CDM-AGROFORESTRY PROJECTS AND SUSTAINABLE DEVELOPMENT: INDONESIAN CASE

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ABSTRACT

Indonesia potentially has about 30 millions ha of degraded land/forest. Fund available for rehabilitating this degraded land/forests is very limited. The adoption of sinks project being eligible under CDM (*Clean Development Mechanisms*) might have benefits for Indonesia as this mechanism could provide alternative funding mechanism for rehabilitating the degraded land/forests. Type activities being eligible under CDM for sink projects are afforestation and reforestation. Agroforestry is the one of the activities that might be potential for CDM as long as it can meet the criteria of afforestation and reforestation. The problem is how to ensure that CDM-sink projects would meet the dual objectives of the mechanism, i.e. reducing carbon in the atmosphere and assisting the host country to achieve sustainable development. This paper highlighted impact of agroforest system in Jambi on socio-environmental factors and an approach to measure the environmental additionality of the project.

I. INTRODUCTION

In line with the spirit of the Convention on Climate Change and the Kyoto Protocol, investment in CDM projects is expected to contribute to economic growth and sustainable development of developing countries. Therefore, CDM activities undertaken by developed countries (Annex I) should consider developing country (non-Annex 1) circumstances and their specific needs. In this regard, non-Annex I countries should identify sustainable development themselves and their specific needs to be assisted by Annex I country Parties. How should sustainable development be defined in the context of national development priorities? In relation to CDM, national authorities of host country should be the sole judge for deciding whether the project activity meets its national sustainable development objective and priorities. Some principles suggested by TERI (2000) in defining sustainable development are:

a. There must not be local opposition towards the projects, and the projects must not impose burden on local communities.
b. There must not be environmental burden shifting.
c. The project must provide multiple social and economic benefits, as well as environmental benefits.

Carbon sink projects that have been considered eligible under CDM are afforestation and reforestation. Agroforestry projects might become potential candidate for the CDM project as long as they fall under categories of either afforestation or reforestation. Potentially, Indonesia now has about 30 million hectares of degraded lands and forests need to be rehabilitated. Government budget available for rehabilitation is very limited (0.75 billion US$). It is approximated that this rehabilitation funding only be able to rehabilitate small part of this degraded lands/forest (i.e. 1.5 million ha; Boer *et al.*, 2001a). Therefore, funds from other sources are required and CDM could be one of the potential funding sources. In order to ensure that CDM projects could meet dual objectives of the mechanisms, i.e. assisting invested countries (Annex-1 countries) to meet their emission reduction commitment and assisting host countries (non-Annex 1 countries) to achieve sustainable development, understanding on how CDM projects will affect the development of host countries is important. This paper highlighted some findings from studies related to the impact of agroforest systems on socio-environmental indicators and an approach to measure the environmental additionality of the project.

II. SUSTAINABLE DEVELOPMENT INDICATORS

In the light of CDM projects, there are several sustainable development indicators that can be proposed. From a survey conducted to 52 respondents by Indonesian National Team of CDM-National Strategy Study, it was revealed that there are about 13 indicators being considered (Fig. 1). Indicator 'no adverse environmental impact' has the highest score. This means that all respondents considered environmental service as the most important indicator for the sustainable development. This conclusion should not be used rigidly as the result of the surveys may change to some extend depending on type of respondent. However, this survey has shown the relative importance of each indicators.

From Figure 1, it can be seen that indicators with score of more than 3.5 include no-adverse environmental impacts, environmentally sound technology, stakeholder participation, socio-economic consideration, capacity building improvement, and local economic benefits. These six indicators are in line with the three principles of sustainable development suggested by TERI. Thus a project with has no adverse environmental impact, and contribute to the improvement socio-economic condition as well as capacity building, and engage all related stakeholders in the project, could be considered as potential CDM project.

Further key question is how far can developing countries promote CDM-projects which would be optimal in the sense of promoting both climate and sustainable development goals? Agroforestry is one of the potential CDM sink projects as it may meet most of the important criteria of sustainable development. Subsequent section discusses how agroforestry systems contribute to achievement of both climate and sustainable development goals.

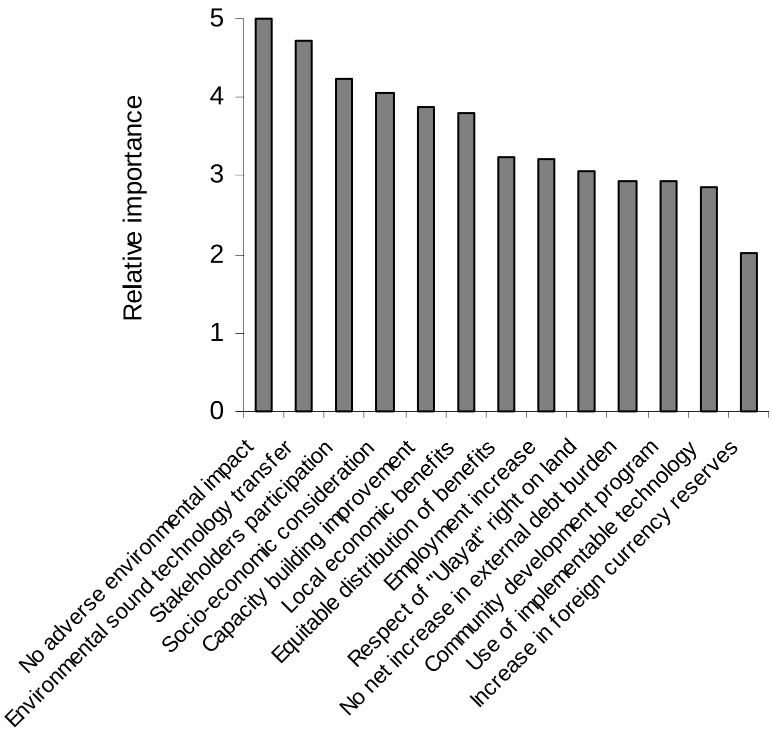

Fig. 1. Score of relative importance of sustainable development indicators (taken from survey conducted by National Team for CDM-National Strategy Study, MoE, 2001). Value of 5 indicates the most important indicator, while 1 is the least important.

III. AGROFORESTRY AND SUSTAINABLE DEVELOPMENT INDICATORS

3.1. Agroforestry System in Jambi

Complex jungle rubber agroforests have remained as major agroforestry systems in Jambi for majority of smallholder farmers. However, as demand for natural rubber has been low in recent years, some of farmers are not interested in establishing this system. In certain villages farmers have stopped tapping (Wibawa *et al.*, 2001). Now, oil palm and clonal rubber plantations are becoming more preferable.

Establishment of agroforest in Jambi follows two systems. The first one is permanent-style rubber agroforest, and the second one is slash-and burn based rotational rubber, or slash-and-burn based rotational oil palm (Figure 2). Both systems were commonly established from the conversion of primary forest, logged-over forest or old secondary forest. This conversion may have negative impact on environment but give positive impact on socio-economic of local people as indicated by Table 1 and 2. However, if these systems were developed on bare lands or critical lands, or grasslands, some socio-environmental benefits might be gained. Some of benefits include the increase in C storage, biodiversity as well as watershed functions and the increase in farmers' income for the long run. However, the magnitude of the benefits will be depending on the types of trees, the ways in which they are managed and the position they have in the landscape. Understanding of the way environmental factors are influenced by changes in land use practices and understanding of the benefit streams is therefore highly desirable.

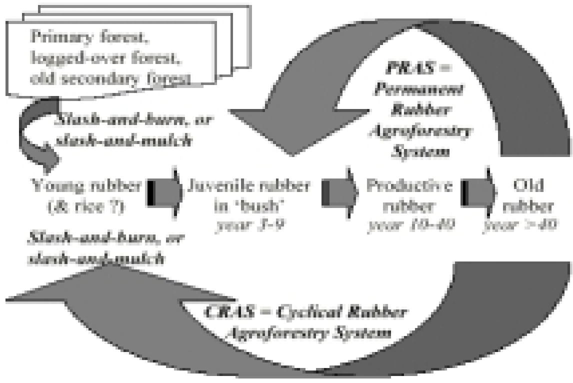

Figure 2. Schematic representation of cyclical and permanent agroforest in Jambi (Anonymous, 2001)

Table 1. Social-environmental criteria of various land use

Land Use Type	Production Sustainability[A]	Human well being			ESI		
		M Rp/ha (return to land)	K Rp/day (return to labor)	Pop. Density (Km^2	C Mg/ha	Biodiversity	Watershed function
Natural Forest	0	0	0	0	250	+++	0
Community-based forest management	0	0.02	11	0.2	175	++	0
Commercial logging	-0.5	-0.4	20	17	150	++	-0.5
Rubber agroforests with seedlings	-0.5	1.6	4	59	116	++	0
Rubber agroforest with clonal planting material	-0.5	0-2.2	6	80	103	+	-0.5
Rubber monoculture	-0.5	-0.2	2.6	71	97	0	-0.5
Oil Palm monoculture	-0.5	0.3	10	58	91	0	-0.5
Upland rice/bush fallow rotation	-0.5	-0.1	4	11	7	+	-0.5
Cassave/Imperata rotation	-1.0	0.1	4.3	54	39	0	-1.0

A: 0=no problem outside of normal farmer management domain, -0.5=probem that may challenge farmers' adaptive capacity; -1=serious problem. B: equivalent human population that can be supported; C: 0=no change, -0,5=some concern justified, -1=serious concern justified (Murdiyarso *et al.* 2001)

Table 2. Likely impact of the various land-use practices on watershed functions

Land Use Type	Concern on watershed function[1]						Main change relative to natural forest
	A	B1	B2	B3	B4	C	
Natural Forest	0	0	0	0	0	0	-
Community-based forest management	0	+0.5	0	+0.5	0	0	Total water yield may increase due to lower tree density

Commercial logging	0	0	-0.5	0	0	-0.5	Logging trails may channel sediment to stream
Rubber agroforests with seedlings	0	0	0	0	0	0	Permanent cover
Rubber agroforest with clonal planting material	-0.5	+0.5	0	+0.5	0	-0.5	Slash-and-burn year for rejuvenation forms risk
Rubber monoculture	0	+0.5	-0.5	0	0	-0.5	More open vegetation compaction on roads
Oil Palm monoculture	0	0	-0.5	0	0	0	Harvesting tracks compact and channel sediment to stream
Upland rice/bush fallow rotation	-0.5	-0.5	-0.5	0/ -0.5	0	-0.5	Less water use, infiltration may lessen
Cassave/Imperata rotation	-0.5	-0.5	-1	-0.5	0	-0.5	Less water use, infiltration likely to lessen

A: On site loss of land productivity; B: off-site water quantity, where 1=annual water yield becoming less than demand or expected yield, 2=strom flow becoming too high leading to flooding or immediate damage, 3=dry season base flow becoming less than expected, 4= groundwater recharge not meeting the ongoing rates of depletion. C: Off-site water quality, siltation of reservoir or effect on coastal coral reefs; 0=no or little change relative to natural forest, -0.5=some concern justified, -1=serious concern justified, +0.5=probably improving relative to natural forest; +1=certaintly improving relative to natural forest (Murdiyarso *et al.* 2001).

3.2. Estimation of Environmental Benefits of CDM-Agroforestry Projects

In the light of CDM project, techniques which are able to quantify the impact of changing land use pattern resulted by the projects on environmental (in particular carbon stock) and socio-economic factors *inside* and *outside* project sites are very important. Referring to Table 1, converting open field agricultural system (e.g. upland rice/bush fallow rotation) into a system that include partial tree cover (e.g. Rubber agroforest with seedlings) will have 109 Mg of Carbon removal per ha. Similarly, we can expect that benefit that return to land would be about Rp1.7 million per ha and biodiversity would definitely increase. These estimates might not be correct if there is a problem of leakage[1]. Thus in CDM project, the leakage needs to be estimated by knowing the likely change of land use pattern in the future with and without CDM projects. At present there are no standard approaches or methods to estimate the leakage. However, IPCC has provided two standard formulas to estimate carbon stock. One of the formulas used land-based accounting system (IPCC, 2000):

$$Q = \sum_{i=1}^{M} \sum_{j=1}^{N} [S_{i,j}(TE) - S_{i,j}(TB)] - \sum_{k=1}^{R} A_k$$

Where,
Q is total carbon sequestered or released,
$i=1, 2, 3,\ldots, M$ index for landscape unit;
$j=1,2, 3,\ldots, N$ index for carbon pools (e.g. above-ground biomass, below-ground biomass, etc) ;
$k=1, 2, 3, \ldots, R$ index for adjustment;
$S_{i,j}$ = stock of carbon on landscape unit-i, in carbon pool-j
TB= Beginning year of the accounting period,

[1] Carbon leakage is defined as the increase in net GHG emissions (leakage) or decrease of net GHG emissions (spillover) outside the project/policy area or time horizon. The same concept can also be applied on non-GHG impacts e.g., costs and benefits of a project experienced outside the target spatial and temporal domain, but these are generally referred to as externalities.

TE= Ending year of the accounting period,
A= Adjustment term to account for leakage, baselines, uncertainty, etc.

Estimation of the likely change in land use pattern with and without project could be done using logit regression. The formula of the equation is as follow (Aldrich and Nelson, 1984):

$$\text{Logit}(P_i) = a + \Sigma(b_j.x_j)$$

where P is probability of land cover change-i, an intercept a and b_j a coefficient of independent variable x_j. The relationship between P_i and Logit(P_i) is as follows:

$$P_i = e^{\text{logit}(Pi)}/(1+e^{\text{logit}(Pi)})$$

Since the result of this equation is a continuous value between 0 (no land cover change) and 1 (land-cover change occurs), lower limit to accept land cover change event probability should be defined. Murdiyarso *et al* (2000) used a value of 0.5 as the lower limit, thus if P_i higher than 0.5 the land-cover change occurs. Furthermore, they found that the significant independent variables (predictors) influencing the odds ratio (ln (pi/(1-pi)), are distance of land to road, to river, to settlements, and to logging area, slope, soil organic matter, population density, NPV of agroforestry. The physical variables can be easily extracted from landsat data, while other independent variables such as soil organic matter, population density, NPV of agroforestry, income per capita, wood price, wood demand and other variables that may drive leakage directly or indirectly should be collected or calculated or estimated.

When parameters of the logit regression equations are developed, the probability of a given land use being converted into other land use can be estimated using the defined predictors. Thus the likely change in land use pattern in the future with and without CDM projects can be estimated by estimating the likely change in predictors under both conditions. Based on the above explanation, analysis should follow the following steps (Boer *et al.*, 2001b):

Step 1. Identify trajectory of land use cover changes.
Step 2. Determine factors that drive leakage (predictors)
Step 3. Develop logit regression based on past data
Step 4. Validate the logit regression using independent data
Step 5. Project the likely change in the predictors with and without CDM project.
Step 6. Apply the equation to estimate the probability of a given land use being converted into other land use using the projected predictors.
Step 7. Define a set of lower limit of the probability to accept land cover change event
Step 8. Estimate the impact of changing the lower limit of the probability on land use pattern. Step 9. Estimate the carbon stock in the project boundary under baseline (without CDM projects) and mitigation scenarios (with CDM projects).
Step 10. Estimate the leakage under different level of the lower limit of the probability.
Step 11. Estimate other possible environmental change under baseline and mitigation scenarios.

For illustration, historical data on land use as well as the predictors can be arranged as in Table 3. A set of logit regressions are then developed to define the probability of a given land use being converted into other land use, e.g. Primary forest (PF) to Secondary forest (SF), SF to agriculture land (AL) etc. Furthermore, projection of predictors under baseline and mitigation scenario is developed to define the land use patterns under both scenarios and estimate the probability of a given land use being converted into other land uses (Table 4). As an example, from Table 4 the probabilities of secondary forest located at grid 1 being converted into agricultural plantation, agroforestry and agriculture land (annual crops) were 0.2, 0.5 and 0.7 respectively. Using lower limit of 0.5, we can assume that this secondary forest is very likely to be converted into agriculture land. On the other hand, the SF of grid 4 would remain the same (no conversion) as all the probabilities are less than the lower limit of 0.5. By repeating this process to all grids, the land use pattern of the study area can be known and carbon stock in the study region can be estimated.

Table 3. Historical land use data and variables that might drive leakage (predictors)

Grid	Land Use		Conversion occur ?	Predictors						
	1986	1992	1986-1992	Distance to road	Distance to river	Pop'n density	Wood demand r. to 1986	Income per cap or GDP	Income from forest resource	Etc
1	Primary Forest	Primary Forest	0	X11	X21	X31	X41	X51	X61	Xn1
2	Primary Forest	Secondary Forest	1	X12	X22	X32	X42	X52	X62	Xn2
3	Secondary Forest	Agriculture land	1	X13	X23	X33	X43	X53	X63	Xn3
4	Secondary Forest	Secondary Forest	0	X14	X24	X34	X44	X54	X64	Xn4
…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…
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Table 4. Projected predictors and probabilities of a given land use being converted into other land uses.

Grid	Land Use	Predictors in 2008							Probability of being converted to (P_{crit}=0.5)		
	2000	Distance to road	Distance to river	Pop'n density	Wood demand r. to 1986	Income per cap or GDP	Income from forest resource	Etc	Agric. Plantati on	Agro-forestry	Annual crops
1	Secondary Forest	X11	X21	X31	X41	X51	X61	Xn1	0.2	0.5	0.7
2	Secondary Forest	X12	X22	X32	X42	X52	X62	Xn2	0.7	0.2	0.3
3	Secondary Forest	X13	X23	X33	X43	X53	X63	Xn3	0.5	0.5	0.6
4	Secondary Forest	X14	X24	X34	X44	X54	X64	Xn4	0.4	0.3	0.4
…	…	…	…	…	…	…			…		…
…	…	…	…	…	…	…			…		…
…	…	…	…	…	…	…			…		…

Furthermore, the magnitude of leakage can be illustrated as in Figure 3. Line AB represents the change in carbon stock under baseline condition (no CDM projects), and line AC represents the carbon stock under mitigation scenario (with CDM projects). However, by implementing CDM projects, there is a possibility that some of predictors outside the project area will change such as road, income etc. This will affect the probabilities of any land use in each grid to be converted into others. This leads to different land use pattern of the study region. If the carbon stock (after considering the change in predictors) under this condition is represented by line AD, the leakage is positive, while if it is represented by line AE, the leakage is negative. Under positive leakage, in the period of 2008 to 2012 the CDM projects will save carbon as much as [(C2-B2)-(C1-B1)]+[(D2-B2)-(D1-B1)] and under negative leakage, it save carbon as much as [(C2-B2)-(C1-B1)]-[(B2-E2)-(B1-E1)]. By knowing the change in land use pattern under baseline and mitigation scenarios, the other environmental indicators can also be estimated using dynamic models or empirical models.

Emperical model that relate the C-stock change with biodiversity index (Plant spp in % of natural forest) has been developed (Figure 4). Thus by knowing the change in carbon stock the impact of the projects on biodiversity can be estimated. Impact on water resources can be might be assessed using dynamic models.

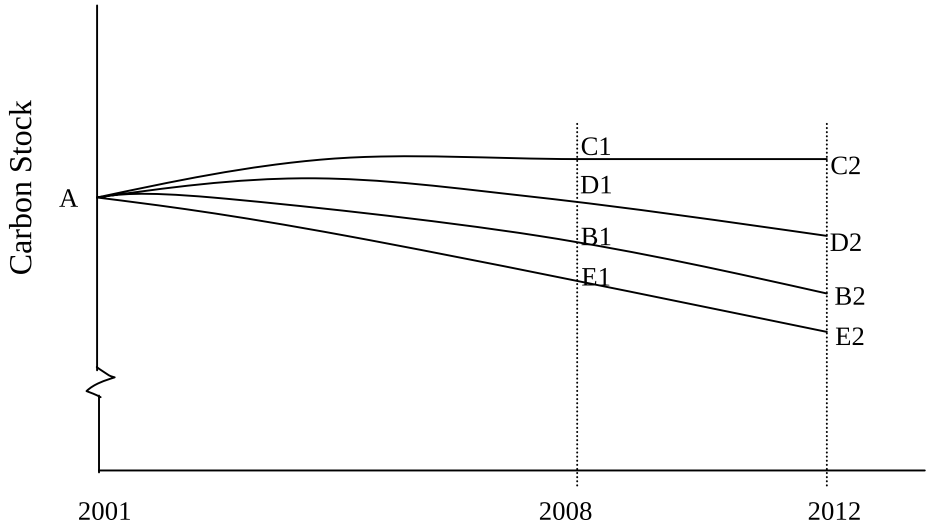

Figure 3. Change in carbon stock under baseline and mitigation scenarios

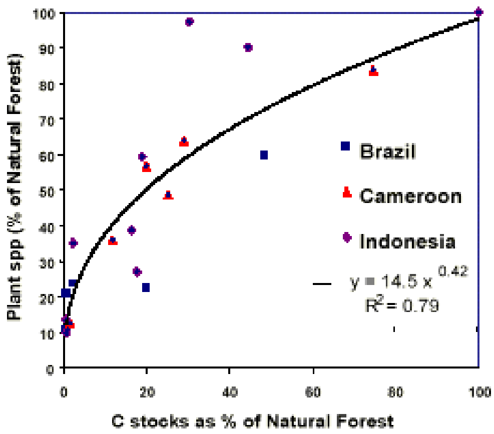

Figure 4. Relationship between C-stock and pant species richness in Jambi transect (Murdiyarso *et al.*, 2001).

IV. CONCLUDING REMARK

Agroforestry may provide three environmental services namely carbon storage, biodiversity and hydrological services. It also can contribute to the improvement of socio-economic condition. In the light of CDM, the magnitude impact of the agroforestry activities on environmental services would be depends on types of trees, type of management, and their position in the landscape as well as the change in other development indicators due to their implementation. A simple logit regression might be used to quantify the impacts. However, this analysis requires a series of land use spatial data as well as series of some development indicator data, such as population, GDP, road construction etc.

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