules and taxation instruments, rather than a direct share in future trade in CER's.

A "removal of constraints" rather than "project" approach may lead to positive spin-offs and enhancement of market function rather than distortion. In this contribution to the debate on the use of CDM we will explore the current constraints to enhancement of trees in the landscape and discuss how removal of such constraints could be the basis of a new type of CDM program that still meets the current project requirements.

Terrestrial carbon stocks in Indonesia

To get a general feeling for the aboveground terrestrial carbon stocks in Indonesia, we can start with remote sensing data on vegetation with a simple legend distinguishing closed canopy forest, various forms of savanna and more open crop fields. For Indonesia as a whole the data (based on imagery in the early 1990s) more than 50% was still closed canopy forest and about 60% met Indonesia's operational "forest" definition (that includes most of the savanna of the IGBP legend). The proportion of the land area forested varies between the islands from more than 70% for Papua to nearly 10% for Java. The data for Sulawesi and the islands of the Nusa Tenggara and Moluccan show the same profile, so they can be grouped.

Overall, there is a clear relationship (Figure 2) at island level between the logarithm of population density (number of inhabitants per km^2) and the fraction of closed forest cover or relative carbon stock (using guesstimates for the various vegetation types). (Note: The logarithmic relationship suggests that an even spread of Indonesia's population over all the available land would lead to a substantial decline in forest cover and carbon stocks). The relationship between forest cover and population density also holds (and explains 61% of data variability) at district scale for a data set of pre-1990 forest cover (Murdiyarso *et al.* In press)

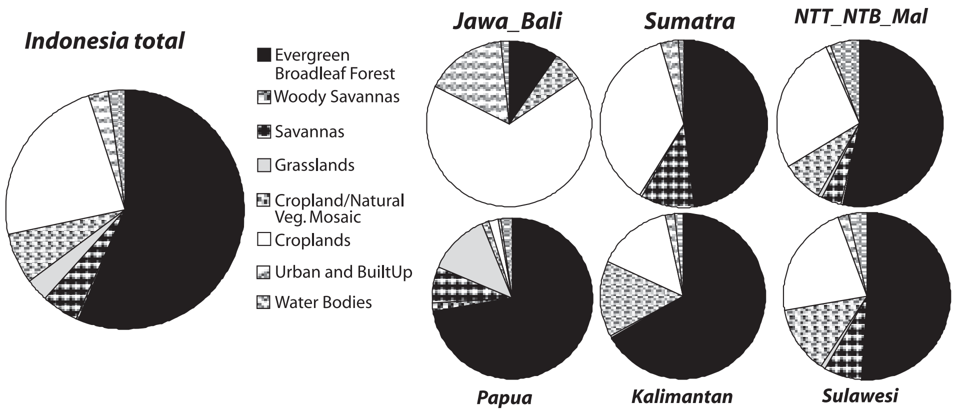

Figure 2. Land cover classification for Indonesia's islands (excluding the seas) according to the IGBP legend (source: Global Land Cover Characterization from USGS EROS Data Center, International Geosphere Biosphere Programme (IGBP) Land cover map; based on imagery of the 1992-1993 period) (Hadi and van Noordwijk 2005).

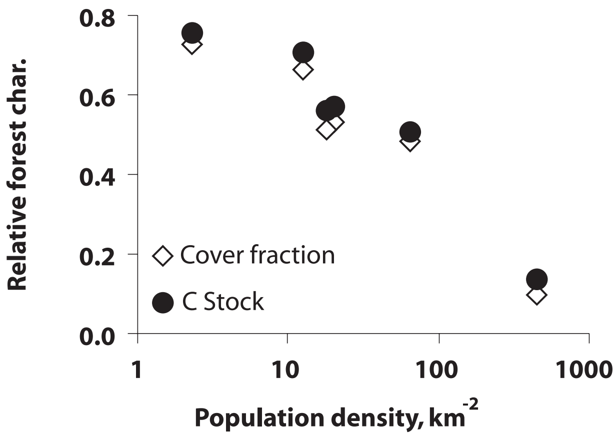

Figure 3. Island scale relationship between population density and the fraction of closed canopy forest (Figure 1) or aboveground carbon stock for Indonesia.

The regression of 1990-forest cover on population density can be used to calculate a difference (residue) between expected and actual forest cover for the various districts. This residue varies from over +30% to less than -30%, suggesting that there is substantial variation. This variation together with data on human development index and fire frequency was used for a cluster analysis (Murdiyarso *et al*. In press). Restricting the choice to districts with below-average Human Development Index (HDI) as poverty indicator and a population density in the range 10-100 persons km^{-2} where the land/labor ratio may be conducive to tree-based livelihoods, suggests three broad groupings for CDM application:

- Cluster 4, characterized by high frequency of fire and the districts are mostly located in the low peneplain areas of eastern part of Sumatra and in West Kalimantan; there are 32 districts in this cluster and 18 are in the priority list for CDM projects; for CDM projects proposed in these districts, fire risk should be taken into consideration.
- Cluster 1, characterized by low frequency of fire and the districts are located in most part of Sumatra, especially along the western mountainous range of Bukit Barisan; there are 126 districts with these characteristics, and 33 are in priority list for CDM projects.
- Cluster 3, characterized by low forest cover (relative to population density) and low fire risk ; the districts are mostly in Nusa Tenggara; 8 districts are in the cluster and 7 of them are in the priority list for CDM projects.

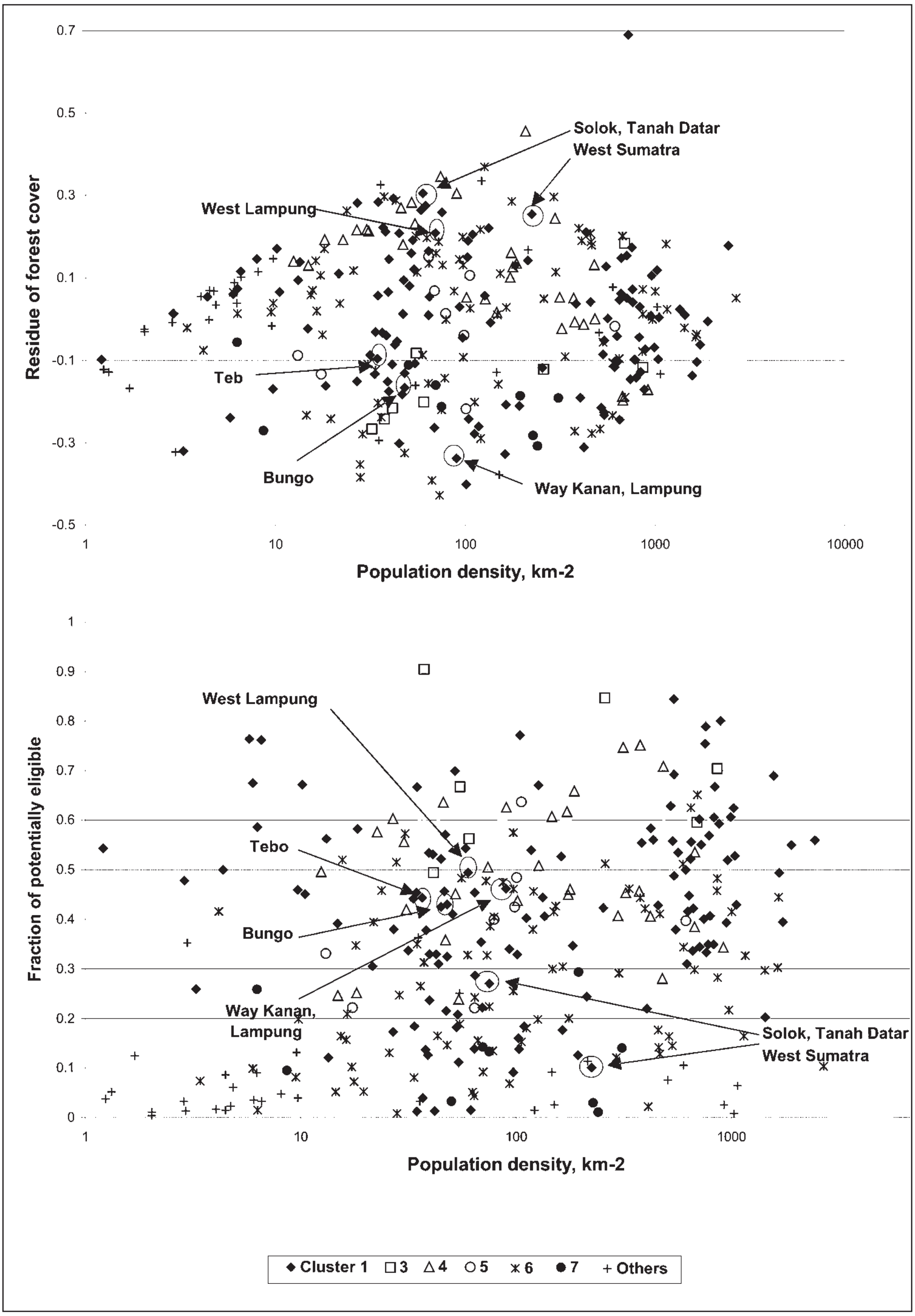

Figure 4. Relationship between population density and the difference between "expected" (on the basis of regression on population density) and observed pre-1990 forest cover as well as the fraction of potentially Kyoto-eligible lands; the distriocts are grouped on the basis of a cluster analysis of similarity (details in Murdiyarso *et al.* In press).

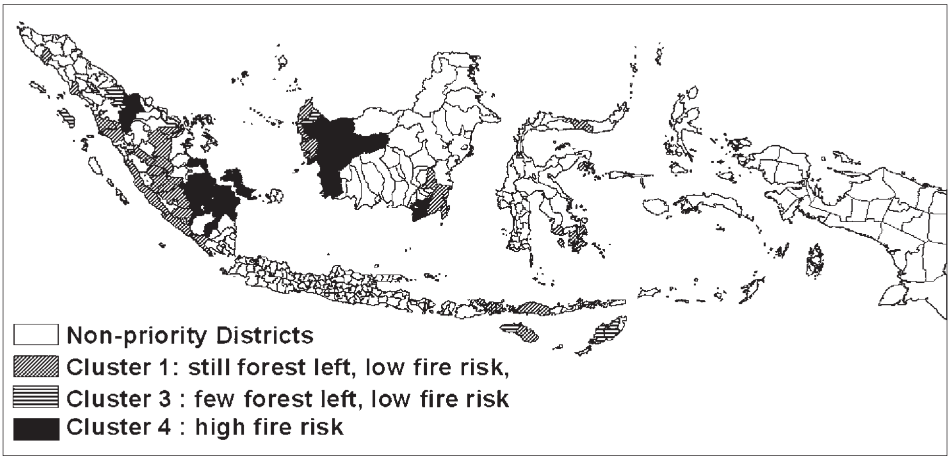

Figure 5. Three clusters of districts that meet priority criteria for reforestation CDM in Indonesia, based on multidimensional similarity (Murdiyarso *et al.* In press).

The ASB benchmark areas in Lampung (West Lampung district with Sumberjaya and Krui as two ASB sites and Way Kanan, formerly part of North Lampung district) and Jambi (Bungo and Tebo districts) are part of clusters A and B. The existing district level data for these benchmark sites are presented in Table 3. Along with the dominant land use types, the opportunities for increasing tree biomass differ substantially.

Table 3. District statistics for three ASB benchmark areas in Indonesia, all falling within the initial priority criteria for CDM development.

ASB benchmark area	1990 closed canopy forest cover, (residue[1]) and rice fraction[2]	1995 Popula-tion density	2000-2004 Fire index	Human develop-ment index[3]	Land use options that increase carbon stocks
Northern Lam-pung (currently Way Kanan district; kecamatan Negeri Besar)	**0.191** **(- 0.308)** **0.07**	**99**	**0.40**	**65**	Conversion from cassava/Imperata to rubber, oil palm or timber based agrofo-restry
West Lampung (Krui and Sumberjaya)	**0.742** **(+0.223)** **0.06**	**84**	**0.02**	**63**	Switch from monoculture to multistrata coffee
Jambi (Bungo and Tebo districts)	**0.454** **0.568** **(-0.130** **-0.037)** **0.04** **0.03**	**50** **42**	**0.19** **0.12**	**64** **65**	Maintaining complex rubber agroforests rather than conversion to oil palm or planta-tion rubber

Residue is calculated on the basis of the following expected value:
1. Paddy rice field on the basis of agricultural statistics
2. The Human Development Index combines data on health, education and household expenditure; average value for Indonesia as a whole is 66

Understanding constraints to increasing tree cover in rural landscapes

In working with farmers in the three benchmark areas and other project sites, a number of constraints to increasing trees in the landscape have become apparent (Table 4). Few of these constraints can be overcome by farmers alone, as they require collective action at the scale of local communities and/or of formal government systems at subdistrict or higher level. Incentives may be lacking at the formal government scale to help overcome these constraints, although greater welfare of farmers is in their long term interest.

Table 4. Scale at which 10 constraints to having more trees in the landscape are primarily determined (as indicated by the number of *).

10 constraint to more trees in the landscape	Require action of:		
	Local governments	Local community organizations	Farmers
1. Lack of land and/or tree tenure (physical or economic ***access to land*** for tree planting linked to use rights of tree products)	*** change of rules	** change of rules	* change of action
2. ***Fire***: reasons for starting fire, lack of fire control	* change of rules	** change of sanctions	** change of action
3. Lack of suitable, ***high-quality planting stock*** adapted to soil, climate, pests and disease, intercropping systems, local preferences and markets	* increased access to knowledge	** better seed sources, increase in knowledge	* increase in knowledge
4. Poor ***delivery mechanisms*** for high quality planting material	-/* better certification schemes	** better nursery supply chains	** increase in knowledge
5. Lack of knowledge, labour or inputs for ***managing tree growth*** in intercropping or monoculture plantations	* increased access to knowledge	** increased sharing of knowledge	** increase in knowledge
6. Lack of ***physical performance*** of the tree due to drought, floods, grazing animals, pests, diseases, suboptimal thinning and pruning	-	* increased sharing of knowledge	*** better farm management
7. Lack of perception of ***non-economic or cultural benefits***, e.g. due to lack of appreciation for microclimatic benefits of trees, concerns over their associated high water use or over their influence on soil conditions or water flows	* general awareness raising	** increased sharing of knowledge, motivation, collective action	* interact with local community
8. Lack of local ***demand*** and/or physical and institutional ***access to markets*** for tree products	** change of rules, better roads	** change of rules, better feeder roads	* increase in knowledge
9. High ***transaction costs*** (permits, formal and informal taxes) for harvesting trees and tree products	** change of rules & taxes	** change of rules & taxes	-
10. High ***opportunity costs***: no-tree land use options are more profitable than tree-based ones	* all the above, lack of special incentives	** all the above, lack of special incentives	** depends on land/labour ratio

A CDM approach based on removal of constraints

At the currently discussed indicate CER price of US$20/t C (that is considered to be optimistic), with an estimated 50% for transaction costs (that is considered to be optimistic), the potential net benefit to farmers of US$10/t C is probably less than 10% of the sale value of timber (low quality ***Paraserianthes falcataria*** (Sengon) has a farmgate price in Indonesia of about US$35 m^{-3} (300,000 Rp) equivalent to US$100/t C, other types of timber fetch higher prices). At this price for CERs the CDM incentive is at best a modifying factor on land use decisions, rather than a primary driver (i.e. reforestation CDM barely meets the additionality test itself). The financial value of CDM is, however, of the order of magnitude of land tax and the transaction costs for HKM type of agreements between farmers and local government. Instead of adding a CDM administration to the already existing ones, we may imagine a situation where CDM is used to reduce existing transaction costs for small farmers, abolish local tax for tree planters and facilitate local use rights agreements. The local government will get part of its income from the future sale of CERs rather than local tax, and will be able to provide services to its citizens. Farmers can benefit primarily through the sale of tree products, including timber, as the market price for timber will be a main driver for farm-level rationality in investing in trees.

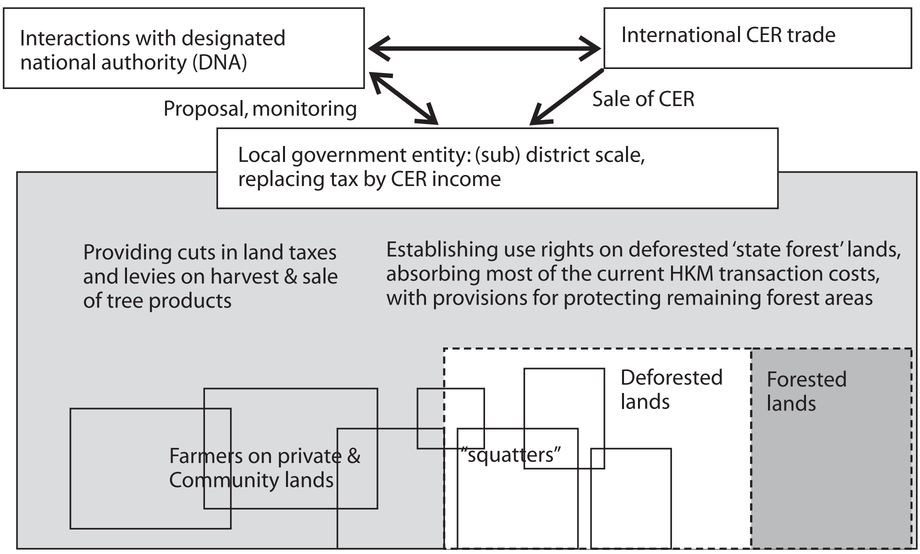

Figure 6. Potential relationships in a district level CDM commitment.

ASB benchmarks

The global Alternatives to Slash and Burn (ASB) program has pioneered the integrative assessment of land use practices in the margins of tropical forests, compiling quantitative indicators of profitability, returns to labour, carbon stocks and biodiversity across the full spectrum of land use from intact forest to degraded lands.

From this data set the various tradeoffs between poverty reduction and environmental services can be explored, as well as the relationships between the various species diversity (Figure 7).

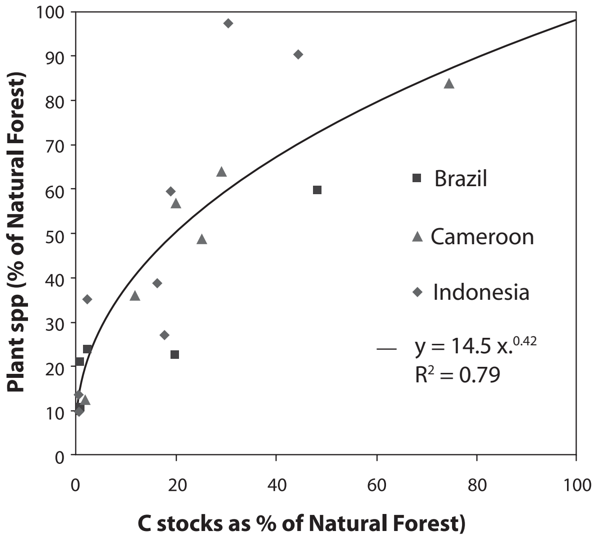

Figure 7. Relative loss of C-stocks and plant species richness for forest-derived land use practices in the Jambi transect, with similar data for the ASB benchmark areas in Cameroon and the western Amazon in Brazil (Murdiyarso *et al.* 2002).

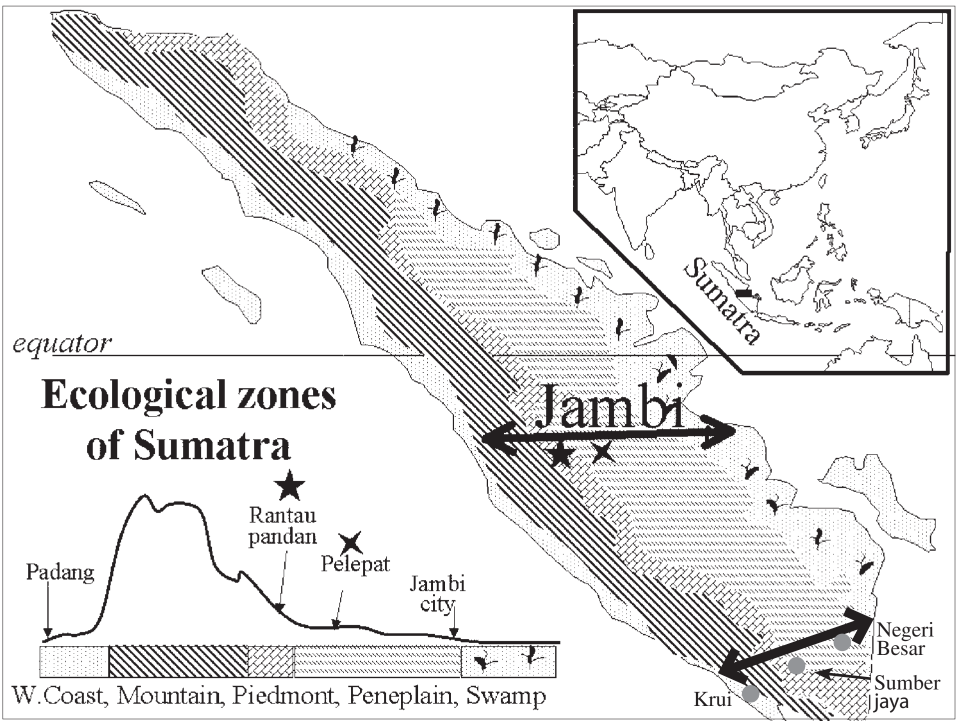

Figure 8. Two transects through Sumatra studied by the ASB consortium in the 1990s (Murdiyarso *et al.* 2002).

1. Sumberjaya benchmark: Coffee systems

Van Noordwijk *et al.* (2002) assessed the change in stored carbon (C) stocks for a 700 km^2 area where in the last 30 year forest cover decreased from 60 to 10% while the area under coffee increased from 7 to 70%, but where a gradual evolution from open sun-coffee systems to multistrata shade-coffee systems provides a partial compensation for C loss. Annual aboveground C stock accumulation rates during the establishment stage after slash-and-burn land clearing were 1, close to 2 or 3.5 Mg C ha^{-1} year^{-1} for sun coffee, shade coffee and fallow regrowth, respectively (Figure 9).

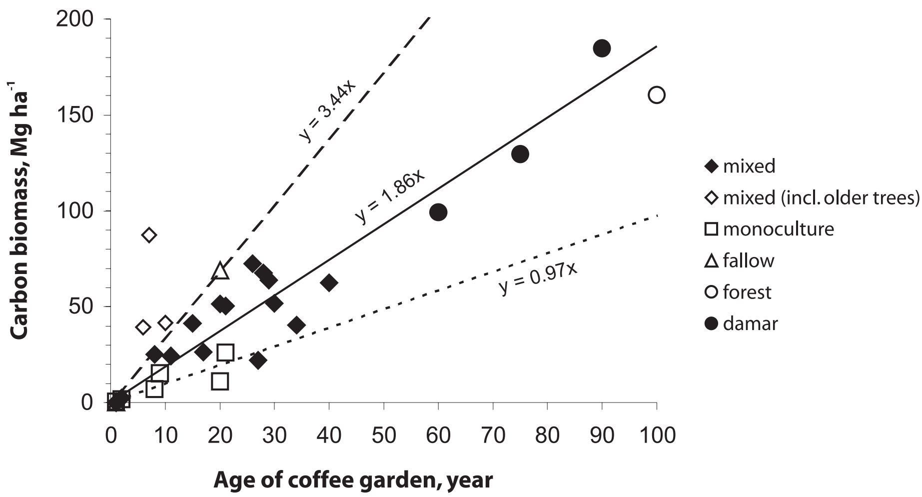

Figure 9. Relationship between aboveground C stock and age of coffee gardens (Van Noordwijk *et al.* 2002).

Forest remnants, shade coffee and sun coffee had soil C stocks in the upper 30 cm of the soil that were 79, 60 or 45%, respectively, of the values expected for primary forest in Sumatra. Total C stock (time averaged, above –0.3 m in the soil) for forest, shade and sun coffee was 262, 82 and 52 Mg C ha^{-1}, respectively. In the 1970 – 1984 period, while forest cover was reduced from 59.5 to 19.7%, the landscape lost on average 6.8 Mg C ha^{-1} year^{-1}; in the 1984-2000 period forest cover was further reduced to 12.6%, but the landscape lost only 0.39 Mg C ha^{-1} year^{-1}, as forest loss was partially compensated by an increase in shade coffee systems. Conversion of all current sun coffee to shade coffee systems while protecting the remaining forest, could increase average landscape level C stocks by 10 Mg ha^{-1} over a timeframe of say 20 years, or 0.5 Mg C ha^{-1} year^{-1} averaged over the whole landscape (Figure 10).

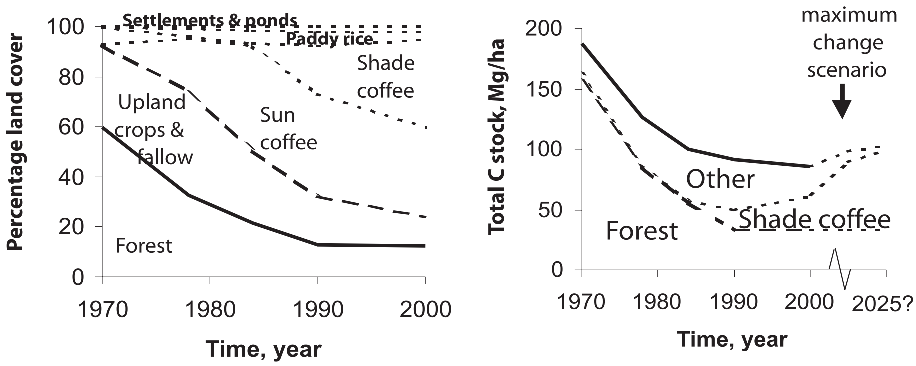

Figure 10. Landscape level C stocks above a soil depth of 0.3 m for Sumber Jaya in the period 1970 – 2000, with an extrapolation to the future assuming all coffee gardens to become shade coffee, while the remaining forest is left intact.

2. *Jambi benchmark: rubber agroforests, rubber and oil palm plantations*

Land use change in Jambi was described by Murdiyarso et al. (2002) and Tomich *et al.* (2001). In this fragmented forest landscape rubber agroforests (Joshi *et al.*) along the rivers still provide an ecological infrastructure. Their carbon stocks are substantially below that of natural or logged forest, but higher than that of intensively managed rubber or oil palm plantations and substantially above the time-averaged

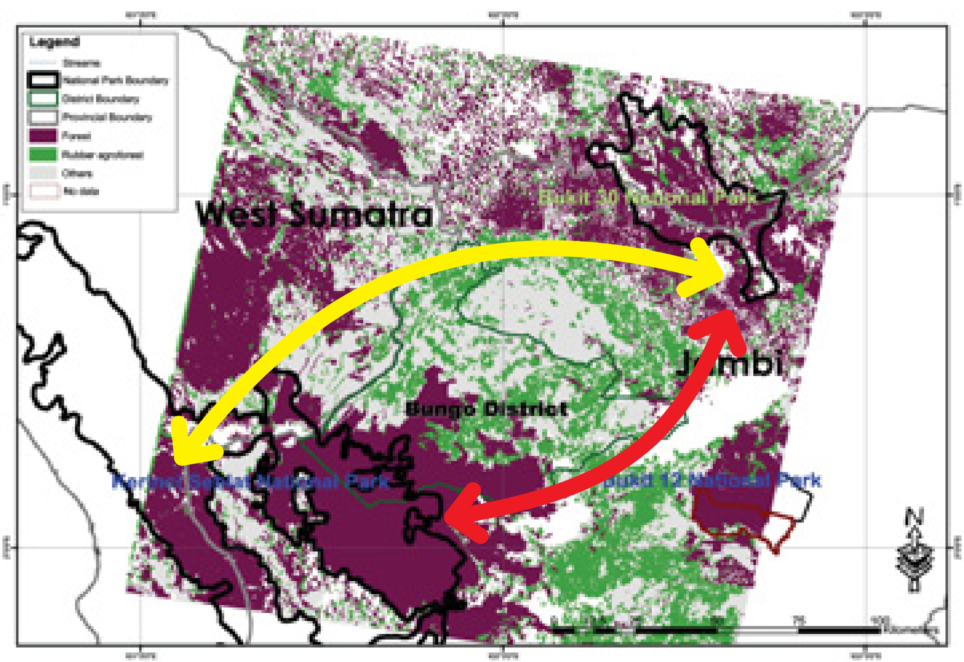

Figure 11. Forest fragmentation and rubber agroforest as corridor between remaining forest in protected areas (Ekadinata *et al.* in prep.).

carbon stock of pulp wood plantations. At landscape scale the "time averaged carbon stock" that considers all stages of the cycle of a land use system is an appropriate measure. During transitions to new land use systems the temporal dynamics may mean that the landscape-level average carbon stock differs from this time-averaged equilibrium value; details of this can be explored with the FALLOW model (van Noordwijk 2002).

3. Way Kanan ASB Benchmark

The Way Kanan (formerly part of N. Lampung) ASB benchmark area represents a landscape that was deforested in the 1980s, with logging followed by conversion to a large sugarcane and industrial tree (HTI) plantations and resettlement of "forest squatters" (spontaneous migrants from Java who came to the fertile soils of the Lampung mountains to establish coffee gardens and were resettled on the much poorer soils of the lowland peneplain (Van Noordwijk *et al.* 1998). The farming systems of these translocated migrants was designed around intensive food crop production systems. However, soil fertility could not be maintained and cassava has become the crop of last resort that still provides some positive returns to labor, although at a low

Table 5. Socio-economic indicators of land use options in Jambi and the time-averaged carbon stocks (aboveground plus top 20 cm of the soil) of these systems (Modified from: Murdiyarso *et al.* 2002).

Land- use type	Returns to labor, relative to minimum wage rate		Labor requirement (Person-days ha^{-1})			Equivalent population density, people [1]	Time averaged C-stocks
	Private prices	Social prices	Establish-ment	Operation phase	Total	km^{-2}	Mg ha^{-1}
F_m Ext. Managed forest	2.9	2.8	Na	0.2 - 0.4	0.2 - 0.4	0.2	254
F_r Sustainably logged forest	-4.3 - 0.5	2.0 - 7.8	15 - 100	17 - 41	31	17	150
T_e Jumgle rubber	1.0	1.0	271	157	111	59	116
T_m Improved RAS	1.0 - 1.7	1.1 - 1.9	444	74	150	80	103
T_{s_rubber} Rubber Plantation	1.7	0.7	344	166	133	71	97
$T_{s\_oilpalm}$, Oil palm	1.5	2.5	532	83	108	58	91
$T_{s\_pulptree}$ Pulp tree					15 ?	13	60
C_e/C_m Rice/fallow	0.75	0.95	Na	15 - 25	15 - 25	11	74
C_l/A_e, Cassava	1.05	1.05	Na	98 - 104	98 - 104	54	39

1. Assuming 300 work days per year for 50% of the total population and 80% of the land area available for productive land use

level. Whitmore *et al.* (2000) concluded that improved soil management practices in intensive intercropping practices following forest conversion with groundnut or cowpea can substantially increase income above the current farm practice, but in the surrounding landscape most of the soils may have been degraded too far for this option to still be available. Gradual conversion of the cassava fields (alternating with *Imperata cylindrica* dominated fallows) to tree-based production systems may provide better options. In follow up research, the Smallholder Agroforestry on Degraded Soils (SAFODS) project is now testing the hypothesis that "The transition into tree-based farming systems has to be gradual to cater for short-term financial and food security needs; certain forms of agroforestry will allow for such transition and are compatible with farmers' livelihood strategies."

PAM (Policy Analysis Matrix) results for food crop and food crop + tree systems in the area show substantial differences between land use systems in terms of profit, more precisely the return on land based on discounted future net revenue flows. The land use system of pepper plus paddy, corn and groundnut found on the better soils provides the highest level of profit (Rp 64.5 million ~ about US$7,100), while the cassava monoculture on the poorest soils provide the lowest level of profit (Rp 2.7 million~ about US$300). All land use systems have negative divergence effects on the net transfer, showing a higher social profit than the private profit. This implies a taxing effect or at least, the government does not provide enough support for agroforestry practices in the study area. Even though the private profit is all positive, the net transfer of policy actually decrease the profit received by farmers or agroforestry adopters. Over-regulation of timber products, some food crops and other important crops in Indonesia or particularly in Lampung also contribute to the decrease in profit or in the return on land management. The policy options should focus on reducing the distorted policies on timber production and marketing, and improving market and financial market for food crops and other important crops in the country at large. Local governments could play more important roles in providing greater opportunities to farmers and agroforestry adopters to grow tree crops and timber-related economic activities. The growing practices of agroforestry involving high value tree crops such as *Acacia mangium*, sengon (*Paraserianthes falcataria*) and teak (*Tectona grandis*) wood suggest more economic opportunities for farmers, at least in the districts of Way Kanan and North Lampung.

Discussion: rewards for rubber, coffee and timber agroforesters?

In the Sumberjaya and Bungo benchmarks the multistrata agroforests based on coffee and rubber provide income as well as carbon storage. In Sumberjaya economic calculations (Budidarsone *et al.* 2001) suggest that the shade coffee systems are in fact more profitable than the open monocultures if farmers have a long-term perspective (and corresponding discount rate). Providing security of tenure is the key in this landscape characterized by conflict in the past. Transaction costs of the lands use agreements are an obstacle (Arifin 2005). A commitment by the district level government to facilitate farmers to make the switch to these more long-term systems may be all that is needed. The idea of a district-level CDM that provides benefits to farmers this way and ensures monitoring and accreditation of the changes in carbon stocks for dale of TCER's may be feasible here.

The rubber agroforest in Jambi is currently losing out from the income opportunities provided by more intensive rubber and oil palm plantations. These rubber agroforests represent substantial value to maintenance of forest biodiversity (Rasnovi and Vincent in prep.), but protecting these carbon stocks is not yet rewardable under current rules. As part of a bundling of services, however, the carbon stocks can be an additional argument for incentives to maintain these systems. Transition of the Imperata/cassava landscape of the Way Kanan benchmark to a tree-based system can easily meet the targets for CDM, as deforestation occurred before 1990 and the transition to treebased systems has been hampered by a number of constraints that require interventions at scales beyond the individual farm. Interventions aimed at removing these constraints can thus pass any additionality test.

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