Case Study

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Way Tenong and Sidrap: Tree Planting and Poverty Alleviation, Indonesia

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Introduction

Under the regime of the Kyoto Protocol, the CDM through its window for 'reforestation' projects can facilitate the transformation of lands that were deforested before 1990 into tree-based land use systems. However, any proposed application of the mechanism will have to ensure additionality (increases of carbon stock in the accounting area due to the CDM intervention over and above what would be expected for a location-specific baseline) and account for leakage (negative effects on carbon stocks outside of the accounting area that are causally linked to the CDM intervention). Furthermore, the mechanism will also have to qualify as 'development', by providing positive socio-economic impacts for the local community by alleviating poverty in the landscape. A direct consequence of the multiple administrative requirements that follow from these concerns, however, are the substantial 'transaction costs' (Cacho *et al.* 2002; Cacho *et al.* 2003; Cacho 2006). A specific issue derives from the confounding of 'leakage' and 'additionality'. The use of nearby 'control' areas for appraising additionality assumes that leakage is negligible, while their use for quantification of 'leakage' assumes the absence of spontaneous change. As the multiple drivers of land use and land cover change are hard to predict, the *ex ante* impact appraisal of carbon sequestration projects is difficult and the economic value on the global carbon market only applies to 'certified emission reduction' statements, after the fact. The procedures before the start of a project thus include substantial risks to all parties involved, translated to further transaction costs.

In fact, a number of barriers to adoption of tree-based systems are commonly observed (Van Noordwijk *et al.* 2003), lack of legal access to land and lack of

profitability within the current local economy being the most common. Further barriers are based on gaps in farmers' knowledge, lack of community-based fire control, lack of capital availability for investment and lack of direct access to markets for tree-based commodities. Fostering the development of tree-based systems can be achieved by removing those constraints through extension, recognition of land tenure or easing of administrative procedures (set up to control illegal logging) for transport of farmer-grown wood (Van Noordwijk *et al.* 2005). So far, most government initiatives address only the supply of planting material through 'trees planting campaigns', and not the underlying factors of land access. Project scale interventions often revert to subsidies to make tree growing look attractive, rather than to more long-term approaches to increase profitability. Interestingly, removal of constraints to land access and simplification of procedures for market access of farmer grown timber does not cost much, so the need for external investment in CDM is limited. While the farmers can get direct economic benefit from the trees, the local government unit that eased the regulations can later sell the 'certified emission reductions' and use the proceeds to enhance local welfare, without requiring any new benefit sharing mechanisms. In fact, such approach would become similar to the market for carbon credits between countries with a commitment to reduce their net emissions. Our hypothesis is:

> Farmer-led development of tree-based land use systems in response to accessible markets, legal tenure arrangements, availability of reliable technical information and local investment can convert degraded forest lands at low public cost and form an attractive alternative to project-based interventions with detailed prescriptions and planning.

We tested the consistency of the hypothesis with available data for two sites designated for CDM in Indonesia: Sidenreng Rappang (Sidrap) in South Sulawesi and Way Tenong in Lampung. These two sites have been selected from a much larger number of potential sites on the basis of institutional readiness, compliance with formal Kyoto Protocol criteria and interest of local stakeholders to enhance the tree biomass in their landscape (Murdiyarso *et al.* 2006).

For both sites, we explored the plausible effects on farmer income and terrestrial C-stocks for two alternative approaches: a 'reforestation' project design with set prescriptions for planting of specified trees at fixed spacing ('project approach') and a generic removal of constraints to all smallholder tree-based production systems ('programmatic approach'). For this purpose, we used a simulation model, the Forest Agroforest Low Value, Landscape or Wasteland (FALLOW) model, to explore the causality chains of land use changes as outcomes of complex human decision making processes. The FALLOW model simulates landscape dynamics and its consequences on the basis of 'drivers' and 'scenarios'. Farmers' decisions, potentially influenced by top-down interventions (*e.g.* CDM interventions), are translated into their spatial consequences for land use and associated carbon stocks. Detailed description of the model is provided elsewhere, *i.e.* Van Noordwijk (2002), Suyamto *et al.* (2003), Suyamto and Van Noordwijk (2005).

Method

We parameterized the FALLOW model for Sidrap in South Sulawesi and Way Tenong in Lampung and calibrated a number of parameters that cannot be independently measured, as described below. After a 'limited calibration' phase, we initialized with land cover data for 1990 and compared observed and simulated land cover change over a period of 10 years to assess the model's validity. The model's uncertainty in carbon stocks predictions was assessed by separating uncertainty on land cover fractions from uncertainty in carbon stock per land class unit. Accepting the model's validity and uncertainty, scenario-based simulations were carried out to 'evaluate' project-based and programmatic approaches.

Options and Economical Attraction

Available options of land use systems in the study sites were identified based on land use/cover maps derived from Landsat imageries, verified through ground surveys. There are four main land use systems available in all sites: natural vegetation systems, agroforestry systems, tree monoculture systems and agricultural systems. The form of agroforestry systems, monoculture plantation systems and agricultural systems vary between sites. In general, Sidrap is cashew growing area, while Way Tenong is coffee growing area.

Profitability of land use options and off-farm jobs in the study sites were estimated based on rapid surveys and secondary data. Payoffs to labour (Rp/person/day) are used to indicate profitability, and defined as profit earned per total labour employed. Profitability of cashew-based systems in Sidrap is about Rp 58,000/person/day, much higher than the provincial-level wage rate of about Rp 26,000/person/day. *Gmelina*-based systems in this area have potential profitability of about Rp 34,000/person/day. Profitability of coffee-based systems in Way Tenong is about Rp 16,000/person/day, a bit lower than the provincial-level wage rate of about Rp 20,000/person/day. In general, agricultural systems in both sites have potential profitability of about Rp 10,000/person/day.

Labour Capital

Labour was estimated using population data from the year 2003 provided by a census at village level, with assumed annual population growth of about 2.3% per year, labour fraction of about 75% and annual working days of about 220 days per year. Estimated labour for Sidrap and Way Tenong in the year 1989 was 940,830 and 2,343,811 person-days respectively.

Land Capital

Land expansion is restricted by some costs: transportation, land clearing and controlling costs. Transportation cost is determined by road or river. Land clearing cost is determined by slope and floor biomass. Controlling cost is determined by settlements or existing plots. In Sidrap and Way Tenong, land expansion is strongly restricted by land clearing cost, less restricted by controlling cost, and barely restricted by transportation cost. The latter can be explained because the main commodities of the sites, cashew and coffee, do not require massive transportation in harvesting.

Land expansion is also restricted by accessibility for the conversion of grasslands. Accessibility to convert grasslands for other uses is strongly influenced by either land use policy or farmers' knowledge on tree/crop-site matching. Relatively low access to grasslands in Way Tenong (about 40% on average) is confirmed to be closely related to forests conservation policy, while relatively high access to grasslands in Sidrap (about 74% on average) is mainly caused by farmers' misinterpretation of legal tenure rights.

Fire

Based on land use/cover maps, unchanged grasslands for the years 1989–2000 occupied 30% and 18% of the total area in Sidrap and Way Tenong respectively. It is the evidence of fire-climax state due to frequent fire events. Based on a rapid survey, farmers confirmed frequent control burning of grasslands in the study sites as part of pest control.

Aboveground Biomass Growth

Growth of aboveground biomass of natural vegetation systems and tree-based systems was estimated using the general asymptotic function of age $y = y_{max} (1 - \exp[-\beta.age^{\gamma}])^{\eta}$ (Vanclay 1994). The parameters (y_{max}, β, γ and η) were estimated based on secondary data using the nonlinear least squares fitting procedure. Since the temporal resolution of the FALLOW model is yearly, it is assumed that aboveground biomass from agricultural plots is zero.

Project Boundary

Proposed project areas for Sidrap and Way Tenong are about 1,152 ha and 8,943 ha respectively. To estimate additionality and leakage, the model was applied to larger areas: ± 85,365 ha in Sidrap and ±30,576 ha in Way Tenong.

Results

Validity

The validity of FALLOW model was tested by its capability to explain driving factors of previous land use/cover change. The spatial goodness of fit between simulated land cover maps and their references was measured using multiple resolution procedure proposed by Costanza (1989). For Sidrap, spatial goodness of fit of agriculture is 33%; grasslands, 57%; forests, 28%; mixed tree-based systems, 38%; and cashew monoculture, 49%. For Way Tenong, spatial goodness of fit of agriculture is 32%; grasslands, 71%, forests, 88%; coffee multistrata systems, 41%; coffee simple shade systems, 72%; and coffee monoculture system, 21%.

Comparison between simulated land cover maps and their references was also done in terms of area difference. In Sidrap, area difference of agriculture is –14%; grasslands, –10%; forests, +60%; mixed tree-based systems, +10%; and cashew monoculture, +6%. In Way Tenong, area difference of agriculture is –43%; grasslands, –11%; forests, +29%; coffee multistrata systems, +32 %; coffee simple shade systems, –17%; and coffee monoculture system, +124%.

Uncertainty

Uncertainty of the model in predicting carbon stocks was estimated by comparing total aboveground carbon stocks estimated from reference land use/cover maps and total aboveground carbon stocks estimated from simulated land use/cover maps. In this case, uncertainty can be caused by carbon density estimates or by simulated land use/cover. For Sidrap, the uncertainties were +13.16 t CO_2/ha due to carbon density and +6.53 t CO_2/ha due to land cover fraction. For Way Tenong, the uncertainties were +13.31 t CO_2/ha due to carbon density and +5.35 t CO_2/ha due to land cover fraction.

Land Use/Cover Changes

Scenarios were developed to simulate land use/cover changes in Sidrap and Way Tenong for the years 2000–2030, with regards to baseline, project interventions and programmatic interventions. Settings for baseline simulations follow the validation settings. Scenarios on programmatic approaches include removal of constraints to smallholder tree-based production systems by recognizing farmers' tenure rights, improving farmers' knowledge and improving tree-based markets.

Baseline trajectory of landscape in Sidrap would likely maintain grasslands and natural forests, reduced agricultural area and slightly increased tree-based systems (**Figure 10.1A**). Project intervention did not help much in converting grasslands into tree-based systems (**Figure 10.1B**). Through programmatic approaches, grasslands could rapidly be converted into tree-based systems (**Figure 10.1C, D, E**).

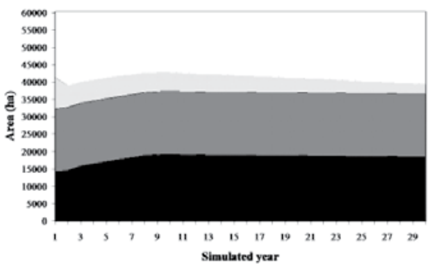
Baseline trajectory of landscape in Way Tenong would likely convert grasslands mostly to agricultural lands and maintain current coffee-based systems areas (**Figure 10.2A**). With the relatively large area of the proposed CDM project, the project intervention helped to decrease agricultural lands expansion, although it could not convert all grasslands into coffee-based systems (**Figure 10.2B**). By giving legal tenure right to access grasslands freely and/or by promoting coffee-based systems (through market improvement and extension), grasslands could rapidly be converted into coffee with simple shade and coffee monoculture systems (**Figure 10.2C, D**). By giving legal tenure right to access grasslands for multistrata coffee systems practices and promoting multistrata coffee systems, grasslands could rapidly be converted into such systems (**Figure 10.2E**).

Carbon versus Farmers' Welfare

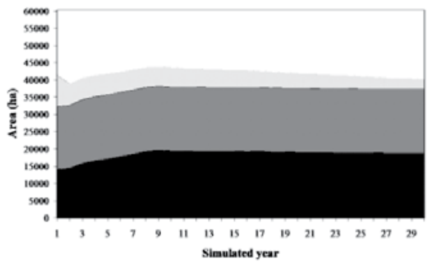
Consequences of land use/cover changes on carbon additionality, carbon leakage and farmers' welfare (*i.e.* nonfood expense per capita) were estimated. The baselines of Sidrap indicated relatively static carbon stocks (+0.15 t CO_2/ha/year) but a negative change in welfare (– Rp 220,000/capita/year). The baselines of Way Tenong indicated negative changes both in carbon stocks (–0.95 t CO_2/ha/year) and welfare (– Rp 71,000/capita/year).

Carbon additionality was calculated based on the difference of carbon stocks after 'interventions' from the baselines. Leakage was calculated as additionality gained at project scale minus additionality gained at landscape scale, relative to additionality at project scale. Welfare improvement was calculated based on differences of nonfood

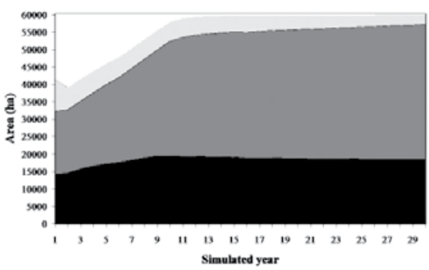
expense per capita after 'interventions' from the baselines. The CDM project in Sidrap was predicted to cause carbon leakage of about +197%, while the project in Way Tenong was predicted not to cause leakage. In terms of carbon gain or welfare improvement, programmatic approaches were superior to a project-based approach in all sites (**Tables 10.1, 10.2**).



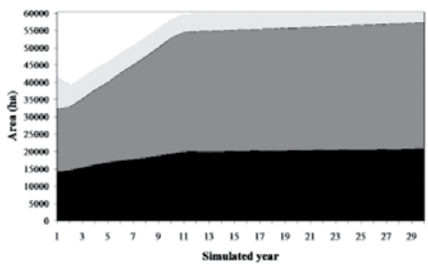
A. Baseline trajectory



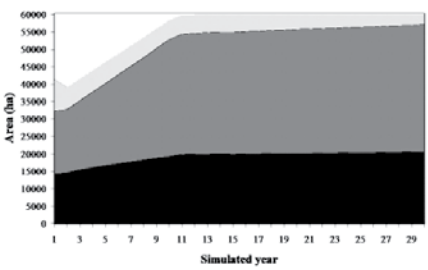
B. With project intervention



C. Giving legal tenure right to access grasslands freely



D. Giving legal tenure right to access grasslands freely and promoting tree-based systems

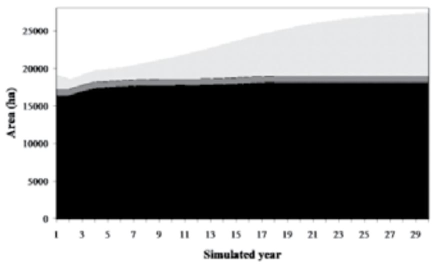


E. Giving legal tenure right to access grasslands for tree -based systems practices and promoting tree-based systems

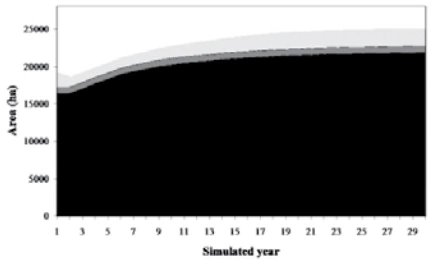
■ For ■ Af ■ Mon ■ Agr □ Gra

For = forests
Af = agroforests (mixed tree-based homegarden systems)
Mon = monoculture tree plantation (cashew or Gmelina)
Agr = agricultural lands
Gra = grasslands

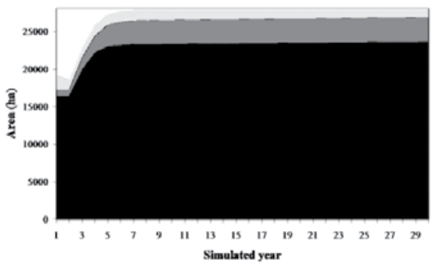
Figure 10.1. Simulated land use/cover change in Sidrap, South Sulawesi for the years 2000–2030 under various 'intervention' scenarios



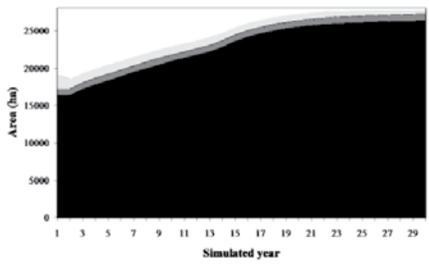
A. Baseline trajectory



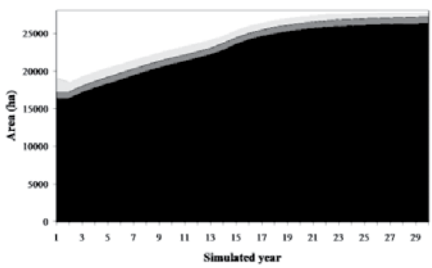
B. With project intervention



C. Giving legal tenure right to access grasslands freely



D. Giving legal tenure right to access grasslands freely and promoting coffee-based systems



E. Giving legal tenure right to access grasslands for multistrata coffee systems practices and promoting multistrata coffee systems

■ For ■ Af ■ Mon ▒ Agr □ Gra

For = forests
Af = agroforests (multistrata or simple shade coffee systems)
Mon = monoculture tree plantation (coffee monoculture plantation)
Agr = agricultural lands
Gra = grasslands

Figure 10.2. Simulated land use/cover change in Way Tenong, West Lampung, for the years 2000–2030 under various 'intervention' scenarios

Table 10.1. Predicted carbon additionality, leakage and welfare improvement in Sidrap for the years 2000–2030 under various 'intervention' scenarios

Scenario	Time-averaged carbon additionality at project scale (t CO_2)	Time-averaged carbon additionality at landscape scale (t CO_2)	Time-averaged carbon leakage (%)	Time-averaged increase of nonfood expense per capita (Rp/capita)
Project-based approach	+25,007	–24,237	+197	–4,000,000
Giving farmers legal tenure rights to access grasslands freely	Not applicable	+472,120	Not applicable	+6,000,000
Giving farmers legal tenure rights to access grasslands freely and promoting tree-based systems through extension, subsidy and market improvement	Not applicable	+226,967	Not applicable	+34,000,000
Giving farmers legal tenure rights to access grasslands for tree-based systems practices and promoting tree-based systems through extension, subsidy and market improvement	Not applicable	+226,820	Not applicable	+34,000,000

Table 10.2. Predicted carbon additionality, leakage and welfare improvement in Way Tenong for the years 2000–2030 under various 'intervention' scenarios.

Scenario	Time-averaged carbon additionality at project scale (t CO_2)	Time-averaged carbon additionality at landscape scale (t CO_2)	Time-averaged carbon leakage (%)	Time-averaged increase of nonfood expense per capita (Rp/capita)
Project-based approach	+117,443	+205,957	–75	–280,000
Giving farmers legal tenure rights to access grasslands freely	Not applicable	+93,353	Not applicable	+1,550,000
Giving farmers legal tenure rights to access grasslands freely and promoting coffee-based systems through extension, subsidy and market improvement	Not applicable	+95,040	Not applicable	+6,130,000
Giving farmers legal tenure rights to access grasslands for multistrata coffee systems practices and promoting multistrata coffee systems through extension, subsidy and market improvement	Not applicable	+221,283	Not applicable	+100,000

Conclusions

- Validation of a simulation model is crucial, especially when we applied the model for extrapolation, aimed at evaluating its 'usefulness' and 'reliability' (Huth and Holzworth, 2005). Validity of the FALLOW model in explaining driving factors of previous land use/cover changes was tested with regard to its accuracy. In this study, the FALLOW model produced relatively low spatial accuracy (about 49% on average) and relatively high area accuracy (about 72% on average). Area accuracy is closely related to complexity of spatial patterns of a landscape, while spatial accuracy is closely related to resolution of spatial determinants in land expansion. At simpler landscape patterns in Nunukan, East Kalimantan, the model resulted in area accuracy of about 89% on average (Suyamto and Van Noordwijk, 2005). In this area, we found that spatial patterns of agricultural areas are associated with spatial patterns of foot pathways, which could not be captured using spatial resolution of the model (*i.e.* 1 ha). Because impacts of land use/cover changes on carbon stocks are additive, area accuracy is considered to overpower spatial accuracy. Furthermore, the model's uncertainty in carbon stocks predictions was assessed. In general, the model overestimated carbon stocks by around +20 t CO_2/ha on average. About 70% of the discrepancy was linked to uncertainty in carbon density and 30% to uncertainty in land cover fractions.
- Extrapolating the models for the years 2000–2030 provided estimates of the dynamic baseline for carbon stocks. The baselines of Sidrap indicated relatively static carbon stocks (+0.15 t CO_2/ha/year) but a negative change in welfare (– Rp 220,000/capita/year). The baselines of Way Tenong indicated negative changes both in carbon stocks (–0.95 t CO_2/ha/year) and welfare (– Rp 71,000/capita/year).
- Leakage due to project-based approach is closely related to area of the projects. The model predicted leakage of about +197% for projects that occupy only 1% of the landscape (Sidrap). At area fraction of about 29% (Way Tenong), the model predicted no leakage. In terms of gain/loss in economical benefits, project interventions were predicted to reduce farmers' welfare by Rp 230,000 and 4,000,000/capita in Way Tenong and Sidrap respectively.
- Win-win prospects on carbon increase and poverty alleviation would likely be achieved using programmatic approach through a generic removal of constraints to smallholder tree-based production systems. This includes efforts to give farmers legal tenure rights to grasslands and to promote tree-based systems through extension, subsidy and market improvement. Through this approach, carbon stocks could likely be increased by 222,597 t CO_2 on average, while farmers' welfare could likely be improved by Rp 13,630,000/capita.
- CDM 'reforestation' projects are made through consensus. Peterson *et al.* (2005) suggest that overuse of consensus-based approaches leads to dilution of socially powerful conservation metaphors by creating multiple meaning with multiple implicit value assumptions, thus resulting in abuse of the term for power interests. Moreover, consensus reduces superficial conflicts of interests among participating groups or individuals, thus legitimizing existing hegemony configurations of

power and precluding resistance against dominant elites. It implies legitimization of further damage to the environment and increasing apathy and cynicism among the public for environmental protection efforts. On the contrary, a programmatic approach respects farmers' freedom to learn and to make choice. This approach is argument-based, which, as argued by Peterson *et al.* (2005), 'will facilitate progressive environmental policy by placing the environmental agenda on firmer epistemological ground and legitimizing challenges to current power hegemonies that dictate unsustainable practices'. Finally, if CDM is just another idea for 'more trees, less poverty', why do we not just put our efforts to remove 'real' constraints to smallholder tree-based production systems with lower risks, lower transaction costs, less concerns about leakage, impoverishment or power abuse?

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