Figure 47. Uprooted rubber stem (left) and collapsed rubber tree (right)

Plot samples in disturbed forest of HLG, rubber agroforests and coconut plantations showed that there were variations of peat depths, bulk density and total carbon contents, which were affected by the different decomposition stages of the peat soils.

Deepest peat was found in disturbed forest of HLG, with an average peat depth of 290.7 cm, and with the lowest bulk density (0.09 g/cm^3) and highest total carbon content (46.68%) (Table 16).

Table 16. Average of peat depth, bulk density, total carbon content and carbon stock in three land-cover systems

Land cover	Depth (cm)	Bulk density (g cm^{-3})	Total C (%)	Carbon stock (Mg ha^{-1})
Disturbed forest on peat	290.7	0.09	46.68	1141.75
Rubber agroforest (25 years old)	31.3	0.17	44.97	240.32
Rubber agroforest (45 years old)	24.7	0.22	41.43	224.62
Coconut mixed with betel nut (20 years old)	22.5	0.33	28.51	195.05
Coconut mixed with betel nut (40 years old) (second cycle)	19.0	0.32	28.15	136.70

Disturbed forest on peat of HLG had the highest total carbon content and lowest bulk density, indicating a young stage of the peat (fibric) or domination by organic matter. Based on the assumption that the land cover prior to rubber agroforest and coconut plantation was secondary/disturbed forest, similar to the disturbed forest of HLG, converting forest to rubber agroforest and coconut plantation that incorporated the construction of drainage system may have increased the rate of peat decomposition. At a similar age of forest conversion, the decomposition rate of peat in rubber agroforests is slower than the rate in coconut plantations, indicated by the bulk density and total carbon content of peat both in rubber agroforests and coconut plantations. Bulk density of peat in coconut plantations is higher than in rubber gardens and its total carbon content is lower than in rubber. Lower carbon content means that organic matter has decomposed into a more mature stage of peat (sapric type).

Using the stock-difference method, belowground emissions from forest conversion were estimated at 132.3 Mg CO_2 eq/ha/year when converted to rubber agroforest and 173.7 Mg CO_2 eq/ha/year when converted to coconut plantation.

2.6.5 Conclusions

- Total aboveground carbon stock in each land-cover system of Tanjabar is affected by vegetation type and age of the land-use system; older systems contain higher carbon stock compared to younger systems.
- Total belowground carbon stock in peat soil is affected by peat depth, bulk density and maturity of peat.
- Mature peat (sapric) has lower carbon content while it has higher bulk density.

2.7 Historical emissions as consequences of land-use changes

Muhammad Thoha Zulkarnain and Atiek Widayati

2.7.1 Extrapolation methods and emission calculations

The Intergovernmental Panel on Climate Change (IPCC) refers to two types of approach in calculating emissions from land-use changes (IPCC, 2006):

1. Gain-loss method, which accounts for the detail of fluxes owing to both human activities and natural processes for a relatively short time scale; and the
2. Stock-difference method, which accounts for changes in stock over a coarser time scale.

The Rapid Carbon Stock Appraisal (RaCSA)method is an adoption of the second IPCC approach, that is, a stock difference and overall methodology for landscape-level carbon dynamics estimation developed by the World Agroforestry Centre (Hairiah et al, 2011). Two types of data are required for RaCSA (see Figure 48):

1. Area of changes and trajectories of land-use systems; and
2. Time-averaged carbon-stock for each land-use system.

Data on area of changes of land-use systems is produced by the Analysis of Land-Use Changes Trajectories (ALUCT) method (see Section 2.3), while time-averaged carbon stock is normally obtained from plot measurements. Annex 12 shows the aboveground carbon stock for each land-use class.

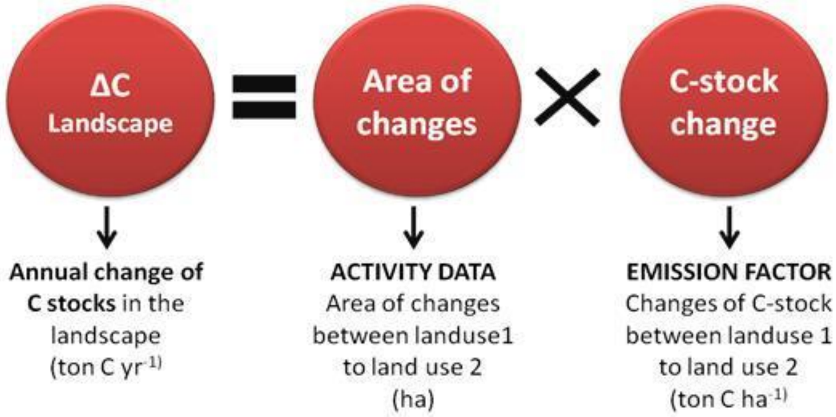


Figure 48. Extrapolation methods within RaCSA

The total amount of emissions, sequestration, and net emissions during the period of study is presented in carbon dioxide equivalent (CO_2e[8]). The net emission number is the subtraction of sequestered emissions. Unlike the time periods in land-use changes, in this section three time series were observed: 1990–2000, 2000–2005 and 2005–2009.

2.7.2 Landscape carbon stock and land-based emissions

2.7.2.1 Aboveground carbon-stock levels in Tanjabar

The total aboveground carbon stock in Tanjabar is presented in the chart below (Figure 49).

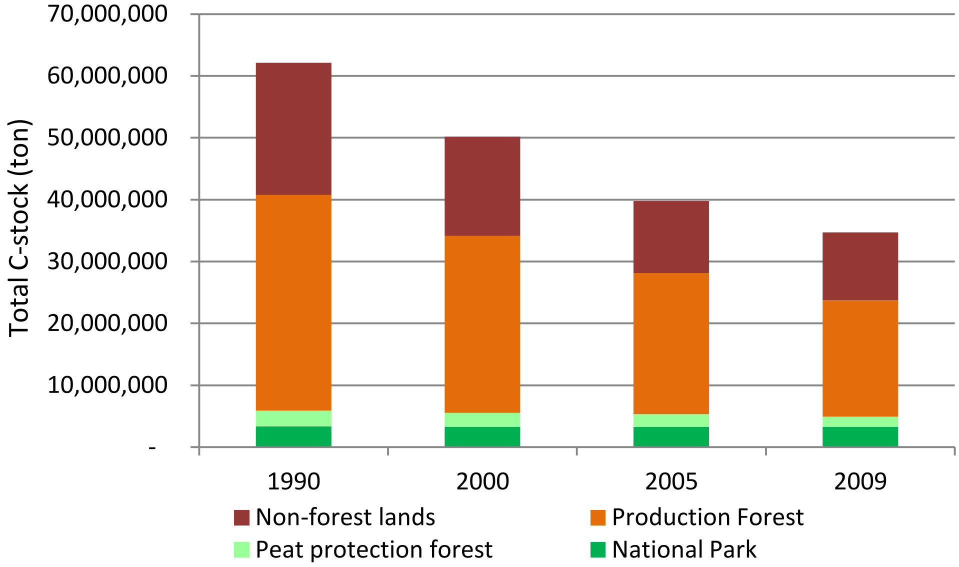


Figure 49. Total aboveground carbon stock in time series

The total aboveground carbon stock in Tanjabar gradually decreased during the two decades of observation (Figure 49). For the first decade (1990–2000), stock decreased as much as 12 M ton or 19% carbon lost, while for the second decade (2000–2009) the decrease was about 15 M ton or about 31% carbon lost. For state forest land throughout the entire time series, the stable

[8] CO_2 equivalent is found by multiplying carbon-stock value by 3.67. This figure is the ratio of atomic mass of CO_2/C.

aboveground stock is in Bukit Tiga Puluh National Park (see also Figure 24 in Section 2.3.2) and the annual rate of loss is almost nil. The largest carbon loss in area is inevitably in the production forest and non-forest land areas, amounting to 6M ha during 1990–2000, with the annual rates of carbon loss ranging between 1% and 6% per year. However, despite the small area and hence amount, it is interesting to note that for the most recent years of observation (2005–2009) the percentage of carbon loss in peat protection forest (5%/year) was as high as those in production forest and non-forest lands. This shows the increasing conversion activity during the last few years despite the peat protection forest status.

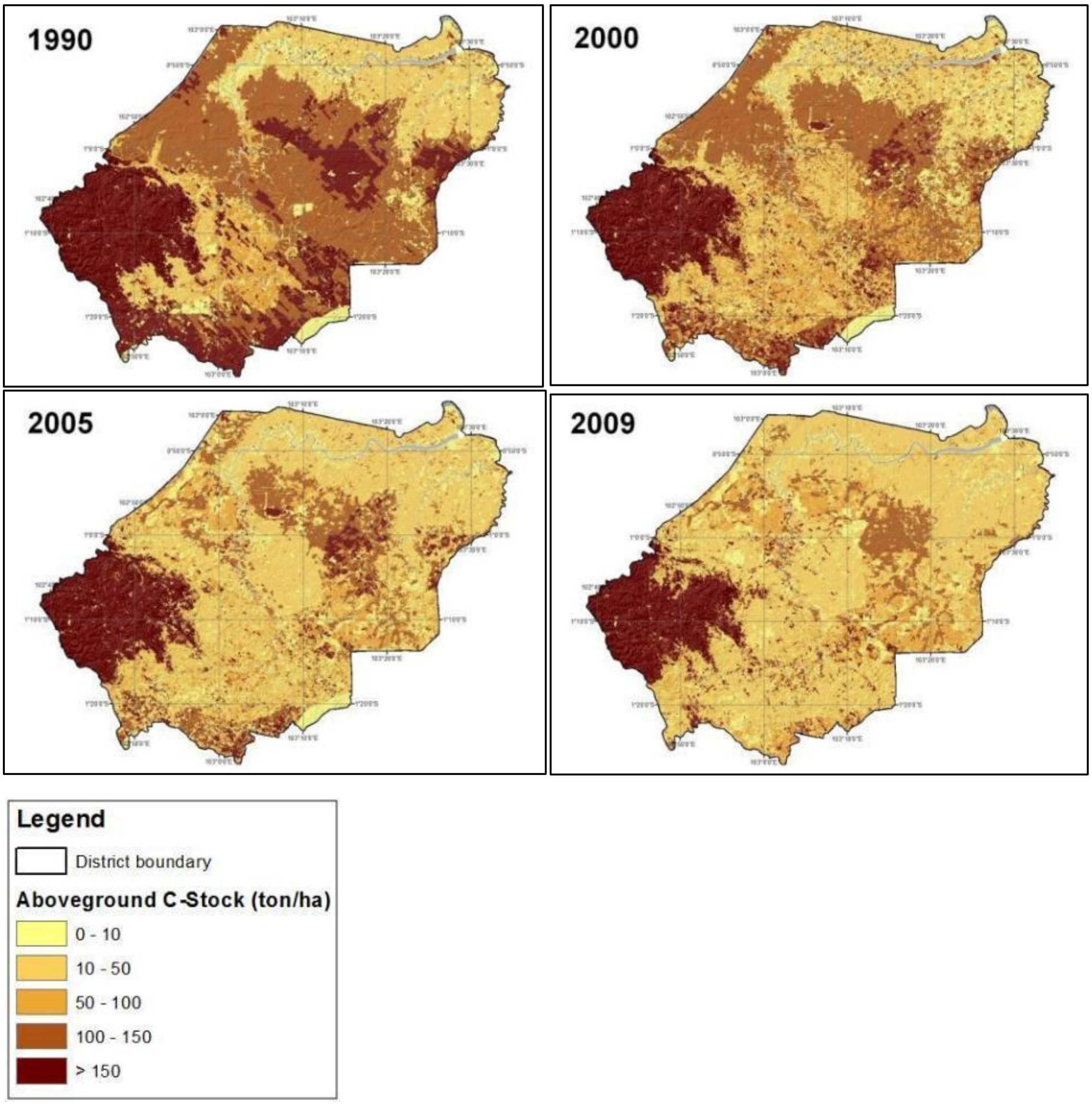


Figure 50. Aboveground carbon-stock map for 1990, 2000, 2005 and 2009

2.7.2.2 Land-based aboveground emissions in Tanjabar

The emissions, sequestration and net emissions for the three periods of observations are shown in Table 17 and Figure 51. Over the period of study, land-based emissions increased from 10.53 Mg CO_2e/ha/year during 1990–2000 to 17.7 Mg CO_2e/ha/year for 2000–2005 and then decreased to 14.7 Mg CO_2e/ha/year for 2005–2009. Sequestration shows a different trend, with an increasing figure throughout the three periods of study: 1.44, 1.9 and 5.1 Mg CO_2e/ha/year.

Table 17. Emissions, sequestration and net emissions from 1990 to 2009, based on aboveground carbon-stock changes

	1990–2000	2000–2005	2005–2009
Emission			
Total emissions (ton CO_2 e)	50 865 581	42 709 687	28 490 475
Annual emissions (ton CO_2 e/year)	5 086 558	8 541 937	7 122 619
Ave. ann. emissions (ton CO_2 e/ha/year)	10.53	17.69	14.75
Sequestration			
Total sequestration (ton CO2 e)	6 971 713	4 626 002	9 840 003
Annual sequestration (ton CO2 e/year)	697 171	925 200	2 460 001
Ave. ann. sequestration (ton CO2 e/ha/year)	1.44	1.92	5.09
Net emissions			
Total net emissions (ton CO_2 e)	43 893 868	38 083 684	18 650 473
Annual net emissions (ton CO_2 e/year)	4 389 387	7 616 737	4 662 618
Ave. ann. net emissions (ton CO_2 e/ha/year)	**9.09**	**15.77**	**9.66**

The net emissions throughout the three study periods show similar trends as the gross emissions. However, the decrease of emission from the 2000–2005 period to 2005–2009 is steeper compared to the decrease of gross emissions owing to increasing sequestration, especially during 2005–2009 (Figure 51).

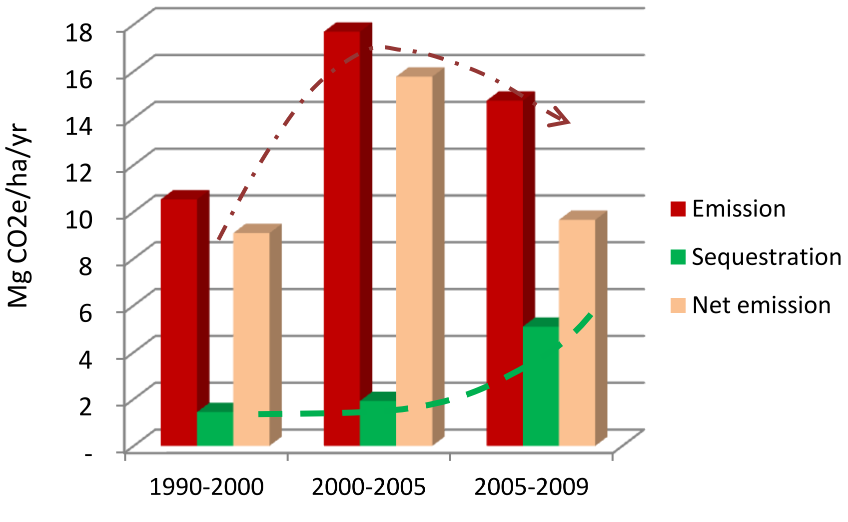
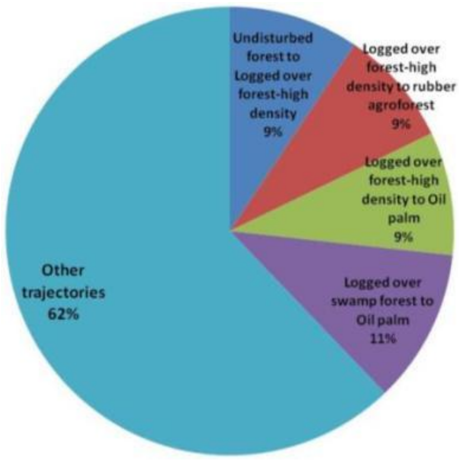


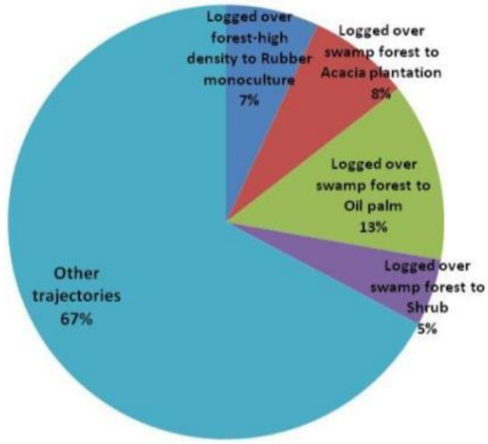
Figure 51. Emissions, sequestration and average net emissions 1990–2009

2.7.2.3 Shares of land-use change trajectories to aboveground emissions

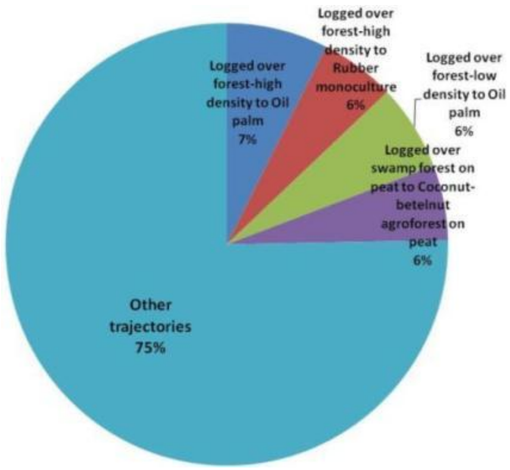
Tracing back the major contributing land-use trajectories of the emissions, Figure 52 shows the four highest shares of emissions.



(a)



(b)

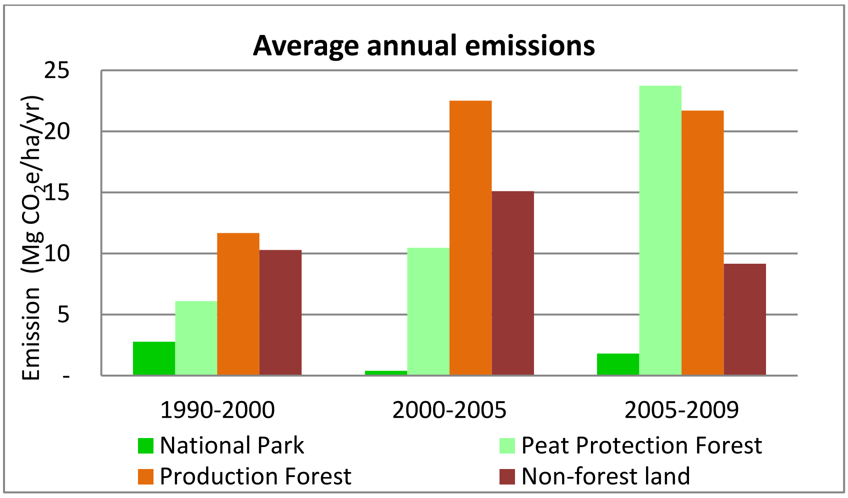


(c)

Figure 52. Emissions 1990–2000 (a), 2000–2005 (b) and 2005–2009 (c) based on land-cover trajectories

The largest shares of emissions during 1990–2000 and 2000–2005 came from conversion of logged-over swamp forest to oil palm plantations (11% and 13%). For 2005–2009, all land-use changes that took place shared less than 10% of emissions, but rather similarly to the preceding periods, the highest was conversion from logged-over forest to oil palm (7%).

2.7.2.4 Land-based emissions based on state forest land status



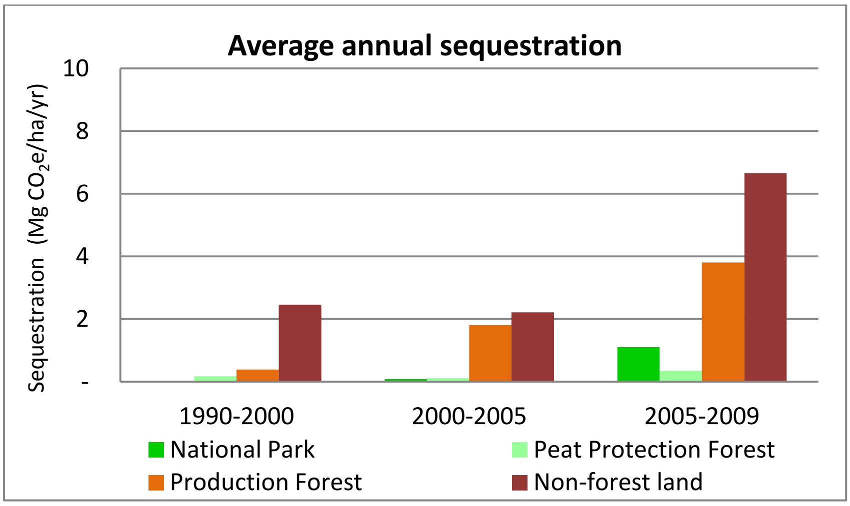


Figure 53. land-based CO_2 emissions (top) and sequestration (bottom)

When observing the significance of forest land status for emissions and sequestration contributions, from Figure 53 (top) we can see that for 1990–2000 and 2000–2005, production forest areas contributed to the highest average annual emissions. An interesting phenomenon is observed for 2005–2009 period, where emissions from peat protection forest exceeded those in other forest zones and in non-forest land and was the highest throughout the three observation periods. This phenomenon can be explained by the dynamics of land uses in HLG areas, as discussed in Section 2.3.2, in which oil palm and coffee-based farms were planted.

On the removal of CO_2e, or carbon sequestration, among the different forest land status, non-forest land is consistently the highest for the entire three decades of observation (Figure 53 (bottom)). The highest amount of sequestration took place for 2005–2009, amounting to 6.66 Mg CO2e/ha/year. Observing the trajectories of changes during that period (Figure 54), the highest contributions for carbon sequestration were identified as the changes of different tree-based systems (rubber monoculture, oil palm plantation and rubber agroforest) into disturbed forest class. This trajectory indicates the high increase of canopy cover of the woody vegetation in the respective farms or plantations. Such increase of trees/plants might be due to deliberate efforts of agroforestation through intercropping of fruit trees or timber trees, and in some other cases it might be to the abandonment of the land.

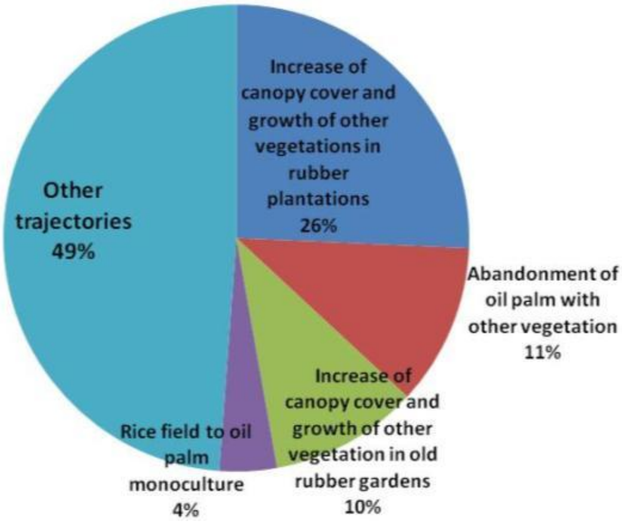


Figure 54. Shares of land-cover trajectories for sequestration, 2005–2009

2.7.3 Summary and conclusions

In Tanjabar, the trend of carbon loss, hence emissions, has the highest rate in the early 2000s. More recently, emissions decreased, which is very likely owing to the minimum stock available. Conversion that brought about the largest share of emissions until the early 2000s came from the loss of remaining forest to monoculture plantations such as oil palm. From the forest land status perspective, emissions were high in production forest marked by logging and later by the development of industrial plantations. However, in recent years, emissions from peat protection forest exceeded those from the other forest status. Despite the protection status, increasing encroachment into the peat protection area for small-scale gardens and cultivation such as oil palm clearly triggered the increased emissions.

Removal of CO_2, or carbon sequestration, shows a persistent increase, with a relatively high figure for the most recent years of observation. Sequestration is shown to be contributed by non-forest land-use systems. Trajectories of sequestration came from an increase of vegetation densities in different tree-based systems, which most likely reflect agroforestation processes, additional intercropping in different tree-based systems or to some extent abandonment of the unproductive/low productivity farms.

We can form preliminary conclusions that Tanjabar has now depleted its natural carbon-stock resources. The district currently is undergoing a phase where a highly commercial, low carbon-stock, land-use system dominates the area. Evidence also shows increasing carbon stock in some land-use systems. The latter may indicate that Tanjabar is embarking on the later stage of the forest transition gradient where vegetation, and hence carbon, increases, although chances are that it will experience a prolonged medium stage in forest transition where low carbon-stock land-use systems dominate.

2.8 Profitability of land use systems

Muhammad Sofiyuddin, Arif Rahmanulloh and Suyanto

2.8.1 Introduction

The purpose of this study was to compare profitability of existing land use in Tanjabar in order to assist with formulation of a REDD+ strategy. The results of a profitability analysis, when added to our understanding of the carbon content of different land uses, is crucial information for assessing the trade-off between different land uses. Net present value (NPV) is the most common indicator used for comparing profit of different types of investment (in this case, different types of land use). The NPV of an investment is defined as the sum of the present values of the annual cash flows minus the initial investment. The annual cash flows are the net benefits (revenue minus costs) generated from the investment during its lifetime. These cash flows are discounted or adjusted by incorporating the uncertainty and time value of money (Gittinger 1982).

Net present value

NPV is one of the most robust financial evaluation tools to estimate the value of an investment. The formula to calculate the NPV is below.

$$NPV = \sum_{t=0}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

where B_t is benefit at year t, C_t cost at year t, *t* is time denoting year and *i* is discount rate.

NPV is calculated at private and social prices. NPV at private price shows private profitability, as a measure of profitability as a production incentive. NPV at a social price shows potential profitability that should be received by a farmer/operator. The investment for one specific land use is labelled profitable if the NPV is higher than zero. The higher the NPV, the higher the profitability of that investment. NPV is also called ‘return to land’. An indicator of profitability is return to labour. Return to labour is defined as the wage rate at NPV equal to zero. Return to labour is calculated by adjusting the wage rate until NPV reaches zero. The investment is profitable if return to labour is higher than the wage rate.

Rapid Rural Appraisal (RRA) was used to gather farm budget data for each land use, including prices, production, labour and input, for 2010. The resource persons and/or key informants interviewed for the purpose of the study were farmers, traders and government officers.

Profitability assessment needs a detailed farm budget calculation. It is necessary to clarify the macroeconomic assumptions and the proper prices for calculating the cost and return used in this assessment. In this study, some macroeconomic parameters were used (Table 18). The wage rate for agricultural work was IDR 50 000 per day and the exchange rate was IDR 9084 = USD 1. Real interest rates (that is interest rate net of inflation) were the discount factors used to value future cash flows in current terms. A private discount rate of 8% and a social rate of 3% were chosen as the initial values to facilitate comparison with PAM (Policy Analyse Matrix) results of different land-use activities. We argue that a private discount rate of 8% is a lower boundary for the actual cost of capital for a smallholder owing to imperfections in capital markets in the area under study. The real social interest rate is less than the private rate and 5% is probably too low. So, somewhat arbitrarily, a rate of 3% has been used for the real social cost of capital, which are both the interest rate and the discount rate for calculating NPV social price. Many experts use a rule of thumb for measuring the social interest rate, with a decrease of 5% from the private interest rate. Therefore, for this study we used 3% for the social rate. Owing to the time constraint and lack of reliable time-series data, the study used single year price data, that is, 2010 prices, for both private and social profitability calculations.

Table 18. Macroeconomic parameters used in the study

Parameters	2010
Exchange rate	IDR 9084 =USD 1
Wage rate in Jambi	USD 5.50 / day
Real interest rates (net of inflation):	
Private	8% per year
Social	3% per year

The analysis for NPV must have the same time horizon across land uses in order to remain comparable. This study uses a 30-year timeframe because we are interested in the opportunity cost of entering a REDD+ contract (World Bank 2011).

Data collection

The first step in the study was to select the land uses for the profitability analysis. We divided land uses into eight major categories—forest, *Acacia mangium,* oil palm, coconut, rubber, coffee, betel nut and crops—divided soils into two—mineral and peat–and further classified land-use into large and small scale. Therefore, 15 land-use systems were selected for profitability analysis (Table 19).

Large-scale operations included forest concessions, industrial timber plantation (*Acacia mangium*) and oil palm plantations. All land-use system for large-scale operations were on mineral soil. For smallholders, we selected oil palm, rubber (monoculture and mixed systems), coconut (monoculture and mixed systems), coffee (mixed systems) and betel nut (mixed systems) to be assessed. On mineral soil, the land-use system was dominated by smallholder oil palm and rubber(both monoculture and mixed systems). Peat soil was dominated by mixed systems of coconut, coffee and betel nut. Agriculture was divided by dry land paddy system on mineral soil and maize on peat.

Table 19. Land cover of Tanjabar and the selected main land-use systems

Land-cover type	Selected land-use system		Scale of operation
	On mineral	On peat	
Forest (undisturbed)	Forest extraction. Logging low density (17 m^3/ha) (45 000 ha)	na	Large-scale enterprises
Forest (Low density)			
Swamp forest (undisturbed)			
Swamp forest (Low density)			
Mangrove (undisturbed)			
Logged-over mangrove			
Acacia mangium	Industrial timber plantation *Acacia mangium* (12.274 ha)	na	
Oil palm	Oil palm (3000 ha)	na	
Oil palm (1–2 ha)	Nucleus Estate and smallholder oil palm	Independent smallholder	Smallholders
Coconut (1–2 ha)	Coconut monoculture	Coconut mixed with coffee and betel nut	
Rubber (1–2 ha)	Rubber monoculture	Rubber monoculture Rubber agroforest	
Coffee (1–2 ha)	na	Coffee-based mixed garden (with betel nut)	
Coconut-Betel nut-Coffee (1–2 ha)	na	Coconut mixed with coffee and betel nut	
Coconut-Betel nut (1–2 ha)	na	Coconut mixed with betel nut	
Paddy (1–2 ha)	Dryland paddy		Crops
Maize (1–2 ha)	na	Monoculture maize	

2.8.2 Profitability of different types of land-use systems

The results of the profitability analysis show that all land uses on both mineral soil and peatland are positive, indicating that those land uses are profitable. Estimates of NPV evaluated at private and social prices are presented in Table 20. Large-scale, oil palm plantations on mineral soil are the most profitable. Indonesia has high comparative advantage in oil palm plantations. In 2007, Indonesia became the world's largest palm oil producer. The development of oil palm in Indonesia has been rapid, with the area of plantations increasing from 120 000 ha in 1969 to almost 8 million ha in 2010. Indonesia now controls more than 45% of the world palm oil market share (Dirjenbun 2009). Not surprisingly, Indonesian oil palm plantation development continues to increase because business is very profitable for both companies as well as for the state.

Large-scale logging also has high NPV, but it is lower than oil palm. Although there are no more forest concession in Tanjabar, large-scale conversion of forest and logged-over forests has taken place for the development of industrial tree and oil palm plantations. This is the dilemma: high profitability from logging will cause people to deplete the forest resource; low profitability will also cause people to convert the forest to other land uses that are more profitable.

Table 20. Profitability of land-uses system in Tanjabar

No.	Land-use system	NPV on mineral (USD/ha)		NPV on peat (USD/ha)		
		Private	Social	Private	Social	
Large Scale						
1	Oil palm large-scale	7615	22 944	-	-	
2	Logging	6114	27 891	-	-	
3	Acacia plantation	1040	3 886	-	-	
Smallholder						
4	Smallholder oil palm	7012	16 596	,866	18 788	
5	Rubber monoculture	2417	18 735			
6	Rubber agroforest	1580	11 541	1481	11 119	
7	Coconut monoculture	734	2,839	-	-	Coconut plantation in coastal area. No intercrops
8	Coffee agroforest	-	-	5722	15 632	Consists of coffee and betel nut
9	Coconut-coffee and betel nut agroforest	-	-	5301	14 596	Coffee, coconut and betel nut
11	Coconut-betel nut Agroforest	-	-	2002	5931	Coconut and betel nut
10	*Jelutung* monoculture	-	-	3590	18 354	
Crops						
12	Dryland paddy	404	709	-	-	
13	Maize	-	-	595	2116	

Acacia plantations also have a positive NPV, but it is not as high as the NPV of oil palm and logging. The development of industrial timber plantations became part of the strategy for national development to satisfy the demand for raw material from the pulp industry. The sector was targeted to develop 9 million ha in 2011 but only realised 45% of this in 2010 (Dirjen BPK 2010). The low NPV for acacia plantations indicates that the business is not very attractive for investors and farmers. Acacia plantations have a high establishment cost— building and maintaining roads and infrastructure—and high national and local government taxes.

All smallholder land-use systems also showed positive profitability. Oil palm had the highest profitability, both on mineral soils and peat. Once again, this shows that oil palm is a very attractive option. Smallholder rubber plantations also showed positive profitability, but oil palm was almost double in comparison. On mineral soil, many farmers changed their rubber systems to oil palm plantations. Large-scale oil palm plantations in Tanjabar are mostly scattered around the Tungkal Ulu and Merlung subdistricts, all on mineral soil (BPS 2010).

If we compare the smallholder oil palm on mineral soil and peat, the results show that mineral soil is more profitable than peat. Management systems on peat are more complex: there are additional costs for the construction and maintenance of a drainage system. The costs are incurred thoughtout the year: maintenance to prevent submersion of plants and trees and acid poisoning from the water. Excess water causes plants to die of thirst, so to speak. For oil palm on peat, the difficulty of market access inspires low prices for fresh fruit bunches.

In the past, coconut plantations on peat were monocultural. However, since the 1990s, the price of coconut has declined. Thus, farmers started to intercrop with coffee and betel nut to increase profit. The NPV of coconut-coffee-betel nut was USD 5301/ha. Similarly, NPV of coffee agroforest was USD 5722/ha. The profitability of the mixed or agroforestry systems on peatland was high. The profitability from these mixed systems has a nearly equal with oil palm plantations on peat. In other words, the competitiveness of these mixed system with oil palm was high.

Another land-use system in Tanjabar that must be considered is *Jelutung* (*Dyera sp*) monoculture. The forestry office in Tanjabar initiated a program to encourage forest protection on peat (HLG). However, about 4600 ha from a total 16 000 ha area has already been encroached (Dishut 2008). Because the *Jelutung* has only recently been planted there was no farm budget data available. Hence, in this study we used the prediction data from a previous study. *Jelutung* was planted with a distance of 5 x 5 m, giving a population density of 400 trees/ha (Rahmat and Bastomi 2007). The results show that the private profitability of *Jelutung* is lower than coffee agroforests, coconut-coffee-betel nut and oil palm plantations.

The results from crop system show that profitability is lower than other land-use systems. The dryland paddy system is the lowest in profitability for crop systems; simple management applied affected productivity.

Table 21 shows the results for return to labour. The return to labour for all land-use systems shows a larger value for wage rates in Tanjabar: on average USD 5.50/per person per day. This suggests all land use is attractive and profitable for farmers and operators.

In large-scale systems, return to labour in private was around USD 8–17/ps-day. Acacia plantations had a higher return to labour. Interestingly, for acacia plantations, although the value of return to labour is quite large it has the lowest NPV compared with other large-scale land-use systems. This is related to the large amount of labour required in the establishment phase and vice versa for the operational phase. The acacia plantation also has a positive cash flow in the tenth year of management. This shows that the land-use system is not efficient. The same thing occurs with *Jelutung* monoculture plantations, which means this system is also not efficient. Oil palm plantations, both large scale and smallholder, have a high NPV and return to labour; this shows the system is very efficient and that oil palm is an attractive and profitable land-use system.

Table 21. Return to labor for all land-use systems in Tanjabar

No.	Land-use system	Return to labour on mineral (USD/ps-day)		Return to labor on peat (USD/ps-day)	
		Private	Social	Private	Social
Large scale					
1	Oil palm	12.39	13.90	-	-
2	Logging	8.47	13.63	-	-
3	Acacia plantation	17.07	26.46	-	-
Smallholder					
4	Oil palm	17.29	20.14	16.06	27.86
5	Rubber monoculture	7.39	12.59		
6	Rubber agroforest	7.09	11.51	8.05	17.02
7	Coconut monoculture	8.93	11.20	-	-
8	Coffee agroforest	-	-	8.91	11.14
9	Coconut-coffee-betel nut agroforest	-	-	8.54	10.14
10	Coconut-betel nut agroforest	-	-	7.75	9.06
11	*Jelutung*	-	-	16.46	37.91
Crops					
12	Dryland paddy	5.83	5.83	-	-
13	Maize	-	-	6.96	6.97

For smallholders, the return to labour ranged USD 7–17/ps-day (for private). Oil palm on mineral soil had a higher return to land and rubber agroforestry had the lowest. This result indicates the reason farmers switch from rubber systems to oil palm plantations. Return to labour is an indicator of profitability for farmers, which is the incentive to production. The high return to labour tends to attract local people to switch and commercialise their land-use system.

For upland crops, the return to labour ranges USD 5–7/ps-day (for private). Although the return to labour is the lowest compared to other land-use systems, the value is still higher than the wage rate in Tanjabar.

2.8.3 Summary and conclusion

The results of profitability analysis show that all land uses, both on mineral soil and peatland, are profitable.

- Large-scale oil palm is the most profitable land-use system.
- Among the smallholder systems, oil palm is the most profitable. Smallholder oil palm on peatland is less profitable than on mineral soils because of the higher costs in establishing a drainage system and the lower productivity.

- Rubber on mineral soils is less competitive than oil palm on the same type of soil; the profitability of oil palm is almost three times that of rubber.
- Mixed gardens, e.g. coffee-based system, compete well with oil palm on peatland. Their profitability is almost the same as that of oil palm.
- The threat of converting land to oil palm is higher on mineral soils than on peatland.

2.9 Opportunity costs of emissions caused by land-use changes

Andree Ekadinata Putra, Suyanto and Atiek Widayati

2.9.1 Introduction

Amid the euphoria of REDD and REDD+ discussions, the expectations of large financial gains raises the interest of all. However, a country will only enjoy REDD benefits if the cost of REDD is lower than the benefit. White and Minang (2011) grouped the cost into three categories.

1. Opportunity cost.
2. Implementation cost.
3. Transaction cost.

Moreover, they argued that their analysis was focusing on opportunity costs because they will

1. be the largest portion of costs associated with REDD+;
2. provide insight into the drivers of deforestation;
3. help to understand impact; and
4. help to identify fair compensation for those who change their land use.

Method

The method used in this study followed the manual for estimating the opportunity cost of REDD+ published by the World Bank Institute and the REDD-Abacus software developed by the World Agroforestry Centre. There were four steps in the analysis.

1. Clarification and description of major land uses.
2. Calculation of time-averaged carbon stock for the major land uses.
3. Calculation of the private profitability of the land uses in terms of discounted net present value.
4. Developing the opportunity cost curve using the REDD-Abacus software. The opportunity cost curve shows the comparison of the opportunity costs of many different types of land-use change in USD per ton CO_2e and shows the quantity of potential emissions reduction per type of land-use change.

The formula to calculate the opportunity cost in USD / ton CO_2e was

$$\frac{NPV_{Time\ 2} - NPV_{Time1}}{3.67 * Cstock_{Time\ 1} - Cstock_{Time\ 2}}$$

Assumptions and limitations

- Private NPV only

- Conversion cost benefit is assumed to be similar for each land-use transition type
- Profitability of logging is assumed as a benefit of forest degradation (conversion from undisturbed forest to logged-over forest)
- Aboveground emissions only, belowground/peat emissions not yet included
- Forward-looking analysis is based on stationary transition probability matrix, no REDD+/policy scenario included yet
- USD 5/tCO_2e was used as the carbon price for emissions reduction

2.9.2 Trade-off curves of different land-use systems

Figure 55 shows a trade-off between carbon stock and profitability of land uses on mineral soil and peatland. There are four clusters (listed below) and a couple of land uses outside the clusters which have low NPV and medium profitability:

- High carbon-stock and low profitability
- Medium carbon-stock and medium profitability
- Low carbon-stock and high profitability
- Low carbon-stock and low profitability

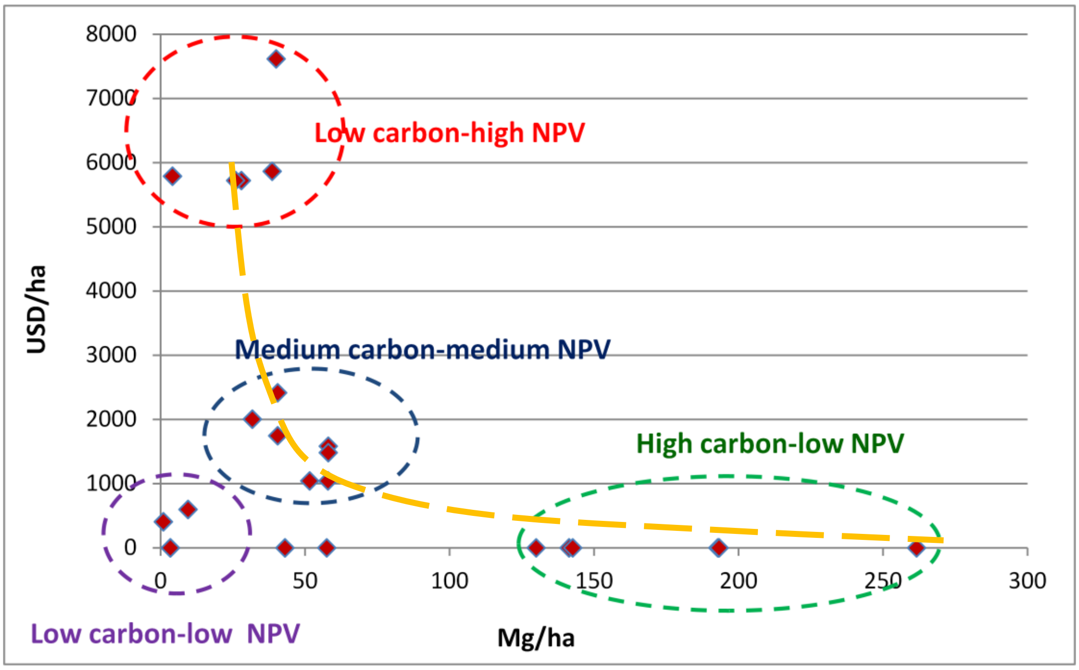


Figure 55. Clusters of land-use systems based on carbon stock and net present value

Table 22. Carbon stock and net present value of land-use systems in Tanjabar

No	Land-use system	Carbon stock (ton/ha)			Private NPV (USD/ha)		
		Mineral	Peat	Note	Mineral	Peat	Note
1	Undisturbed forest	262		Merangin measurement	0	0	Primary forest without any activities; NPV set as zero
2	Logged-over forest: high density	193		Lubuk Beringin measurement	0	0	No activity
3	Logged-over forest: low density	130		Bengkulu and Aceh measurement	0	0	No activity
4	Undisturbed swamp forest	193	193	Mineral is assumed equivalent with peat measured in Aceh	0	0	No activity
5	Logged-over swamp forest	141	141	Measurement in Jambi (peat), Lampung and South Sumatra (mineral)	0	0	No activity
6	Undisturbed mangrove	143		Measurement in Central Kalimantan	0	0	No activity
7	Logged-over mangrove	58		Measurement in Jambi	0	0	No activity
8	Rubber agroforest	58	58	Measurement in Jambi	1580	1481	Assumed equal Carbon stock on mineral and peat soils
9	Coffee-based agroforest	28	26	Mineral is assumed equivalent with peat measured in Jambi	5722	5722	Based on profitability analysis of coffee-based agroforest on peat soil in Tanjabar. Assumed equal NPV on mineral and peat soils
11	Acacia plantation	58	52	Measurement in Jambi	1040	1040	Assumed equal NPV on mineral and peat soils
12	Rubber monoculture	41	41	Peat is assumed equivalent with mineral, ICRAF Database	2417	1747	Profitability analysis in Tanjabar
13	Oil palm	40	39	ICRAF Database	7615	5866	Profitability analysis of large-scale oil palm on mineral and smallholder on peat. There is no large-scale oil palm operation on peat in Tanjabar
14	Coconut-betel nut agroforest	32	32	Measurement in Aceh and South Sumatra	2002	2002	Profitability analysis of coconut-based system in mineral and betel nut-based system on peat. Coconuts are found in betel nut-based system in small number
15	Shrub	43	43	ICRAF Database	0	0	No activity
16	Grass	3	3	ICRAF Database	0	0	No activity
17	Other crops	10	10	ICRAF Database	595	595	Assumed as maize cultivation
18	Rice field	1	1	ICRAF Database	404	404	Upland rice paddy system
19	Cleared land	3	3	Assumed to be equivalent with grass	0	0	No activity
20	Settlement	4	4	Averaged from measurements in Lampung, Jambi and Kalimantan	5787	5787	Assumed to be the same as cost of developing transmigration settlement

The land uses belonging to the high carbon-stock and low profitability cluster were forest and logged-over forest both on mineral and peat. Agroforestry systems such as coconut-betel nut agroforests on mineral soil and coffee agroforests on peat most likely belonged to low-to-medium carbon stock and medium profitability. Large-scale and smallholder oil palm on both mineral and peat were categorised as low carbon-stock and high profitability.

Figure 56 and Figure 57 show the changes of land-use configuration in Tanjabar in terms of carbon stock and economic profitability. Both on mineral and peat, a sharp decline of land-use systems with high carbon-stock and low profitability was obvious. On mineral soil, low carbon-stock and high profitability (mostly oil palm) has increased rapidly, especially in the period 2000–2009. It has become the dominant land-use system. The low-to-medium carbon stock and medium profitability land-use category increased from 1990 to 2005 but declined from 2005 to 2009. The low carbon-stock, low profitability category was constant and the proportion of the area was below 15%.

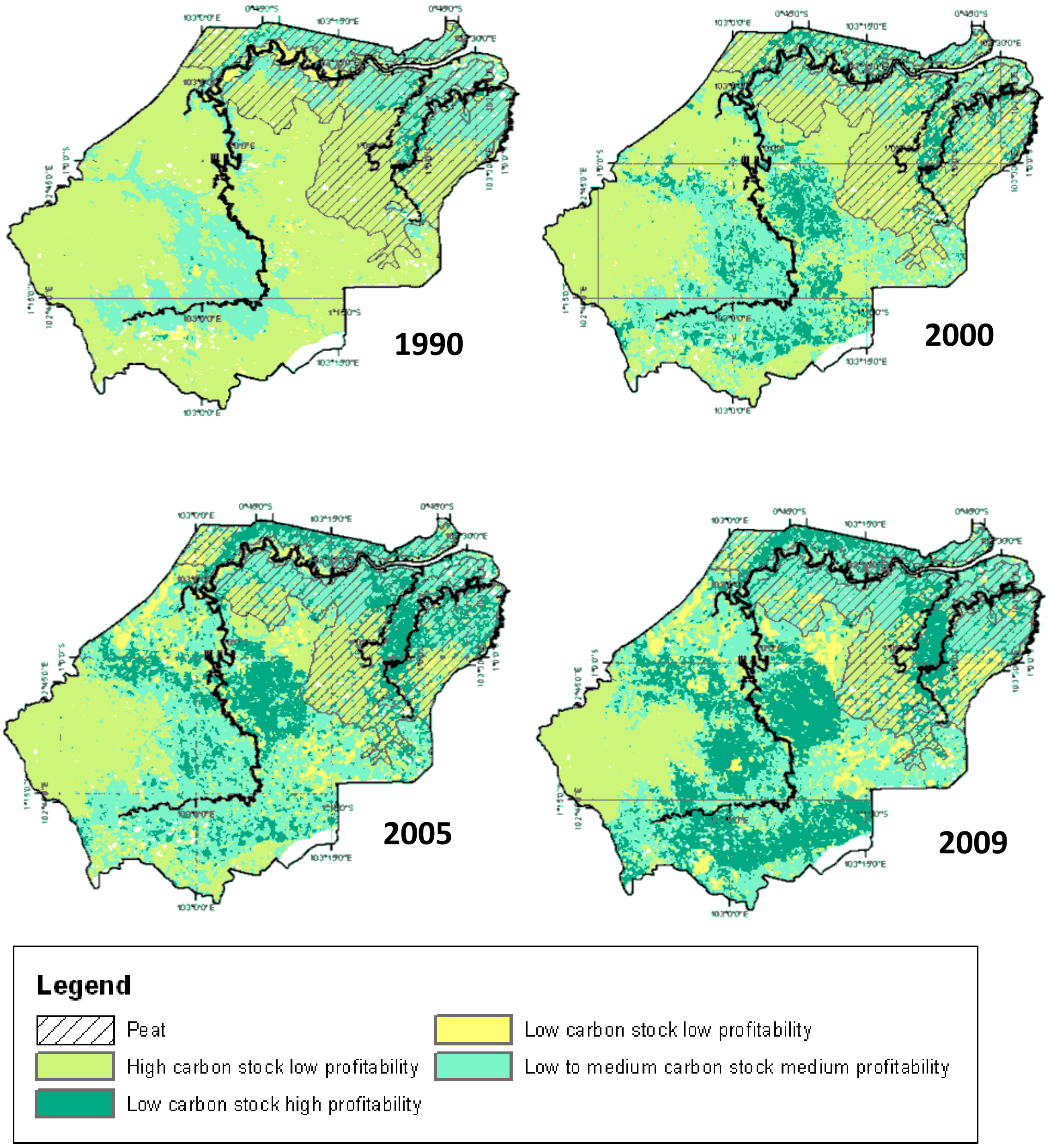


Figure 56. Changes of land-use configuration in Tanjabar in terms of carbon stock and economic profitability

On peat, low-to-medium carbon stock and medium profitability land use increased sharply in the period 2000–2009. This category was mostly agroforests and was the dominant land use on peat soil. The low carbon-stock, high profitability category also increased but the proportion of the area was still lower than the low-to-medium carbon stock, medium profitability category.

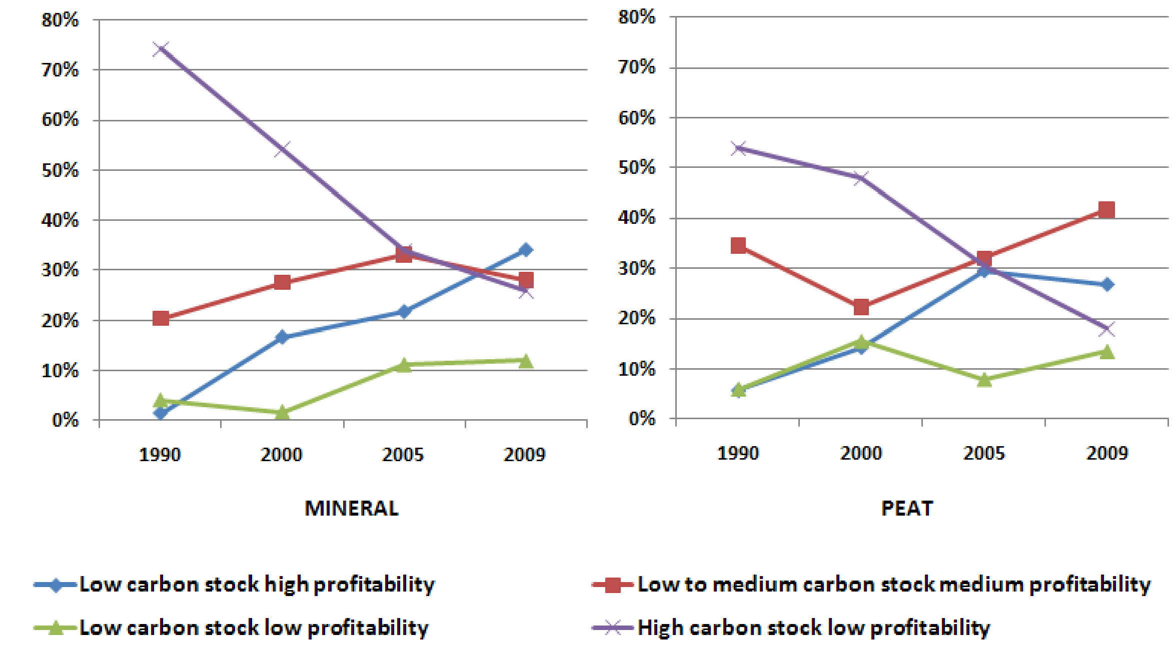


Figure 57. Land-use system changes in Tanjabar

2.9.3 Retrospective analysis of opportunity costs for emission reduction

Opportunity cost curves for Tanjabar in the periods 1990–2000–2005–2009 are shown in Figures 58, 59 and 60. The dynamics of emission and sequestration have been discussed in Section 2.7.2, which can be observed visually in Figure 51.

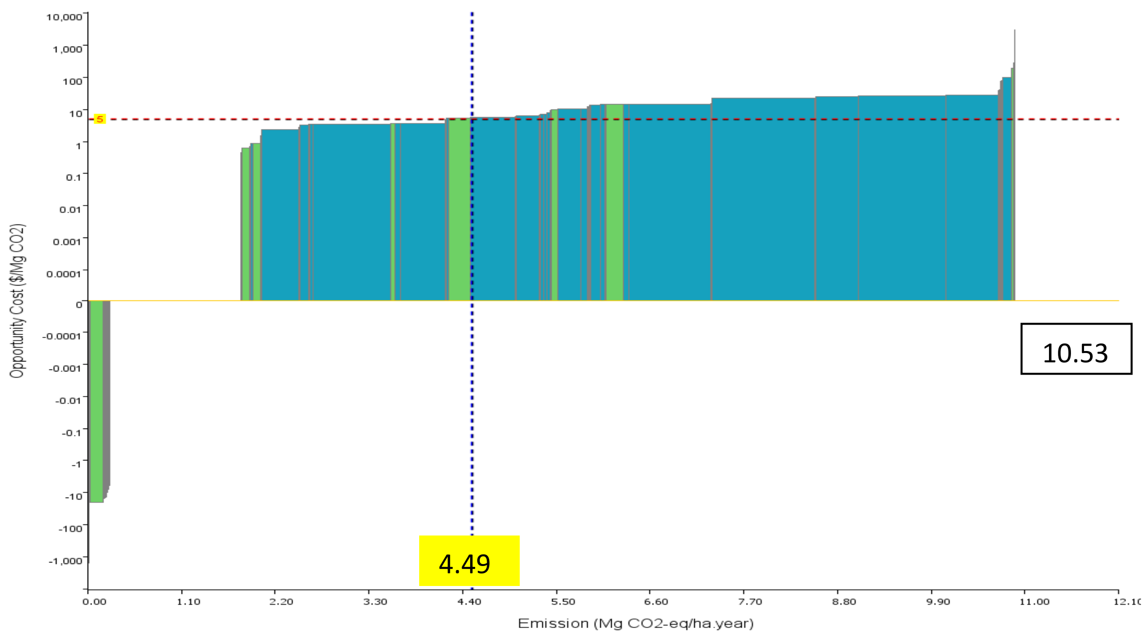


Figure 58. Opportunity cost curve for Tanjabar, 1990–2000

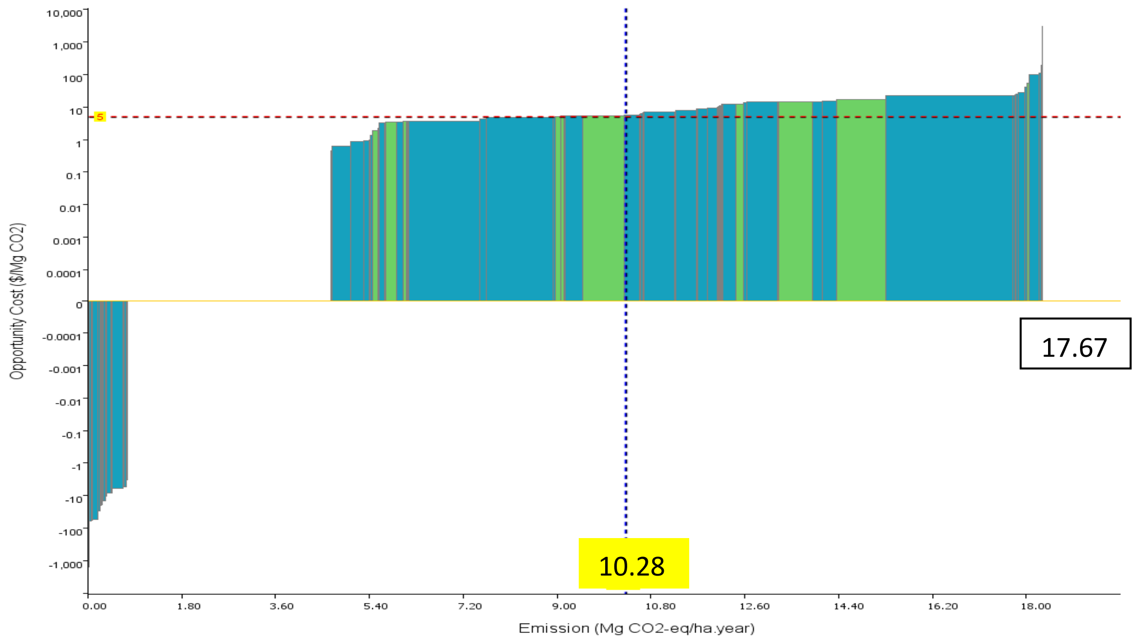


Figure 59. Opportunity cost curve for Tanjabar, 2000–2005

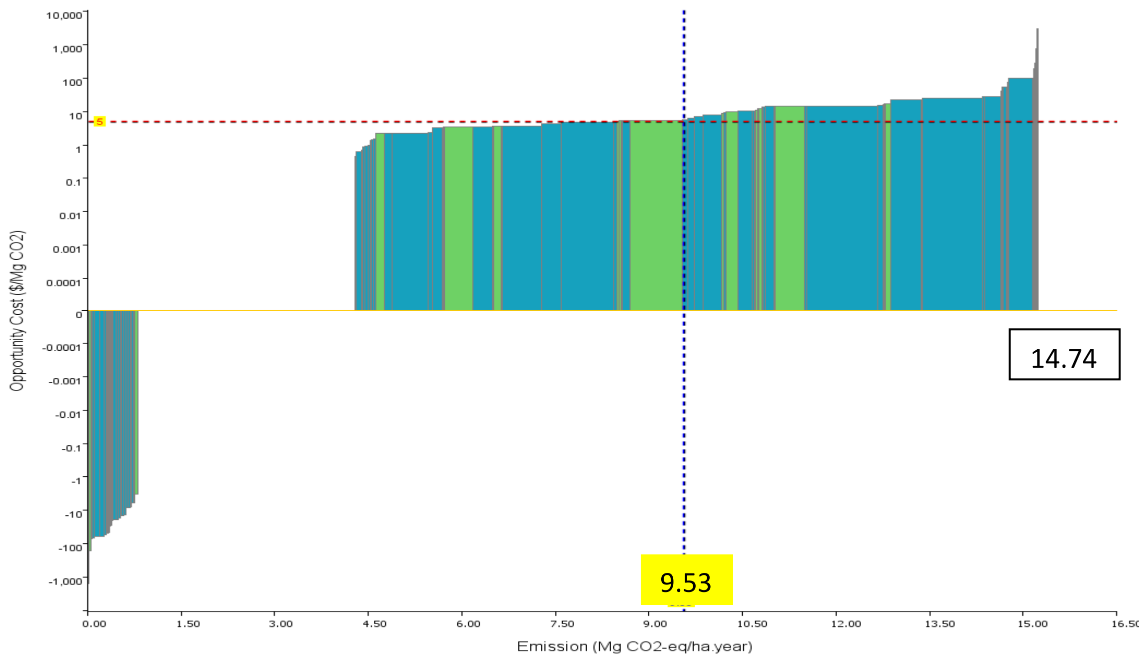


Figure 60. Opportunity cost curve for Tanjabar, 2005–2009

By examining the threshold of US dollars as the potential price of 1 ton CO_2 we can see how much emissions could have been compensated or abated.

During 1990–2000, emissions below the threshold of USD 5 were 4.49 ton CO_2e/ha/year and increased to 10.28 ton CO_2e/ha/year for 2000–2005 (Figures 59 and 60). The increase of eligible emissions demonstrates the higher emissions from conversion to lower NPV land uses. During 2005–2009, the amount of emissions below the USD 5 threshold decreased slightly to 9.53 ton CO_2e/ha/year (Figure 61).

From the total annual emissions, the proportion of emissions that could have been avoided in Tanjabar increased over the period of analysis. For 1990–2000, the proportion was 42%, for 2000–2005 it was 58% and for 2005–2009 the proportion was 64%. These increasing figures demonstrate that emissions reduction efforts could have been successful. A higher proportion of emissions could have been avoided with a similar price of carbon. This also shows potential for future emissions reduction in Tanjabar through REDD+/REALU approaches.

2.10 Projected land-use changes based on historical trends

Based on the discussions in Section 2.3.2, and considering the persistent changes and/or rates of change for the 'business as usual' trend, land-use and land-cover development for the next 5–10 years can be projected linearly or geometrically following the patterns of the past decade.

By taking the persistent figures that appear both in the decade (2000–2009) and the most recent period of observation (2005–2009), we can project the types of changes that are likely to take place in the following years. Some land-use types will likely decrease while some others will increase. Observing the dominant trajectories of changes and the magnitudes (see Tables 6 and 7, in Section 2.3.2), the two types of changes are briefly discussed below.

Reduced areas

Some land-use types in the district are likely to keep decreasing as a result of the development of some other land uses. Disturbed forest will keep decreasing in the following years through conversion to other uses, mainly oil palm, acacia plantations and, to a lesser extent, rubber plantations. Considering the annual change areas for all the different land uses (Tables 6 and 7, Section 2.3.2) and assuming the magnitude will persist and there are no measures to stop the conversions, the 68 000 ha disturbed forest in 2009 may vanish in approximately seven years. Changes to oil palm have been observed from rubber agroforest, too. Taking the annual change areas from rubber agroforest to oil palm, rubber agroforest gardens (17 000 ha in 2009) will likely vanish in six years. Although very small, degradation of undisturbed forest will likely persist in the form of timber extraction. For the area of undisturbed forest under production forest status (28 000 ha), the current annual degradation rate will cause the loss of good quality forest in approximately 21 years.

Increasing area

Land-use development is predominantly towards monoculture of oil palm and industrial plantations of acacia, hence increasing areas of those two systems. By simply taking the average growth rates of oil palm and acacia plantations in the last decade (2000–2009), Table 23 below shows the predicted areas of those two land uses in 2015 and 2020.

Table 23. Projected areas of major land uses

	Rate of growth (%/year)	Area in 2009 (ha)	Predicted area in 2015 (ha)	Projected area in 2020 (ha)
Oil palm	10%	103 852	174 170	267 982
Acacia	20%	46 000	137 355	341 783

This rough projection shows that by 2015, 311 000 ha (60%) of the district may be covered by oil palm and acacia plantations. Linear prediction for 2020 is impossible since the figures exceed the district size of 500 000 ha. It is important to note also that a number of constraining factors might hinder the linearity of the prediction, for example, land status/designated forest zone and land suitability (for example, elevation and slope).

3. Options for REALU through low emission growth strategies

3.1 Simulation of land-use dynamics with FALLOW[9]

Rachmat Muli, Atiek Widayati and Suyanto

3.1.1 Introduction

The landscape mosaic in Tanjabar is complex, decorated with peat and non-peatlands, and threats to the viability of forest and high-biomass land uses owing to conversion into plantations or agricultural crops by both smallholders and large concession holders. Different types of tree-based systems, either monoculture or mixed, exist and, besides rubber, other systems usually involve coconut, betel nut or coffee as the predominant or secondary product (see Section 2.4 in this document). Oil palm is relatively new to the local people but quickly draws attention because of its high commercial value. Large-scale oil palm plantations also provide local people with off-farm jobs as labourers.

Conservation programs to protect forest or high-density land cover, on one hand, and the need to make profits to sustain life and expand business, on the other, produce trade-offs between economic and ecological values, with (so far) little opportunity for win-win solutions. Converting natural forest or high-biomass land uses such as agroforests into monoculture plantations or coal mining offers higher economic return but also reduces environmental integrity, while conserving existing forests as such reduces income opportunities.

Managing trade-offs thus involves a review of the overall development strategy, as land, labour, capital, knowledge and markets interact in creating economic opportunities, while the fractions of land and their spatial configuration determine the ecological outcomes. A dynamic land-use model that integrates components of a rural landscape and their interactions can be used to measure the impact of land-use strategies on the economic and ecological prosperity of local people living in that landscape.

Among various models of landscape dynamic available (for example, as reviewed by Lee et al, 2003, Messina and Walsh 2001, Soares Filho et al, 2008) we consider the 'Forest, Agroforest, Low-value Lands Or Waste?)' (FALLOW) model (van Noordwijk 2002, Suyamto et al, 2009) as more complete because it explicitly considers not only biophysical and socio-economic aspects, but also the 'knowledge' of agents as a constraint and as a dynamic property in learning landscapes. It may be most suited for exploration of land-use change in complex landscape mosaics without requiring a huge investment in prior data collection and parameterisation. As with all other models, however, the model outcomes are sensitive to parameter values and assumptions (van Noordwijk 2002). Therefore, they should not be used for prediction as such but instead to help design strategies that are more feasible for implementation. This section aims to describe several related matters.

- Land-use scenarios including 'business as usual' that reflect current trends, views and planning of different stakeholders in Tanjabar

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[9] Based on Mulia, R., Widayati, A., Suyanto, Agung, P. and Zulkarnain, M.T. *Landuse scenarios that reduce emission across all land use in a peatland district in Sumatra: case study of Tanjung Jabung Barat with the FALLOW model,* in preparation

- Economic and ecological impacts owing to scenario implementation and trade-off analysis, and income deficit relative to reference income
- Possible carbon reward as compensation for the loss of income owing to conservation programs

3.1.2 FALLOW model

The FALLOW model was designed to simulate land-cover changes at landscape level that were driven by farmers' decisions on labour and land allocation (van Noordwijk 2002, Suyamto et al, 2009).

The model considers various external drivers that can influence farmers to make decisions related to their current and future livelihoods options. These include both biophysical and socio-economic aspects.

1. Market mechanisms and relevant regulations are articulated through, for example, commodity prices, costs and harvesting labour productivities.
2. Development programs are articulated through extension activities, subsidies, infrastructure (settlements, roads, markets, processing factories) and land-use productivities.
3. Conservation program are articulated through forest reserves as prohibited zones for local agricultural activities.

Smallholder farmers consider all these factors when making decisions on labour and land allocation. Their decisions are influenced by their experience of past and current year profits, their profit-oriented inclination, suggestions from others and cultural/traditional values. The impact of a land-use strategy on economics and ecology are usually represented by income per capita and standing carbon stock, respectively. Figure 61 shows the four core modules of the model and their primary interactions that describe the relations between farmers' decision-making and a spatial pattern of land-use change with consequences for productivity and households. Detailed description of the model is given by van Noordwijk (2001, 2002) and Suyamto et al (2009).

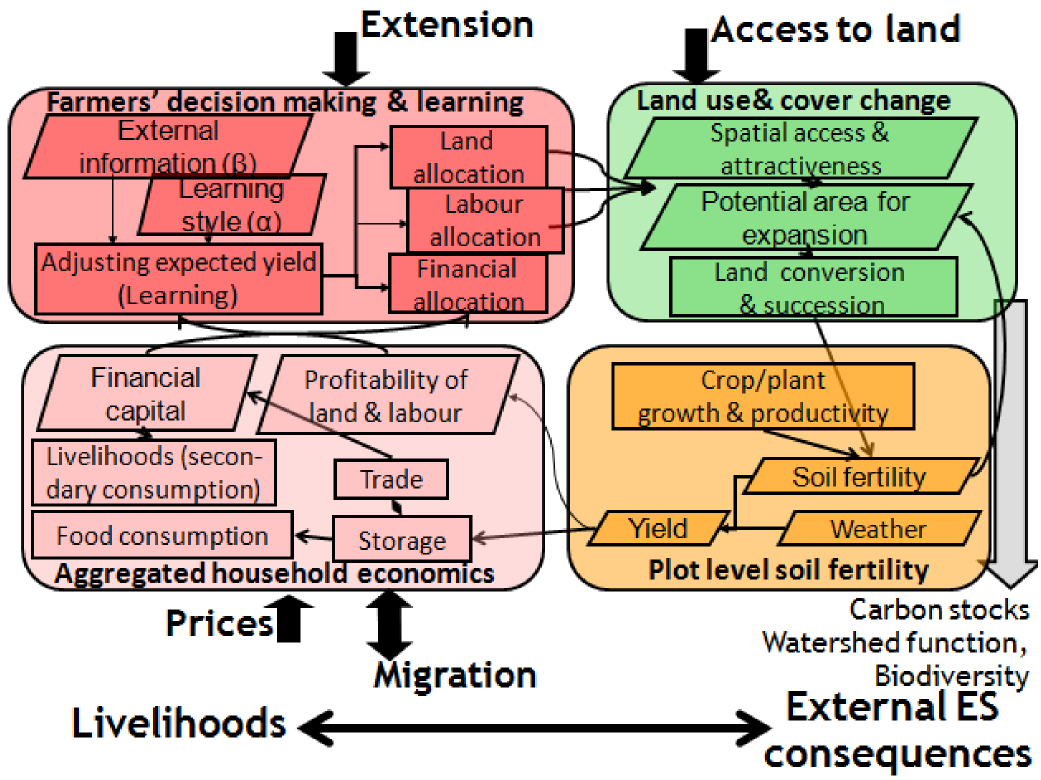


Figure 61. The four core modules of the FALLOW model that relate farmers' decision-making to a spatial pattern of land-use change with consequences for productivity and households

3.1.3 Initial parameters

For the simulation conducted in FALLOW, land-cover classes of Tanjabar as presented in Section 2.3.2 were adjusted to the model requirements. Table 24 shows the configured land-cover classes.

Table 24. Land-cover classifications in the FALLOW model for Tanjabar

Class	Land cover	Remarks
1	Settlement	
2	Forest	Non-peat, peat, swamp and mangrove
Agricultural crops		
3	Paddy	Paddy: *sawah ladang, irigasi* and *pasang surut*
4	Crops	Crops: all other crops
Tree-based systems		
5	Rubber	Peat or non-peat, monoculture or agroforest
6	Oil palm peat	Oil palm monoculture on peat
7	Oil palm non-peat	Oil palm monoculture on mineral soil
8	Coffee	Usually mixed with a few betel nut trees
9	Coconut	Coconut agroforest (usually with betel nut) and monoculture, home gardens(which are also usually mixed with betel nut)
10	Acacia	Only in Hutan Tanaman Industri (HTI) area

Figure 62 shows the different boundaries used for the bases of different simulation rules. The boundaries refer to both actual (from existing data) as well as designated based on different sources. In Tanjabar, there is part of KPHP in the middle area which is partly categorised as limited production forest and partly as production forest and is not allocated for HTI or any particular use. This covers approximately 50 000 ha. Comparing the boundary map with the actual land cover map of 2009, it is seen that in reality parts of HTI areas are still covered by other types of vegetation. All simulations run for 30 years to deal with a complete cycle of an oil palm plantation as one of the major simulated land uses in the landscape. The land-cover map of the year 2009 was used as the initial land-cover map. The impact of each scenario is measured in two aspects that serve as well as the basis for trade-off analyses:

1. Income per capita to represent economic level.
2. Standing carbon stock to represent ecologic level.

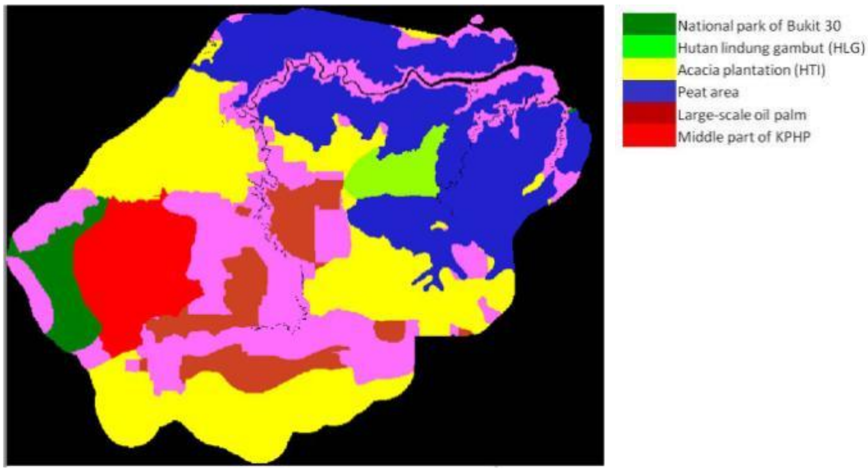


Figure 62. Areas of different boundaries applied in FALLOW simulation

Aboveground biomass in rubber systems is higher compared to those measured in other tree-based systems (Table 25). For acacia plantations, timber harvesting was not simulated because the income from timber selling will not affect income per capita of smallholder communities. Protocol for biomass measurements in Tanjabar both in peat and non-peatlands is presented in Section2.6).

The simulation area for Tanjabar included a 5 km buffer outside the district boundaries to allow for observation of the dynamics in the vicinity of the district (Figure 62), hence the coverage of approximately 660 000 ha.

Table 25. Observed aboveground biomass (AGB) and yield of each land use in Tanjabar**

Landcover type	AGB (ton ha^{-1}) in mature (late) production stage	Yield (ton ha^{-1}) in mature (late) production stage
Settlement	9.2	-
Pioneer forest	36.81	0
Young secondary	208.30	0
Old secondary	352.16	5.1#
Primary	439.18	5.1#
Paddy	2.20	1.3
Crops	21.11	1
Rubber	196.08	0.66
Oil palm peat	147.80	13.51
Oil palm non-peat	153.16	18.87
Coffee	99.54	0.86
Coconut	120.13	1.2
*Jelutung**	27.4	1.35
Acacia	126.65	Not simulated

*** Yield of acacia plantations is not measured because income from selling acacia timber by the concession holder of Hutan Tanaman Industri (HTI) is not included in the calculation of income per capita. #Timber production in HKM (m^3 ha^{-1}) with price IDR 1.5 million/m^{-3} *Based on assumption that growth rate of* Jelutung *diameter is 1.75 cm/year (Bahtini 2009). The values here are for* Jelutung *trees at a density of 121 trees/ha. The biomass is estimated with the equation 0.043*$Dbh^{2.62}$.*

Table 26 shows that oil palm is still of great interest for smallholders in Tanjabar because of its higher economic return, followed by coffee, rubber and coconut. In general, tree-based systems offer higher profit than agricultural crops. For the simulations, we assumed that smallholders would invest more land and labour in livelihoods with higher profit.

Table 26. Economic parameter values for all land-based livelihoods options used in the FALLOW simulations

Land use	**Return to labour (IDR 000/pd)**	**Return to land (IDR 000 000/ha)**	**Price (IDR 000 000/ton)**
Paddy	57.16	3.64	6.0
Crops	62.64	5.36	2.0
Rubber	67.60	15.58	16.0
Oil palm peat	144.55	52.79	1.2
Oil palm non-peat	155.61	68.54	1.4
Coffee	80.17	51.50	16.5
Coconut	75.07	18.02	3.8
Jelutung	148.14	9.77	3.0

3.1.4 Scenarios developed

Table 27 describes four land use scenarios to be simulated with the FALLOW model: 1) 'Bussiness as Usual' (BAU) that reflects the current trend and a possibility that the remaining peat forest (HLG) is opened for conversion into smallholder plots. The only protected forest is the national park of Bukit 30. The rest of mineral forest in the southern part (ex-KPHP) is not legally protected; 2) 'Peat/HLG Protection' that protects the remaining peat forest (HLG) from conversion into other landuse type; 3) 'REALU' reduces emission from all land use by protecting existing forests (HLG, Bukit 30, and also KPHP), rubber and coffee agroforestry system from conversion into another land use type. This is also an effort to support product diversification by maintaining local agroforestry practices but excludes coconut agroforestry due to its lower market price compared to other livelihood options; and 4) 'Green REALU' that is similar to REALU scenario and allows new oil palm plantation in non-productive mineral soils such as grass or shrub lands only.

Table 27 Four landuse scenarios for FALLOW model simulation those possibly describe the future of the rural landscape in Tanjung Jabung Barat, Jambi province.

No	Scenario	Description	Remarks
1	Business as Usual (BAU)	• No protection for trees outside the National park of Bukit 30 for conversion into smallholder plots • Illegal conversion of the remaining HLG into smallholder plots • Six types of tree-based system and 2 types of agricultural crops (Table 1) are simulated as livelihood options for local people	• No new concession for oil, coal, and natural gas exploration is assumed for 30-year simulation • No change in road and settlement distribution and market price is assumed during 30-year simulation
2	HLG Protection	• Protection of the remaining HLG • No protection for trees outside the legally protected forests (HLG and National Park of Bukit 30) for conversion into smallholder plots	Other conditions are the same as BAU
3	REALU	• Protection of rubber and coffee systems: no conversion is allowed into another livelihood option. Post production rubber and coffee systems are rejuvenated • Protection for trees inside legally protected forests (HLG and national park of Bukit 30) and in the area of ex KPHP	• Other conditions are the same as BAU
4	Green REALU	Similar to REALU scenario PLUS: • New oil palm plantation is established in non-productive mineral soils (i.e. shrub or grass lands in mineral soils) only • Post production rubber systems are not rejuvenated to naturally transform into secondary forest	• Oil palm is introduced in shrub or grass lands to increase profitability and C stock in the lands • Other conditions are the same as BAU

3.1.5 Results of simulation

3.1.5.1 Land-cover output maps

In the year 2009, the peat areas in the upper part of the landscape were dominated by coffee and coconut agroforests (Figure 63A). Forests were still relatively abundant especially in the southern part that includes the area of national park Bukit 30. The number of oil palm plots in the mineral soils was already significant and distributed among young rubber agroforests. The large area of industrial plantation was for the most part not yet converted into acacia plantation. We assume that a thorough conversion takes place in the fifth year of the simulation. The number of paddy and crop agricultural plots was not significant and scattered over the landscape. In the BAU and HLG Protection scenario, most of the coffee and coconut agroforests in the peat areas are replaced by new oil palm plantation (Figure 63B & C). In mineral soils, oil palm competes with rubber system to dominate the landscape. In HLG Protection scenario, forests still exist due to protection of HLG in the upper part and national park in the lower part of the landscape. Difficult topography also constrained forest conversions outside the national park that maintains a relatively significant forest area in the lower part of the landscape. Figure 63B and 63C also show the massive blocks of industrial acacia and big-scale oil palm plantation. The final landuse distribution in the BAU is relatively similar to HLG Protection scenario except in the remaining HLG area where conversion from the unprotected peat forests to smallholder plantation occurred. Preventing conversion of coffee and rubber system to another landuse type produces significant area of the two systems in the landscape (Figure 63D & E). Coffee agroforests were maintained and developed in peat areas and rubber agroforests in the mineral soils. In the green REALU scenario, areas of oil palm are not significant because only few shrub or grass lands in the landscape were available (Figure 63 E). Consequently, coffee agroforests well developed in peat areas and rubber agroforests in the mineral soils.

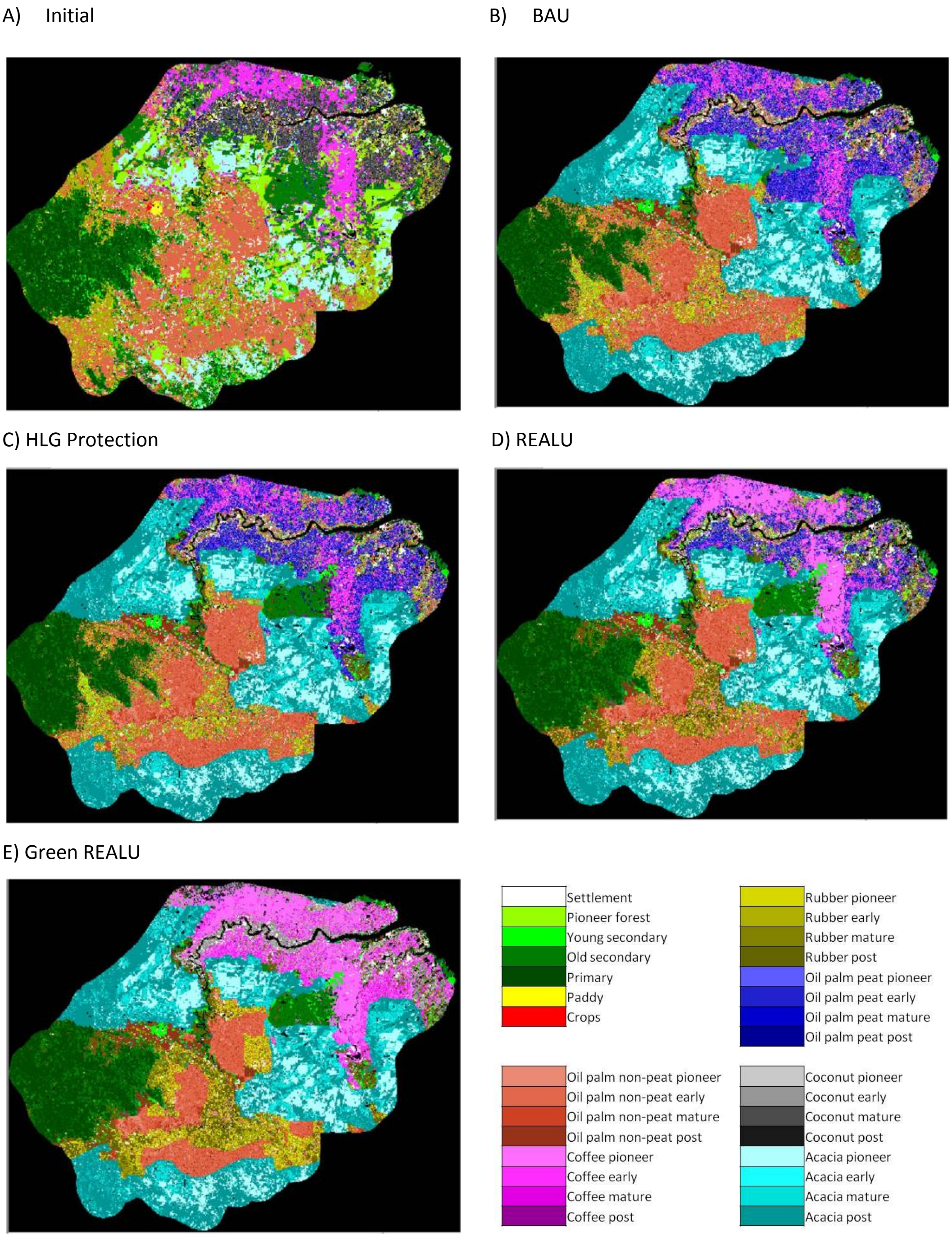


Figure 63 Landcover map of the year 2009 (initial) according to the FALLOW model classification and the output maps based on different scenarios at simulation year 30.

3.1.5.2 Tradeoff and compensation

The ecological and economical impact of each scenario implementation is measured relative to the BAU (Figure 64). All scenarios result in a lower income percapita compared to BAU. In another hand, higher C stocks are obtained mainly through conserving larger forest areas (i.e. the remaining HLG, area of Bukit 30 and ex-KPHP as its buffer zone). In the Green REALU, protection of old rubber systems from rejuvenation contributes to increasing C stocks.

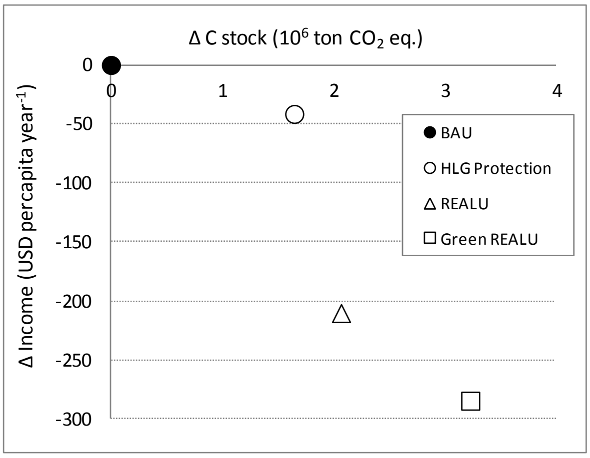


Figure 64 Impact of each scenario application relative to BAU scenario. Ecological impact is represented by standing C stock in the landscape (10^6 ton CO_2 eq.) and economic impact by income (USD percapita) measured as average over 30 year simulation.

From the economical aspect, however, there is a clear trend of income reduction from HLG Protection into Green REALU scenario. The decrease is well correlated with the percentage of oil palm area in the landscape (Table 28), indicating that income from oil palm plantations largely affects the income at the district level. In the other hands, the correlation is negative with the areas of agroforestry plots. Table 29 shows potential income loss as an impact of preserving forests and agroforestry plots in the landscape. Higher tradeoff value is obtained when protecting existing rubber and agroforestry systems as well as restricting the new oil palm plantation in areas other than unproductive mineral soils. This is because there is a great potential income loss due to preventing the conversion of agroforestry systems into oil palm as the most profitable landuse, and in the same time the C stock in agroforestry system is not higher than in oil palm plantation except when comparing with the old rubber system. The higher C stock in REALU and Green REALU compared to HLG Protection scenario is mainly because of the larger forest areas conserved and not rejuvenating old rubber plantations.

Table 28 Area of each type of tree-based system in the landscape of Tanjung Jabung Barat. Initial was measured in the year 2009, and for other scenarios the values represent average over 30 simulation period with the FALLOW model.

	Total area in the landscape (%)				
Tree-based system	Initial	BAU	HLG Protection	REALU	Green REALU
Rubber	10.86	6.11	6.01	8.77	10.37
Coffee	7.55	6.80	6.46	9.89	14.02
Coconut	11.12	4.56	4.78	4.39	0.05
Total agroforestry	29.53	17.47	17.25	23.05	24.44
Oil palm in peat	1.39	8.45	7.32	4.06	0.28
Oil palm in non-peat	19.45	20.06	19.34	16.82	14.42
Total oil palm	20.84	28.51	26.66	20.88	14.7

Table 29 Potential loss in annual income per ton C stock sequestration as an impact of scenario implementations in Tanjabar district calculated by the FALLOW model

No	Intervention	Area (ha)	Δannual population income (10^6 USD)	Δannual C stock in the landscape (10^6 ton)	Tradeoff (USD ton^{-1} CO_2 eq.)
1	Protection of HLG ≈ **REDD+**	15.000	-10.17	1.65	-6.17
2	Protection of rubber and Coffee agroforestry	123.000	-41.35	0.42	-98.32
3	Oil palm restriction	38.000	-18.21	1.16	-15.67
4	Total (1+2+3) ≈ **REALU**	176.000	-69.73	3.23	-21.58

3.1.6 Discussions

3.1.6.1 Cost for forest conservation and product diversification

The REALU first three main pillars (van Noordwijk et al., 2009; Figure 1) are translated in different landuse strategies in the REALU and Green REALU scenario: REDD is by protecting existing forests and high-biomass landuses from logging and/or conversion into smallholder plots or large concession area; RE-Peat through protecting the remnants peat forests (HLG); and RE-Stock by introducing oil palm in non-productive mineral soils. Only REGG is not explicitly simulated. Therefore, the simulated landuse scenarios put a more concern to trees outside forests, agroforestry systems, and/or community-based forest management as they are also important components for C balance in the landscape. Related to agroforestry systems, the concern is also for maintaining biodiversity level and product diversification; not merely from the C aspect.

The implementation of landuse scenarios that give priority to forest conservation or restoration usually produces tradeoff that is negative in income percapita and positive in standing C-stock compared to scenarios without conservation. Protection of buffer area for Lamandau river wildlife reserve and its neighbouring area in Central Kalimantan (Khasanah et al., 2010), protection of remaining forests and restoration of peat forests in Tripa, West Aceh (Mulia et al., 2011), and protection of Batang Toru habitat area (Mulia et al., 2011) are other examples. In the Tanjabar district, the difference in C stock and income percapita between scenarios is mainly determined by how large forest areas are protected and which landuse strategies applied in the peat areas. Different degrees in restricting the establishment of new oil palm plantation and maintaining the local agroforestry practices are the key factor that makes the two REALU scenarios to end in strong negative economic direction compared to the BAU. In the Green REALU, limited availability of non-productive mineral soils such as grass lands that are possible for conversion into new oil palm plantation is far from sufficient to prevent significant loss in income compared to BAU. Opportunity cost for forest conservation and product diversification by maintaining the practice of local agroforestry thus reaches a high negative value in income loss per ton CO_2 eq. sequestration in the two REALU scenarios. The calculation of tradeoff value here, however, does not take into account the prevention of belowground C stock emission that prevails in all scenarios other than BAU. Otherwise, the resulting potential losses in income will be significantly lower than those presented in

Table 29. The calculation also does not translate the environmental services that the forest and high biomass landuses can offer such as more and higher quality soil water availability, prevention from the event or possible destruction from flooding, higher air quality, and higher biodiversity level, into economic values. Related to flooding, the potential loss in infrastructure and human life can also be considerable and should be taken into account for a fair assessment to the benefit of protecting forests and high biomass landuses. The loss in human life due to disaster, in particular, is for surely beyond any economic number. In another side, product diversification by maintaining native agricultural practices can also ensure the viability of smallholder income in case oil palm market is one day slackening. The current great excitement at a global level to establishing new oil palm plantation might in the future produces unbalance supply-demand and gives opportunity for another potential commodity such as rubber or coffee to play important role in the local and global market.

3.1.6.2 Reducing the potential loss in income

There are two possible ways for reducing the potential income loss due to the conservation programs: either getting compensation from external sources or creating a more sustainable way through other sources of income that involves more efforts from the local people in the landscape. The first may relate to the reward due to the C storage achieved and the level of C emission avoided. The high tradeoff values in the two REALU scenarios however may prevent the expectation for obtaining compensation from the C trading mechanism beside the current challenge of the application of C compensation scheme itself such as the still ongoing discussion on the reliable method of C stock measurement, payment mechanism and related institutions, accountability, and the potential donors. There is an issue of valuing biodiversity or available water quality; but this has the same challenge as the application of C trading mechanism. Introducing new technologies in managing agricultural crop lands or new profitable commodities that can get along with the preservation of forest and environment-friendly landuses are examples of the more sustainable ways. The productivity level in the plots of local agricultural crops has been recognized to be generally low and can be enhanced with a better management practice. An intriguing aspect to explore in Tanjabar is the effort to carry back the practice of tapping Jelutung (*Dyera lowrii*) as a traditional practice in the district. This expectedly can be another source of significant income for the local people whilst conserving peat forest to maintain ecological level. The resin can serve as non-timber peat forest product and the wood of old Jelutung trees can be used for different derivative products such as plywood. The local government in the district is currently making an experiment of introducing Jelutung between oil palm trees within plantation in the peat areas. This will later serve as a demo-plot for the local people and the results of the experiment deserve to be waited. Based on a rapid survey conducted in several villages in the district, around 20% of local people seem to be interested to convert their old oil palm plantations into Jelutung plantation (data not published). An intensive extension that re-introduces this potential product for local and international market might enhance the interest.

3.1.6.3 Model scenario and outcomes

From the ecological aspect, the BAU represents a baseline and 'negative' scenario whereas the others represent 'positive' scenarios. The results thus describe a range of possibility that might take place and the related stakeholders in the district might have to face in the future. An appropriate response to the results of scenario analysis, however, is not to wait until one of the cases happens, but instead to use the model outcomes to design a more sensible development strategy for implementation. Moreover, as all other models, the model outcomes cannot be insensitive to parameter values and assumptions. Therefore, the model outcomes should not be used as prediction as such.

The current model version simply considers standing C stock as a representation of ecological level and income percapita as economic level. The next version might have to take into account e.g. biodiversity level as one of key factor that also determines ecology level, and if possible translating the biodiversity into economic value. This might result in a lesser discrepancy in economic level between conservation scenarios and those are purely profit-oriented scenarios.

3.1.6.4 Conclusion

Cost for maintaining biodiversity level and product diversification through ensuring the viability of forest and local agroforestry systems in the Tanjabar district is high indicated by the great potential loss in income due to the implementations of conservation programs. This is because the landscape will otherwise be dominated by oil palm monoculture plantation either in smaller or bigger scale that offers higher profit returns. A possible compensation for the economic loss might come from C rewards due to C storage achieved and C emission avoided; and/or creating a more sustainable way e.g. through improving the skill of local smallholder in plot management practice. A reward due to maintaining biodiversity level and better environmental services that the forest and agroforestry system can carry forward, currently only gets a little concern; and it should be developed for a fair assessment of the impact of 'green' scenario implementation. The model gives a range of possible outcomes that might represent the future landscape in the district. These should be used as a basis for designing a more sensible strategy for implementation.

3.2 Emission reduction under REALU

Andree Ekadinata, Atiek Widayati and Muhammad Thoha Zulkarnain

3.2.1 Nested baseline for emission reduction in Tanjabar

The magnitude of mitigation levels for the various parts of the country from the AFOLU sectors should be developed through a nested approach of emissions calculated at different subnational administration levels, that is, provincial and district (*kabupaten*). Upon the identified level of emissions and the comparative magnitude with provincial and national emission levels, attempts towards emission targets and the relationship with nationally committed emission reduction strategies can be carefully set up.

By observing the national data set from 1990–2005 (Ekadinata et al, 2011, Ekadinata and Dewi 2011), Tanjabar can be categorised as a district with a high emission rate. By adjusting the data set from Ekadinata and Dewi (2011) by only taking into account the aboveground emissions, the annual average emission rate of Tanjabar is higher compared to those of other provinces, including Jambi (Figure 65).

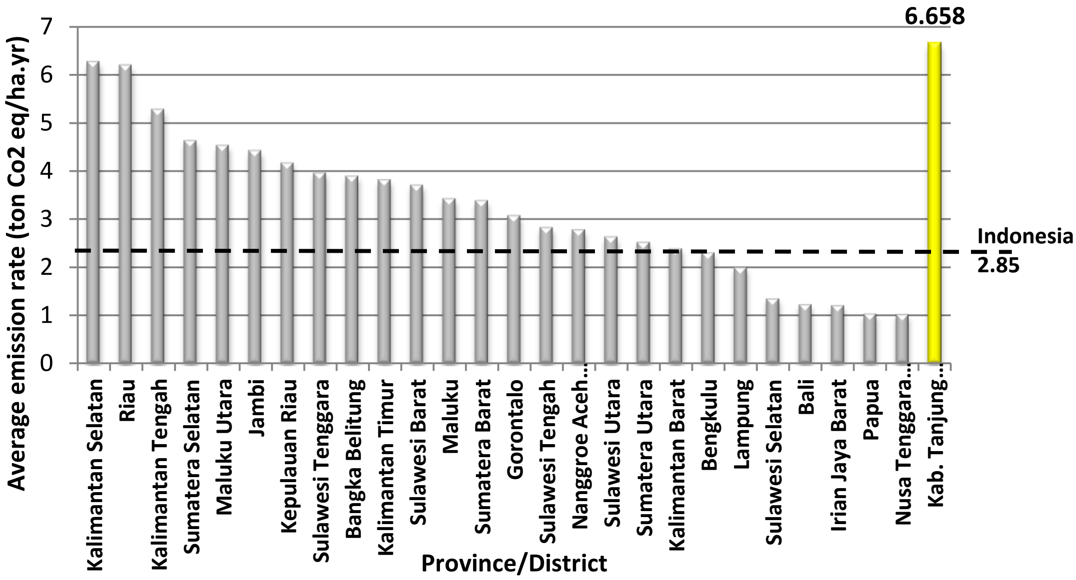


Figure 65. Comparison of average net emissions rate in Tanjabar and provincial emissions rates in Indonesia

Observing the share of emissions for Jambi province for the period 1990–2005, Tanjabar contributes as the second highest emitter (Figure 66). As a result, by 2005 the total amount of remaining carbon stock in Tanjabar was considerably lower (9%) compared to other districts in Jambi. As previously discussed (Section 2.7.2), the remaining carbon stock in Tanjabar was approximately 40 M ton in 2005 and 35 M ton in 2009.

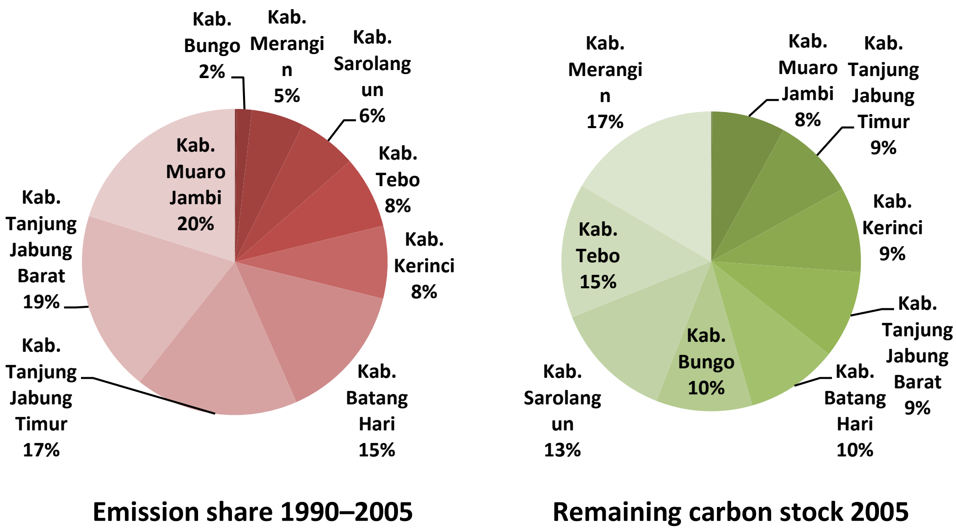


Figure 66. Comparison of average net emissions rate in Tanjabar and provincial emission rates in Indonesia

Owing to the high magnitude of emissions in the past, the potential contribution to Jambi's locally appropriate adaptation and mitigation actions (LAAMA) from Tanjabar will come from other relative emissions reduction efforts and not from actual emissions reduction. Contribution to relative emissions reduction efforts may come from two sources.

1. Carbon enhancement in different areas through replanting and restoration efforts.
2. Maintainance of the remaining high carbon stock areas through improved forest governance and forest management, that is, establishment of KPHL and strengthening protection in conservation area.

3.2.2 Reference emissions level and emissions reduction strategy

Negotiating the appropriate baseline or reference emissions level (REL) is one of the first steps in developing LAAMA. REL is the amount of estimated emissions in the future if there are no interventions to reduce the amount of emissions. REL can be estimated through three approaches:

1. historical trend;
2. adjusted historical trend; and
3. forward looking trend.

Once REL is negotiated and determined, an emissions reduction strategy can be formulated. The emissions reduction strategy will estimate the amount and types of reduction activities that need to be undertaken.

For Tanjabar, approaches towards setting up REL took into account two approaches:

1. historical trend; and
2. forward looking trend.

The first approach used the emission rate for 2005–2009, while the latter approach was implemented through land-use dynamics simulation using the FALLOW model (see Section 3.1). Upon determining the REL, three emission reduction strategies were considered for Tanjabar, based on three scenarios in FALLOW: HLG protection, REALU and Green REALU.

REL curves for each possible baseline and emission reduction strategy is shown in Figure 67.

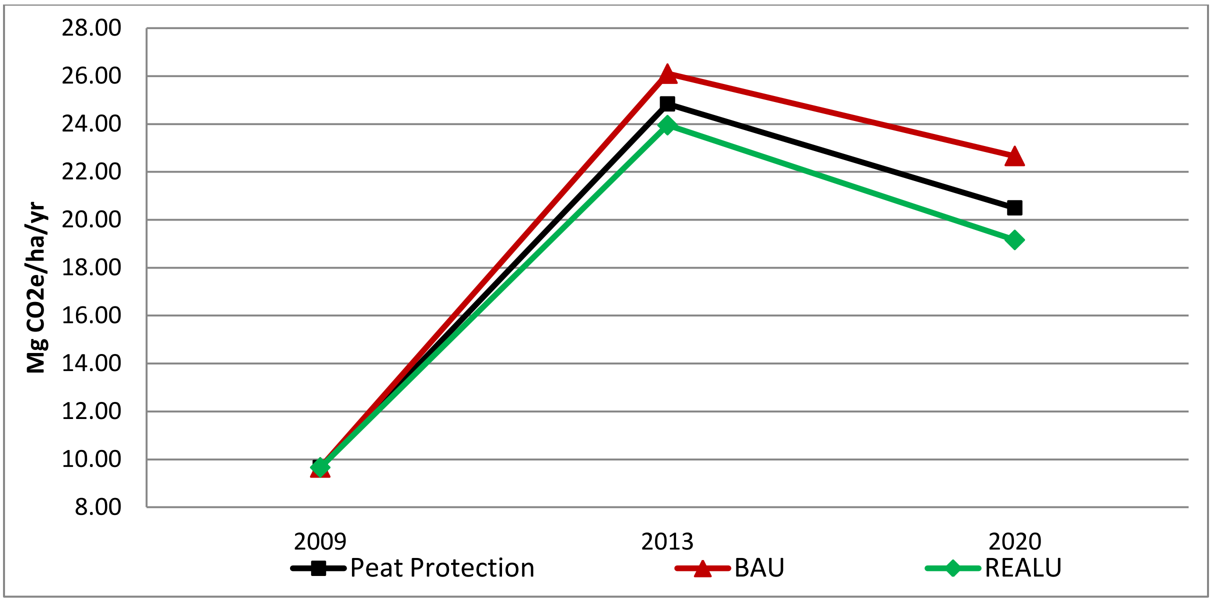


Figure 67. Estimated cumulative emissions in 2020 under various scenarios of reference emissions level and emissions reduction strategies

3.2.3 Emissions reduction strategy

Choosing the appropriate REL for a certain area, in this case an administrative area, requires negotiation with different stakeholders since it implies strong commitment to reduction efforts.

However, in this project we used the following two parameters as an exercise to determine an appropriate REL and emission reduction strategy:

1. The amount of emissions reduced; and
2. The amount of forgone opportunity or forgone land-use profitability caused by emission reductions.

Forgone opportunity is defined as the total reduction of profitability of all land uses in the area owing to a certain emissions reduction strategy, while profitability of land use is calculated from the NPV of the land uses (see Section 2.8).

Table 28 summarises the amount of emissions reduction percentage based on different pairs of REL and emission reduction options.

Table 30. Emission reduction based on various RELs and strategies

Reference emission level	Emission reduction strategy	
	REALU	**Green REALU**
BAU-historical	-15.4%	-20.7%
BAU-forward looking	15.5%	11.6%

For Tanjabar, the appropriate REL is 'BAU-forward looking', taken from the BAU scenario of the FALLOW model (Table 30). As a comparison, the other REL from BAU-historical is also presented. In the FALLOW simulation, emissions reduction strategies based on the REALU scenario is considered locally appropriate for Tanjabar and is therefore recommended. Based on this combination, an emissions reduction strategy for Tanjabar should be able to reduce emissions by 15.5% from the determined REL.

The REALU emissions strategy shows the 'risk' of the forgone opportunity as much as 9.3 % lower compared to the total profitability under the agreed REL (BAU-forward looking) (Table 31). As a comparison with the other REL and strategy, this figure is relatively low and hence supports the emissions strategies of REALU in Tanjabar.

Table 31. Forgone opportunity on various RELs and emissions reduction strategies

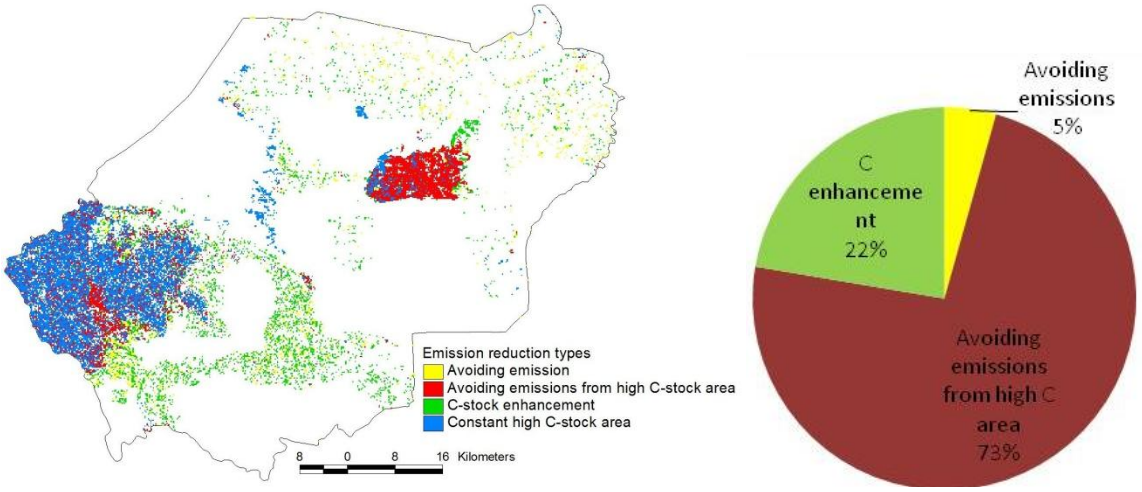
Reference emission level	Emissions reduction strategy	
	REALU	**Green REALU**
BAU-historical	-32.7%	-25.5%
BAU-forward looking	9.3%	14.2%

3.2.4 Emission reduction activity

Emission reduction strategies are realised into activities on the ground. For Tanjabar the land-use activities result in three types of REALU relevant conditions (see Figure 68).

1. Avoiding emissions: this shows areas where emissions can be avoided in 2020 through the implementation of REALU as compared to BAU.
2. Avoiding emissions in high carbon stock areas: refers to similar activity as above but this will take place in forested lands where carbon stock is high.
3. Enhancement of carbon stock: this refers to areas where sequestration takes place under REALU by 2020 as compared to the absence of it in BAU

In addition, maintained high carbon-stock areas are also identified which refers to forest areas which are maintained whether or not the implementation of emission reduction activities will take place.



Figur 68. Areas of emissions reduction activities (left) and contribution of reduced emissions for each activity relative to BAU (right)

Based on the findings of the FALLOW simulation for 2020, the implementation of REALU scenario brings about emission reduction that take place in approximately 9 % of the district area (see Figure 68 (left)). It can be seen that 'avoiding emissions from high carbon stock area' covers the largest area (4 %) and is located in the vicinity of HLG, and a small area of west forest area. Constant high carbon stock areas occupy 8 % of district area, which mostly covers the remaining forest cover around Bukit Tiga Puluh National Park. The remaining reductions of 'avoided emissions' and 'enhanced carbon stock' cover 3 % and 4 % of the district area, respectively, and they cover spotty areas in the various complex and monoculture tree-based crop areas. Maintenance of carbon stock in the forest may actually include carbon enhancement, although, unfortunately, the amount cannot be captured in an accounting assessment using stock difference methods such as in this study.

With regards to the emissions reduced in 2020 relative to BAU, 73 % comes from avoided emissions in high carbon stock areas. Despite the relatively small area in comparison to those of other emission reduction activities, this activity proves to contribute large amount of reduction. This clearly points out to the importance of high carbon stock land cover type, which contributes to the efficiency of emission reduction activity. Carbon stock enhancement contributes 22 % in the emission reduction activities, while emissions avoided from the other areas contribute only 5 % (see Figure 68 (right)). Rough estimate of the reduced CO_2 emissions under the REALU scenario as relative to BAU may reach roughly 3.3 M ton CO_2e or about 38 % reduction relative to BAU.

3.3 Institutional settings for REALU: current status

Putra Agung, Gamma Galudra and Suyanto

3.3.1 Introduction

Although the word 'institutions' is well known, its definition is often problematic, as it can be defined in different ways. Policies and institutions are at times difficult to separate, just like two sides of a coin. A good policy without good institutional bases in place will not result in a smooth development process. Peter (2000) explains there are four main approaches to define institutions, namely: (1) normative institutionalism; (2) rational institutionalism; (3) historical institutionalism; and (4) empirical institutionalism.

In the review of an institutional setting for a REALU implementation plan in Tanjabar, the rational institutionalism approach was used. In the rational approach, the institutional set up and the establishment of incentives for its members and the behavior of the members are determined by the incentives that are available. This approach is used considering that implementation of REALU relies heavily on existing policies, not only at national and subnational level, but also in the existing 'rules of the game' within communities.

3.3.2 Institutional setting at the national level

Indonesia is among the few countries that have made quick progress in responding to the need for policies for REDD and climate-change mitigation efforts. Throughout the past few years, a number of national policies have been issued by several government bodies. In line with that, many national forestry and environmental acts have been proclaimed in order to be the bases for future REDD+/ REALU implementation. Below are several policies that have been put in place in the past few years.

Minister of Forestry regulation No. P. 68/Menhut-II/2008

This regulation is about organising REDD demonstration activities for reducing carbon emissions from deforestation and forest degradation. It regulates the procedures that must be adhered to when carrying out demonstration activities, prior to full implementation of REDD, scheduled to begin in 2012.

Minister of Forestry regulation No. P.36/Menhut-II/2009

This regulation is pertinent to the procedures to grant licences in commercial utilisation of carbon sequestration and/or storage in production or protection forests. The regulation governs the issuance of business licenses to engage in carbon sequestration or carbon storage activities and also states that acceptable REDD activities in Indonesia therefore include production-related activities such as lengthening the cycle of cutting, environmentally-friendly cutting and protection and security in areas with protection functions.

Within this regulation, the Government, through the Ministry of Forestry, explains the standard project development and marketing of carbon, referring to existing frameworks such as CCB, CarbonFix, Plan Vivo and AFOLU voluntary carbon standards. It also states that licenses for carbon sequestration for commercial utilisation could be issued as both large- and small-scale concession permits. For small-scale forestry concessions, a permit could be given for restoration of an ecosystem (IUPHHK-RE), community plantation forest (IUPHHK-HTR), community forest, social/community forestry, customary forest, village forest and forest management unit (KPH).

National strategy of REDD+

In response to Indonesia's commitment to reduce emissions by up to 26% and to increase national economic growth by 7%, a National Strategy of REDD+ was developed under the coordination of the National Planning Agency (BAPPENAS) and the President`s Development Supervision Unit (UKP4) , facilitated by the UNREDD program. A first draft was published in September 2010. The Strategy contains identification of the drivers of deforestation and a formulation of strategies to eliminate causes of deforestation and forest degradation. This strategy was developed to achieve further impacts rather than consider emissions reduction as a single goal. It also considers efforts such as increasing forest carbon stocks, maintaining biodiversity and payments for ecosystem services, and also how to increase national economic growth.

Presidential instruction No. 10/2011

As part of the Indonesia–Norway Letter of Agreement, the Government of Indonesia brought into force a two-year moratorium on the granting of new forestry concessions, which applies to primary forest and peatland. This regulation can have a powerful impact on areas like Tanjabar since 40% of the total area is covered by peatland both in state and non-state forest areas.

3.3.3 Institutional setting at the subnational level

3.3.3.1 Forest Management Units

The national government launched the Kesatuan Pengelolaan Hutan (KPH, Forest Management Units) scheme, which allocates state forest land to a number of management areas in accordance with the basic functions and purposes of the forest. The KPH itself is considered to be the solution to the lack of forest governance in Indonesia. The presence of KPHs is expected to address the fundamental problems in forest management over the years, to conduct forest management at the site level instead of the administrative work that used to be the major role of central government in managing forest.

As mandated in forestry law no. 41/1999, to achieve sustainability of forest management, site-level management should be established in accordance with existing legislation. KPH`s development itself is based on Ministry of Forestry regulation no. P.6/Menhut-II/2009.

In the era of climate-change mitigation, KPH is perceived to be one of the enabling conditions to the success of any emissions reduction efforts such as REDD+. KPH itself is a multi-layer institution operating at national, provincial, and district level. However, tasks and KPH functions lie on its being an independent institution at the subnational level government both provincial and district level.

3.3.3.2 Environmental Strategic Assessment

Kajian Lingkungan Hidup Strategis (KLHS, Environmental Strategic Assessment) is a series of systematic analyses, holistic and participatory to ensure that the principles of sustainable development become a fundamental and are integrated in the development of an area through policies, plans and programs (the definition of KLHS in the draft Environmental Protection and Management Law)

In principle, KLHS actually is a self-assessment method to see whether policies, plans and programs proposed by national and subnational levels of government have considered the principles of sustainable development. KLHS implementation guidelines are set out in Ministry of Environment regulation no. 27/2009.

The Indonesian government nowadays is currently conducting a series of discussions on KLHS by embracing local government through BAPPEDA and the district environmental bureaux (Badan Lingkungan Hidup Daerah, BLHD). This can be an important entry point for enabling an institutional setting for implementation of REALU, especially in the non-state forest area.

Most of the subnational institutional setting for REALU implementation is derivative of national policies, such as KPH and KLHS. In Tanjabar, there are three KPHs being issued by the Ministry of Forestry under decrees no. SK.787/Menhut-II/2009 and SK.77/Menhut-II/2010. One KPH belongs to the provincial government because the area is located in two districts and the other two KPHs cover production forest and protection peat forest in Tanjabar.

The KPH for the protection of peat forest, known as Kesatuan Pengelolaan Hutan Lindung Gambut (KPHLG, Forest Management Unit on Protection Peat Forest), is one of the few model forest management unit in Indonesia. As a model, the establishment of the institution is faster than for non-model KPH. This can be seen from the enactment of KPH institutional arrangements through the district head of Tanjabar under regulation no. 18/2010 that governs institutions and human resources needed within the KPHLG.

Unlike the KPHLG, the other KPH, known as Kesatuan Pengelolaan Hutan Produksi (KPHP), that covers production forest does not yet have any clear direction. For REALU, this leaves an opportunity to engage with local policy makers in establishing a conducive institutional setting. The same can also be applied for implementation at district-level KLHS. KLHS should control district spatial planning, which is still in the process of obtaining legality from the national government.

3.3.4 Institutional setting within communities

Communities have their own ways to manage resources, especially forest and land. Therefore, it is necessary to synchronise the government's plans with the needs of local communities. Communities in Tanjabar are made up of various ethnic groups and have different perceptions and interests in forest, land and other resources. 'Institutional arrangements' within communities can be observed in the types of land tenure recognised by community members and they ways in which they claim a piece of land or forest.

Nevertheless, community institutional arrangements often do not find any place in the Government's management of natural resources, especially management of state forests. This might be due to the Government's distrust of the ability of communities to manage forests sustainably.

This leaves room for REALU to increase the Government's trust because it is crucial for communities to improve their institutional capacity in managing natural resources, especially forest.

4. Feasibility of REALU in Tanjabar

4.1. Towards intervention designs

This section discusses designing REALU in the demonstration landscape. Factors to consider are the major drivers of forest loss and land-use changes, local context and issues and the appropriate emissions reduction strategies.

4.1.1 Major drivers of emissions in Tanjabar

As discussed above, Tanjabar has long been engaged in land-use activities that imply loss of carbon stock and low carbon development (Sections 2.3 and 2.7), leading to being a high CO_2-emitting district (Section 3.2.1). Our preliminary conclusion leads to two types of land-use change drivers.

(1) External drivers at the national policy level triggered changes that were responses to trade demands nationally and globally or to any other development need. Examples of such drivers range from pulp and paper industries and palm oil trade through forestry policy to transmigration, and these strongly impact on the development of large-scale plantations in the district.

(2) Owing to large-scale trends that also provide infrastructure locally, local agents react accordingly by converting their plots—originally traditional agroforestry systems, like rubber—into a more profitable monoculture system such as oil palm. In-migration also takes place, in which migrants are lured by the possibility of engaging in highly profitable farming. As a result, more land is converted to oil palm, both through land trade with locals or earlier migrants and by occupying 'open access' land under state forest land status.

As discussed by van Noordwijk et al (2011a), the land use–driver relationship may fit into different types of feedback loops. Intervention designs to optimise the situation should carefully take into account the relationships (Figure 69). These discussions reflect two relationships in the diagram as indicated by the dashed boxes (1) and (2).

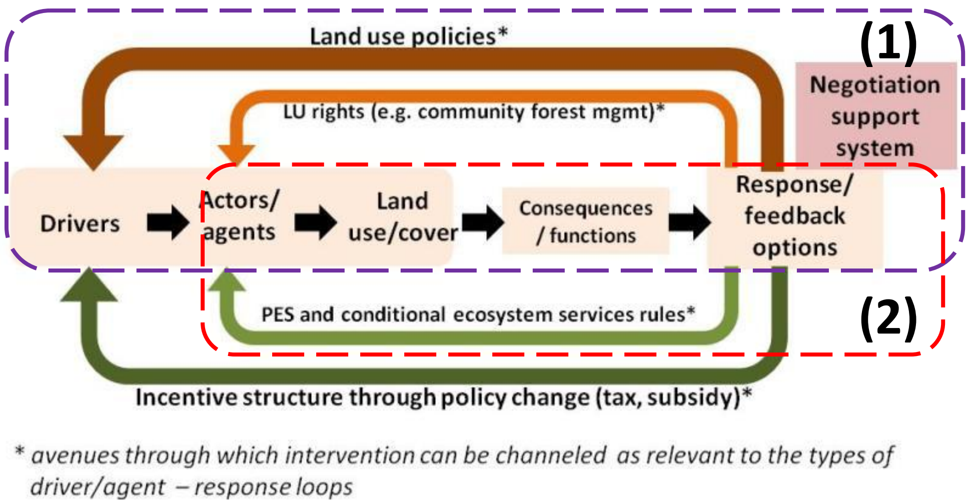


Figure 69. Feedback loops of land-use changes and drivers (based on van Noordwijk et al, 2011a)

4.1.2 Emissions reduction strategies that are locally relevant and appropriate

The land-use dynamics simulation through the FALLOW model was developed to take into account both locally relevant aspirations as well as constraining factors. The first refers to different local stakeholders such as farmers and ongoing programs while the latter considers factors such as large-scale policies and forest conservation efforts (see Section 3.1 for details). The appropriate emissions reduction strategy was determined by following the REALU scenario. Reduced emissions include magnitude and areas (Figure 68). At this point, rough estimates based on the simulation for 2020 have been set as the basis for REALU intervention in the demonstration landscape, although it should be noted that several issues need to be studied further to avoid project implementation that is too simplistic. Considering both, ways forward relevant to the REALU foundation and pillars can already be identified and design of intervention activities can be initiated.

1. For Tanjabar, emissions reduction may fit at least two pillars in REALU architecture: REDD and REStock.
    a. As identified in Section 2.3, the REDD pillar is well reflected in activity that can maintain high carbon stock areas, in this case the forest remnants around the HLG and Bukit Tiga Puluh national park.
    b. The REStock pillar is represented in both forested and non-forested land. In the forest, part of the maintenance of carbon stock is enhancement through rehabilitation and an increase of forest tree carbon in the absence of severe disturbance. Outside the forest area, REStock activity takes place on smallholder farms, through intercropping and agroforestation.
2. Local efforts to restore parts of the forest and enhance carbon stock have been committed through several policies, institutional settings and programs, as discussed in Section 3.3. Nevertheless, as these efforts are still at early stages, areas of improvement need to be identified and addressed, including the crucial area of supporting the livelihoods and rights of local people, especially smallholder farmers.

4.1.3. Potential REALU intervention sites

Two potential project sites are being considered for further REALU interventions, with the following criteria and considerations.

1. The sites represent category (2) of land use–driver relationships (Figure 69).
2. Two pillars of REALU architecture are represented, with the major emphasis on REDD and , to a lesser extent, REStock.
3. The sites represent large emissions reduction by 2020, as simulated by FALLOW, that is, avoided emissions through the maintenance of high carbon-stock areas.
4. Supporting policies, institutions and programs are not equally in place for different areas in Tanjabar. These varied baselines will influence the way the REALU project designs interventions for the two sites.

The two potential sites for REALU interventions in Tanjabar are (Figure 70):

- The first site is that covered by the Forest Management Unit on Protection Peat Forest (Kesatuan Pengelolaan Hutan Lindung Gambut, KPHLG), referred to as 'Site 1' or 'KPHLG'.
- The second site is that covered by the Production Forest Management Unit XVI (Kesatuan Pengelolaan Hutan Produksi, KPHP) , in the western part of the district (Figure 18, Section 2.2.1). The major part of this area is under the KPHP for limited production forest and the smaller part is under the KPHP for production forest. This area is considered as 'open access', where different land-use activities have been taking place and in which land use allocation has not yet been formalised, unlike industrial plantation allocation in the other KPHPs. We will refer to this site as 'Site 2' or 'KPHP-OA' (Open Access).

The following sections describe simulated land uses and emissions in the two potential intervention sites based on REALU emissions reduction strategies.

4.1.3.1 Land-use dynamics in KPHP-OA and KPHLG

Some parts of Site 1 KPHP-OA have been encroached on by rubber and oil palm, as seen in the 2009 land-cover map. The BAU scenario shows the converted areas in the forest are larger in the central part of the forest with plantings of oil palm, rubber and annual crops (box (a) in Figure 70) with slightly larger encroached areas inside the forest. Under Peat Protection scenario, logically, in this area there is only little difference compared to BAU. Under REALU, the forest can be conserved, as demonstrated by the increasing density of undisturbed forest, or the restored forest in this case. The existing rubber and oil palm gardens are not to be rejuvenated, leaving rubber as old gardens/dense agroforest and, in some areas, becoming secondary forest (box (c) in Figure 70).

The situation in KPHLG shows a rather different trend. The BAU scenario results in the complete conversion of the area into oil palm gardens, being the most profitable and favoured cash crop (box (d) in Figure 70). With dominant disturbed forest in this site and the existing reinforcement of KPHLG by the forestry office, the Peat Protection scenario reflects what to expect under such scenario, i.e the maintenance of forest cover and some small areas of oil palm plots (box (d) in Figure 70). The REALU scenario sees a similar condition under Peat Protection scenario, with oil palm plantations being converted into *Jelutung* plantations, following the current forest rehabilitation program (box (f) in Figure 70).

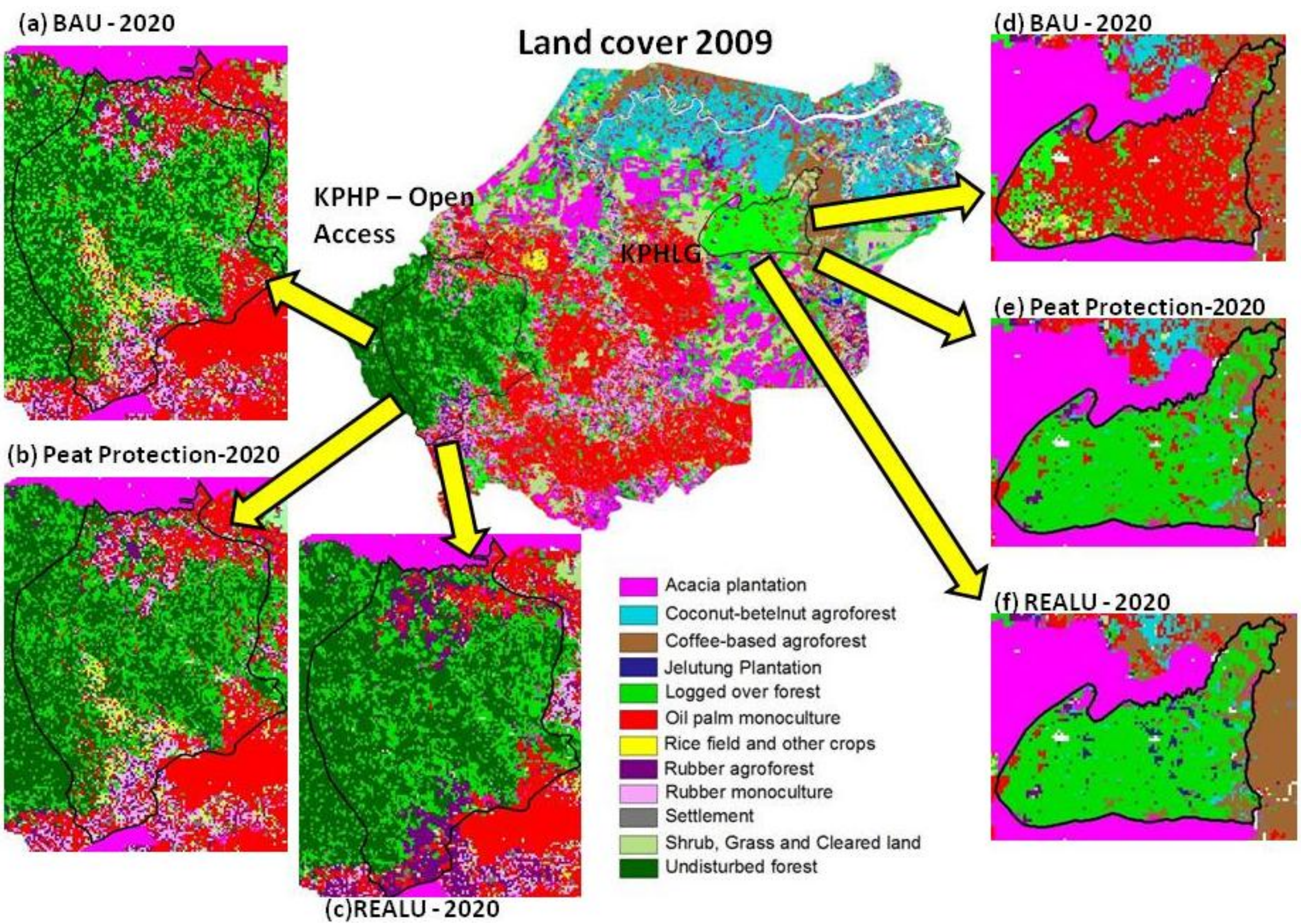


Figure 70. Simulated land uses based on different FALLOW scenarios in the two potential intervention sites at KPHP-OA (a)-(b)-(c) and KPHLG (d)-(e)-(f)

4.1.3.2 Emission trends for KPHP–OA and KPHLG

From the net emission calculation based on simulated land uses for 2013 and 2020, the KPHP-OA (solid lines in Figure 71) BAU (red-solid line) shows an increase for 2009–2013 and a decrease for 2013-2020, but it ends in a similar emissions figure for 2013–2020 compared to Peat Protection scenario (black-solid line). For the REALU scenario (green-solid line) from 2009 to 2020 there is a persistent decrease of emissions, reaching low level of net sequestration in 2013-2020.

For KPHLG, the trend is rather different (dashed lines in Figure 71). BAU (red-dashed line) results in an increase of emissions between 2009-2013 and a decrease for 2013–2020. Peat protection scenario and REALU scenario (green and black dashed line) reflect similar figures of reduced net emissions in 2009-2020 and both reach net sequestration in 2020.

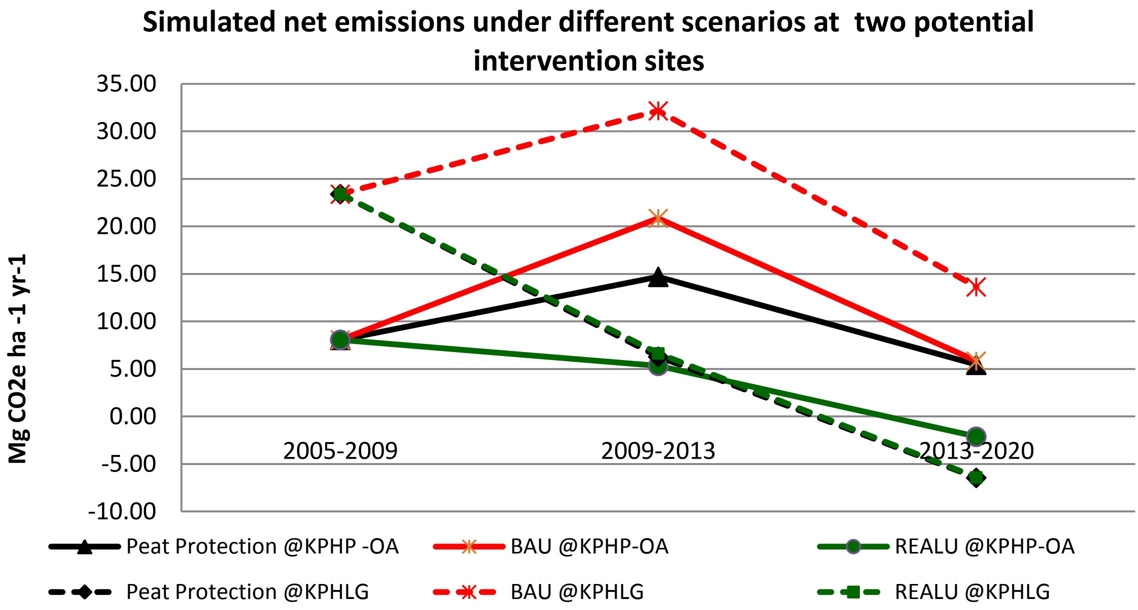


Figure 71. Simulated net emissions at the two potential intervention sites

At KPHLG, the peat protection scenario shows similar trend as that of REALU scenario, as a result of the focused protection efforts for the peat area in the vicinity of KPHLG. The REALU scenario in this area will support emission reduction efforts to maintain carbon stock and enhance it in some parts that have been under cultivation. Under BAU, there is increasing emission until 2013, and it decreases in 2013-2020. The latter can be the result of the limited forest left after 2013, hence little to emit. As compared to BAU, the two scenarios show substantial emission reduction by 2020. Therefore efforts in relation to rehabilitation of peat forest areas are key.

In the KPHP-OA area, there is only little-to-none effect of peat protection scenario to the emissions by 2020. In this area, the 'open access' nature of the area and lack of an institutional baseline lead to continuing encroachment and cultivation. Under the REALU scenario, it is expected that emission can be avoided in high carbon stock parts and carbon can be enhanced in the formerly encroached areas. Efforts should be focused on stopping the encroachments while allowing small-scale forest extraction and finding appropriate forest safeguards and co-management schemes.

4.2 Links and partnerships to support REALU

There are three local institutions that are potential partners in REALU implementation in Tanjabar. As described in the previous chapter, for the next year the REALU project will engage with existing efforts and collaborate with local partners such as KPH, KLHS and the district spatial planning agency.

Potential partners

1. **District forestry agency (Dinas Kehutanan Kabupaten)**
   Although KPH is supposed to be an independent institution, the district forestry agency had a very significant role in its establishment. The agency was mandated by the regulation to accelerate not only the establishment of the institution but also the basic forest management plan for it. REALU can play an important role in helping the agency design a management plan for KPH, especially in KPHP.

2. **District planning, development and investment agency (Badan Perencanaan Pembangunan dan Penanaman Modal Daerah, BAPPEMDAL)**
   BAPPEMDAL plays a major role in designing the district development and spatial plans and also is closely engaged with KLHS implementation.

3. **District environmental bureau (Badan Lingkungan Hidup Daerah, BLHD)**
   This bureau is an extension of the Ministry of Environment at subnational level. With the KLHS assessment becoming one of the important features of the development process, this bureau takes on a greater role.

4.3. Possible interventions at potential sites

4.3.1 Kesatuan Pengelolaan Hutan Lindung Gambut (KPHLG)

One feasible intervention in this area is to empower local community institutions. The area consists of around 16 000 ha, of which about 4000 ha has already been occupied and converted to oil palm plantations. The management of KPHLG has been much more advanced compared to that of KPHP. KPHLG has its institutional arrangements and clear forest management plans with intensive supervision by the district forestry agency.

Empowering local community institutions means strengthening local people with knowledge and the ability to deal with the district forestry agency program in order to maintain or improve the welfare and livelihoods of the community. The agency program focuses on maintaining the forest’s function as protection peat forest through community-based forest management (Pengelolaan Hutan Bersama Masyarakat, PHMB) in an area that is already occupied by farmers and has been converted to oil palm plantations. The communities were asked by the agency to plant *Jelutung* on the borders of their plots.

The conditionality of this intervention could follow that already developed by the district forestry agency.

- The existence and sustainability of KPHLG should be maintained.
- Rehabilitation of the occupied area by planting *Jelutung* to maintain the function of protection peat forest.
- Communities are allowed to harvest oil palm for only one cropping cycle and are no longer allowed to plant crops other than those recommended by the agency.
- The borders of the oil palm plantations should be planted with *Jelutung* as an intercropping system, with planting costs borne by the government.
- Communities are not permitted to build permanent dwellings in the area of KPHLG.

The district forestry agency also has a benefit-sharing mechanism.

- Sharing the benefits of *Jelutung* extraction: 60% goes to the communities and 40% to the local government.
- Communities can manage the land for 35 years, with three extensions.
- There is the possibility of proposing the area is designated a 'village forest' (Hutan Desa), with a mandate to maintain the area's status as protection forest.
- Communities can get technical assistance from the government.

4.3.2 Kesatuan Pengelolaan Hutan Produksi (KPHP)

Compared to the KPHLG area, KPHP receives far less attention from the district forestry agency. Almost 80% of the KPHP area has already been conceded to timber plantation companies and the remaining 20% (around 41 000 ha) still suffers from deforestation and forest degradation. This KPHP is a former logging concession area that was abandoned and encroached upon. The abandoned area became 'open access' and the Government until now does not really have any ability or program to address the situation. Consequently, the government is faced with various problems related to land tenure, forest governance and deforestation.

REALU intervention attempts to assist in solving these problems through KPHP. REALU intervention should start from the local government to communities. At the local government level, intervention could focus on accelerating the establishment of the KPHP institution, designing the basic forest management plan, designing forest co-management between government and the communities and also contributing to low-emissions development strategies.

At the community level, intervention could empower the community with knowledge and skills in forest management. There is also a need to enhance local communities' institutional capacities regarding management of land in order to contribute to the low-emission development strategy.

REALU could provide options to both local government and the communities on forest co-management. Indonesia's forest regulations provide many paths for such partnerships. The challenge ahead is how to find the best formulation of forest co-management options that can accommodate the interests of the communities who already control the 'open access' state forest area. Options should take into account the biophysical and social condition of the communities.

Benefit sharing, incentives distribution and a possible forest co-management strategy might be possible under existing regulations, such as through community plantation forest (IUPHHK-HTR), community forest, social/community forestry, customary forest and village forest schemes.

4.4. Challenges and ways forward for REALU in Tanjabar

Some gaps, challenges and opportunities based on the assessments towards REALU intervention in Tanjabar have been identified which cover the following topics/aspects:

1. Leakage and leakage mitigation

The emission reduction strategies resulted from REALU may create displacement of activities, hence emissions. Such leakage may also cover, among others, issues of labour and social aspects. A follow up assessments towards identification of leakage and the mitigation will be important to carry out as part of REALU approach.

2. Emissions estimation from peat

With the vast areas of peatland in Tanjabar, belowground emissions should be taken into account as part of quantified total emissions. Emission estimate pertinent to activities in peatland area should cover both emission resulting from land use conversion/establishment on a peat area and that resulting from land and water management of particular land uses/farming systems.

3. Interface with land-use planning for low-emission development

To address the emission reduction efforts at the entire district scale, it is important that the formal spatial planning addresses points relevant to low-emission development strategies. The aim of this intervention is to improve governance of land and forest resources through strengthened natural resource governance capacity and spatial planning implementation. The World Agroforestry Centre has developed a methodological tool for this kind of intervention: Land-Use Planning for Low Emission Development Strategy (LUWES).

LUWES is a framework to create development plans that can minimise greenhouse gas emissions while maintaining sustainability of economic growth. There are six steps in LUWES.

1. Create an inventory of land-based activities
2. Determine a development priority scale
3. Allocate the development plan
4. Analyse the consequences of the development plan
5. Reconcile the development plan
6. Develop and negotiate the low-emission development strategy

4. Feasibility studies on agroforestry commodities

Interaction with local stakeholders in Tanjabar indicates that there is local effort which promotes timber species as part of recommended species for small holders' lands in peatland areas, e.g. *jelutung, pulai*. There are mixed impressions on the success of the promotion and, in addition, there is unclarity of market potentials including price and access into the market chain by small holders. These leave room for further feasibility assessments prior to the promotion and recommendation of particular species as carbon enhancement and agroforestation commodities.

4.5. Global relevance of the Tanjabar case study for the REALU debate

The rich details in the various component studies contained a number of ‘surprises’ relative to current $REDD^+$ discourse, which need to be further corroborated. Key among them is the apparently low emission use of peatland for profitable tree crops in a shallow drainage pattern. The case study also showed the complexity of social issues on the interplay with a long, multiphased human migration history, defying simple indigenous/migrant classification schemes, synergistic as well as competitive relations between large-scale and small scale land use types, and the opportunities for local forest policy reform. Despite the high emissions per unit area in Tanjabar, the economic gains per unit emissions have been relatively high and $REDD^+$ at current ‘carbon price’ levels will not easily buy out the drivers of emissions. Stronger controls over migration and expansion of large-scale plantations are needed to achieve Indonesia’s NAMA target. Local public debate on the desirability of various land use change scenarios has only just started, and the intensity of conflict over land use rights means that reconciliation between stakeholders and their various claims on legality is needed before joint progress towards REALU goals may be feasible. Tanjabar as hot spot of emissions may well show the level of challenge involved in changing the local course of history towards cleaner development pathways.

5. Annexes

Annex 1. Brief explanation of Analyses of Land Use and Land Cover Trajectories (ALUCT)[10]

The overall procedures applied in ALUCT are presented in Figure A1.1 below.

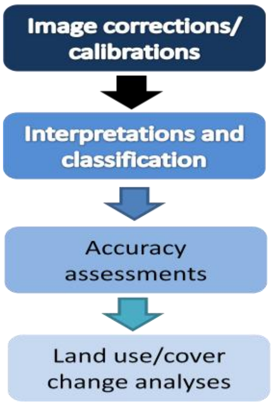


Figure A1.1 ALUCT work flow

1. Image corrections

Image corrections normally consist of radiometric calibration and geometric correction. Radiometric calibration fixes the image from the distortions caused by atmospheric factors, viewing angles, scene illumination, and instrument response characteristics (Lillesand and Kiefer 1994, Chavez 1996), while geometric correction fixes the image into the geo-reference coordinates of the earth surface. With Landsat images having been geometrically corrected, coded as L1-G (NASA, 2005), consequently, only radiometric corrections is conducted.

2. Image interpretation and classification

Image interpretation and classification in ALUCT applies an 'object-based hierarchical classification' approach. This classification system is built in several levels or hierarchies, each of which consists of two stages: image segmentations; and image classifications (Blumberg and Zhu 2007). Image segmentation is conducted to obtain 'image objects', which are a set of pixels having homogeneous spectral and spatial characteristics (see Figure A1.2).

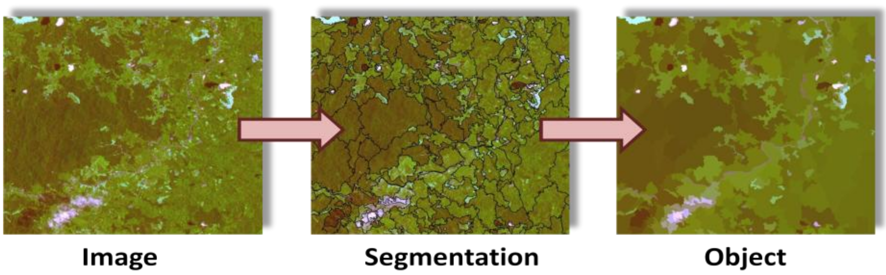


Figure A1.2. Image segmentation

[10] Based on Dewi and Ekadinata, 2010

The hierarchical image classification processes are implemented by applying different sets of rules, depending on the types of land cover classes and the levels in the hierarchies, and are guided by 'groundtruth' (verification at selected sites) samples, auxiliary information and/or expert judgments. The hierarchical nature of this classification approach can be seen in Figure A1.3 below.

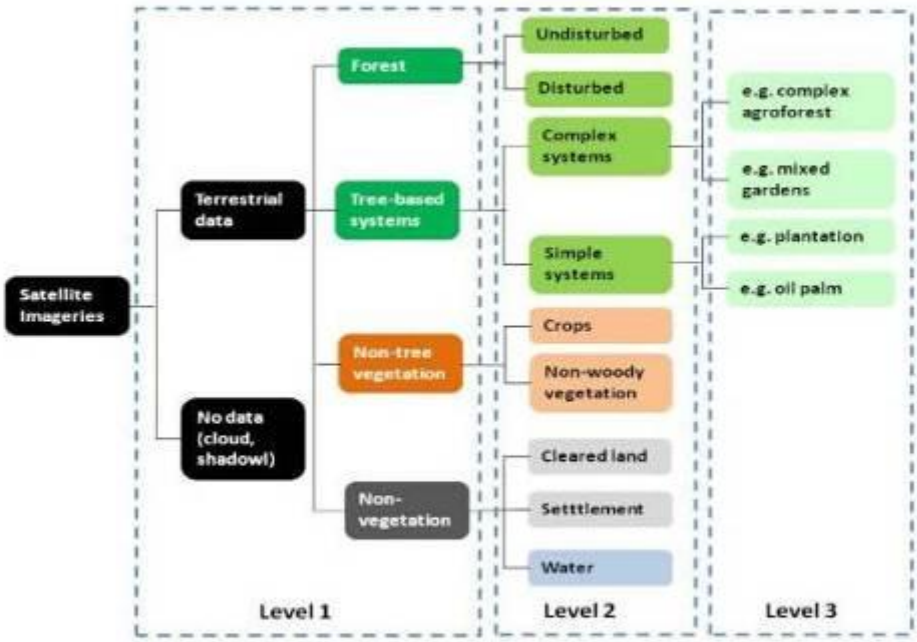


Figure A1.3. Hierarchichal classification

Land-cover types to be classified are determined and defined prior to the classification processes.

3. Accuracy assessments

After producing the final land-cover maps and prior to applying further analyses, the quality and accuracy of the maps need to be assessed. Accuracy assessment is applied by evaluating the maps using an independent set of groundtruth data and, for time-series maps, such as were produced in this study, commonly conducted to the most-recent-year map. 'Overall accuracy' is the proportion of correctly classified pixels over the total number of references (Lillesand and Kiefer 1994). To reduce the effect of random errors and chance agreement in the accuracy assessment, the overall accuracy figure is usually accompanied by the Khat (sometimes called Kappa) statistics, which is a measure between the actual agreement between reference data and the classifier and the chance agreement between the reference data and random classifier (Lillesand and Kiefer 1994).

4. Land-cover change and trajectory analyses

Land-use/cover trajectory analyses are normally conducted through a matrix of changes in which each cell presents unique magnitude or proportion of a particular trajectory of change from Time 1 (T1) and Time 2 (T2) (Figure A1.4).

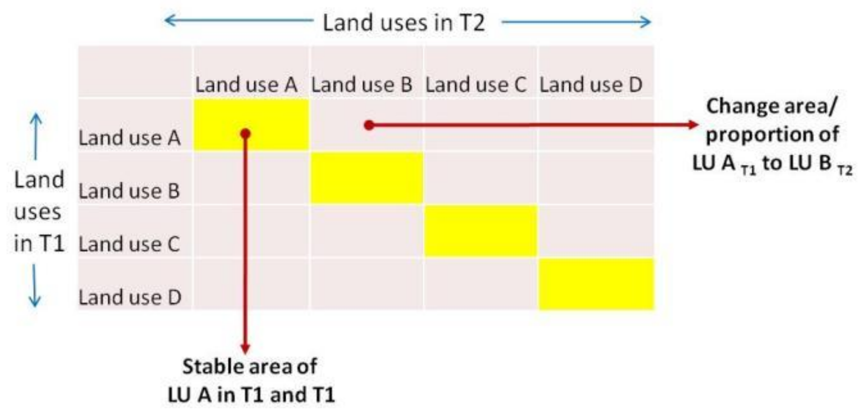


Figure A1.4 Land cover trajectory matrix

5. Common problems and solutions in ALUCT

Problematic issues that normally appear in land-cover change analyses are 1) illogical change; and 2) no data in one or more of the time-series maps. To address problem 1, adjustments need to be made by providing expert judgments and/or refining the classified images. For problem 2, the common solution is to accumulate all no-data patches throughout the period of analysis and apply them to all the time-series maps. As a result, the no-data areas are constant throughout. The water body class also, when relevant, follows the same treatment as no-data areas.

Annex 2. Land use/cover types in Tanjabar identified in the maps.

No	Land use type	Definition
1	Undisturbed forest	Undisturbed forest is natural forest cover with dense canopy, highly diverse species and basal areas. It has no logging roads, indicating that it has never been logged, at least not on a large scale, and is usually located in areas with rough topography. Canopy cover of undisturbed forest is usually >80%. In satellite images it is indicated by high value of vegetation index and infrared spectrum channels and lower value in visible spectrum channels.
2	Logged over forest-high density	Natural forest area having been disturbed by logging or other timber extraction or fire but still has relatively dense tree cover and dense canopy. Canopy cover is around 30–60%. Large trees with diameter >30 cm can be found.
3	Logged over forest-low density	Natural forest area having been disturbed by logging or other timber extraction or fire with low tree cover and low canopy density. Canopy cover is around 10-30%. Large trees with diameter >30 cm can be found.
4	Undisturbed swamp forest	Similar to #1, but located in swamp environment and normally with lower vegetation and canopy density compared to lowland and mountainous forest
5	Logged over swamp forest	Similar to #2 and #3, located in swamp environment
8	Undisturbed mangrove	Undisturbed forest with similar definition of #1, located in coastal environment and with typical mangrove tree species (see Section 2.6)
9	Logged over mangrove	Natural mangrove forest having been disturbed by logging or other timber extraction
10	Rubber agroforest	Rubber agroforest is characterised by the presence of old rubber trees mixed with other tree species and shrubs, which form a complex stand structure. Rubber trees typically account for 70% or less of the population of trees above 10 cm dbh (diameter at breast height). When the presence of non-rubber trees is dominant and the plot is old enough, the gardens will be very hard to differentiate from secondary or disturbed forest (see also explanation in Sections 2.1 and 2.6). In Tanjabar rubber agroforest is classified as simple rubber agroforestry system.
11	Coffee-based agroforest	Farming system typically dominated by coffee bushes and intercropped with coconut and/or betelnut planted sparsely as 'productive' shade trees or as fence (see also explanation in Sections 2.1 and 2.6)
12	Acacia plantation	Large scale plantations planted with Acacia sp
13	Rubber monoculture (or Rubber plantation)	Monoculture plantation of rubber (Hevea brasiliensis) (see Section 2.1)
14	Oil palm	Oil palm gardens or plantation, mostly monoculture and refers to both large scale and small-holder (see also explanation in Sections 2.1 and 2.6)
15	Coconut-betelnut	Farming system typically dominated by coconut or coconut as the major tree cover with intercropping of paddy or seasonal crop (see also explanation in Sections 2.1 and 2.6)
16	Shrub	Area dominated by non-woody vegetation, which is usually an ex-forest clearing area that undergoes natural secondary regrowth. For old shrubs, there is a low cover of trees, around 5% cover; but no trees with diameter >20 cm.
17	Other crops	Annual or seasonal /annual crop, horticulture /vegetable crop

Annex 2 (continued)

No	Land use type	Definition
18	Rice field	Area planted with rice cultivation, both inundated or dryland paddy
19	Grass	Area of grass or imperata
20	Cleared land	Land having just been cleared which can be bare from vegetation or is covered by herbaceous vegetation or
21	Settlement	Settlement refers to built area (city or village), which includes road, main road and/or logging road; presence of sparse trees might be found.

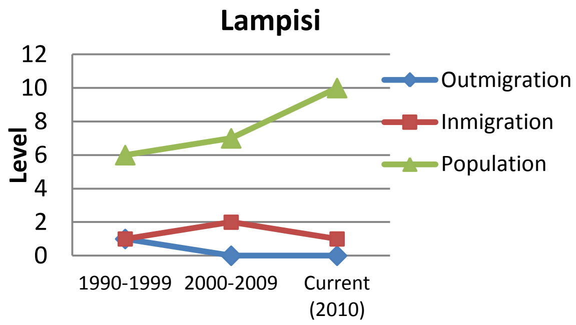
Note: there are corresponding land uses/land covers on peat areas

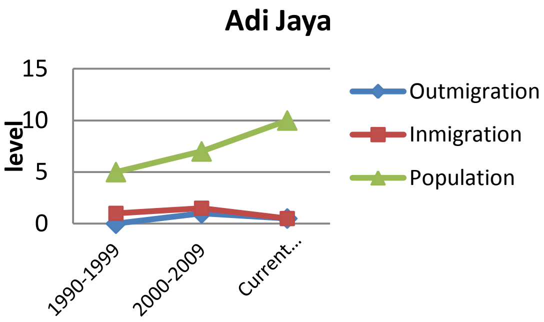
Annex 3. Areas of each land cover type in Tanjabar for 1990, 2000, 2005 and 2009

Land cover group	1990	2000	2005	2009
Undisturbed forest	107,074	56,218	53,587	42,118
Disturbed forest	208,929	186,804	100,573	68,185
Rubber agroforest	32,501	54,618	31,091	17,183
Rubber monoculture	34,491	23,617	58,253	29,811
Coffee-based agroforest	6,368	20,452	29,045	29,686
Coconut-betel nut	46,379	33,458	42,825	55,317
Oil palm	79	46,350	69,524	103,852
Acacia plantation	-	8,755	19,725	46,000
Shrub	5,117	4,651	20,125	31,106
Grass	-	746	7,375	11,987
Other crops	1,599	2,382	1,972	2,928
Rice field	3,150	15,021	10,341	4,980
Cleared land	11,475	2,914	6,375	5,602
Settlement	5,661	6,837	12,012	14,068
Waterbody	3,387	3,387	3,387	3,387

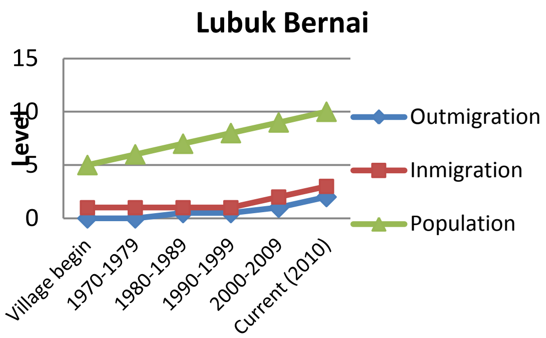
Annex 4. Rate of migrations in different villages/communities evaluated by village FGD

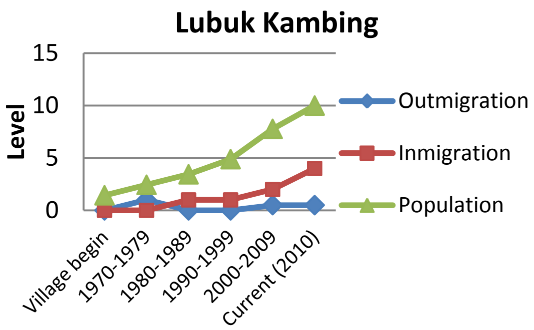
Mineral soil – transmigrant villages

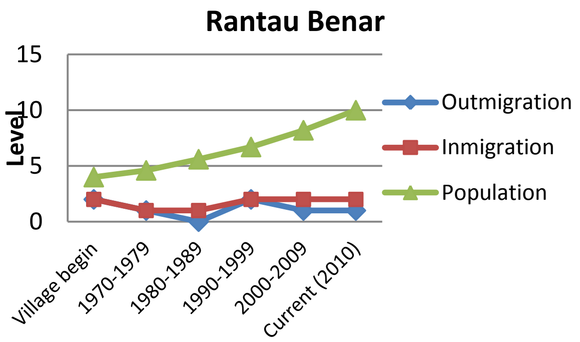




Mineral soil – local villages

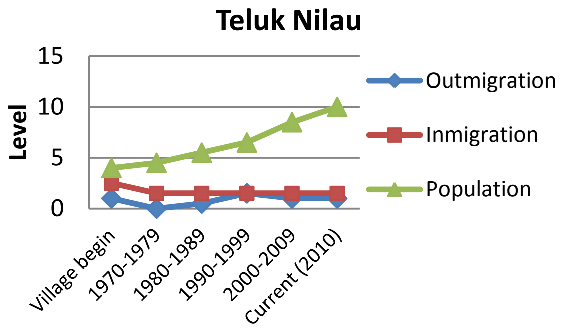


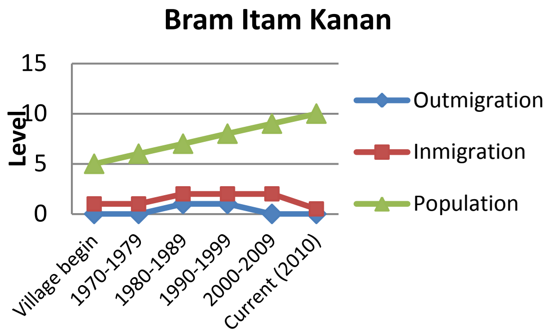


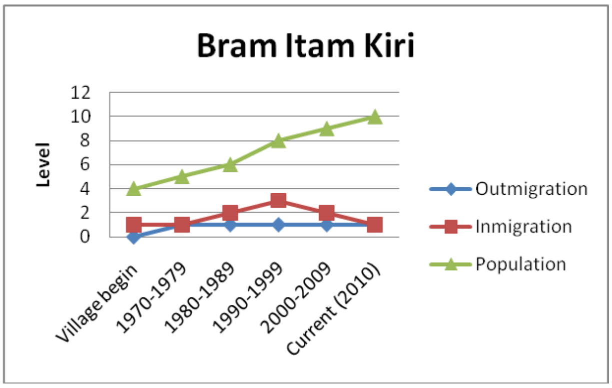


Annex 4 (continued)

Peatland –migrant villages







Annex 5. Sources of income in Tanjung Jabung Barat

Sources of income	Income per household								Income per capita			
	Mineral soil				Peatland				Mineral soil		Peatland	
	Transmigrants		Local		Early migrants		Recent migrants		Transmigrants	Local	Early migrants	Recent migrants
	IDR	%	IDR	%	IDR	%	IDR	%	IDR	IDR	IDR	IDR
1. Agriculture												
Rubber plantation	-	0.00	26,350,266	60.68	-	0.00	-	0.00	-	5,547,424	-	-
Oil palm plantation	87,324,765	75.24	3,866,625	8.90	154,650	0.32	24,692,286	54.05	19,623,543	814,026	37,720	5,487,175
Mix garden	-	0.00	-	0.00	30,051,188	61.82	5,333,750	11.67	-	-	7,329,558	1,185,278
2. Other agriculture	1,941,950	1.67	2,601,500	5.99	1,906,125	3.92	3,648,500	7.99	436,393	547,684	464,909	810,778
3. Labourer	8,010,000	6.90	5,193,000	11.96	3,205,500	6.59	2,223,500	4.87	1,800,000	1,093,263	781,829	494,111
4. Remittances	1,367,500	1.18	37,500	0.09	300,000	0.62	75,000	0.16	307,303	7,895	73,171	16,667
5. Entrepreneur	5,159,000	4.45	1,380,000	3.18	6,307,500	12.98	3,290,000	7.20	1,159,326	290,526	1,538,415	731,111
6. Professional	2,402,500	2.07	590,000	1.36	4,330,000	8.91	570,000	1.25	539,888	124,211	1,056,098	126,667
7.Other	9,855,000	8.49	3,405,000	7.84	2,356,750	4.85	5,854,700	12.81	2,214,607	716,842	574,817	1,301,044
8.Total income per year	116,060,715	100	43,423,891	100	48,611,713	100	45,687,736	100	26,081,060	9,141,872	11,856,515	10,152,830
9. Income per day									**71,455**	**25,046**	**32,484**	**27,816**

Source: *ICRAF Household Survey 2011*

Annex 6. Income inequity in mineral soil area and peatland (Tanjung Jabung Barat, Jambi) in 2011

	Mineral soil			Peatland		
	Income share	Coefficient Concentration	Pseudo Gini Ratio	Income share	Coefficient Concentration	Pseudo Gini Ratio
1. Agriculture						
Rubber plantation	16.52	0.67	0.26	0.00	0.00	0.00
Oil palm plantation	57.18	1.52	0.59	26.35	0.10	0.02
Mix garden	0.00	0.00	0.00	37.52	1.89	0.41
2. Other agriculture	2.85	0.03	0.01	5.89	0.16	0.03
3. Labourer	8.28	0.06	0.02	5.76	0.18	0.04
4. Entrepreneur	4.10	1.26	0.49	10.18	1.34	0.29
5. Professional	1.88	1.74	0.68	5.20	1.46	0.32
6.Other	8.31	1.65	0.64	9.11	1.17	0.26
			0.39			0.22

Source: *Computed from ICRAF Household Survey 2011*

Annex 7. Land-use change trajectories in Tanjung Jabung Barat, 1990–2000

1990–2000	Undisturbed forest	Disturbed forest	Rubber agroforest	Coffee-based agroforest	Acacia plantation	Rubber	Oil palm	Coconut-betel nut	Shrub	Grass	Other crops	Rice field	Cleared land
Undisturbed forest	56,218	40,017	3,109	1,536	75	649	2,051	935	353	6	594	579	715
Disturbed forest	-	136,152	21,558	2,379	8,079	1,298	30,640	3,292	976	169	857	2,346	1,109
Rubber agroforest	-	1,946	17,937	649	68	3,355	7,338	248	160	69	110	455	39
Coffee-based agroforest	-	300	16	5,658	3	18	30	33	33	3	4	256	2
Acacia plantation	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubber	-	1,212	8,885	1,357	185	17,166	3,337	437	293	155	320	783	77
Oil palm	-	2	-	10	-	-	55	-	-	-	-	12	-
Coconut-betel nut	-	5,200	612	6,601	75	240	474	23,529	1,566	203	199	7,338	123
Shrub	-	772	374	511	121	227	380	582	1,103	46	27	694	175
Grass	-	-	-	-	-	-	-	-	-	-	-	-	-
Other crops	-	296	10	448	7	-	4	425	58	-	261	66	5
Rice field	-	182	308	25	36	31	331	19	-	9	-	2,102	27
Cleared land	-	725	1,809	1,278	106	633	1,710	3,958	109	86	10	390	642

Annex 8. Percentage of area changes in Tanjung Jabung Barat, 1990–2000

1990-2000 (%1990)	Undisturbed forest	Disturbed forest	Rubber agroforest	Coffee-based agroforest	Acacia plantation	Rubber	Oil palm	Coconut-betel nut	Shrub	Grass	Other crops	Rice field	Cleared land
Undisturbed forest	53%	37%	3%	1%	0%	1%	2%	1%	0%	0%	1%	1%	1%
Disturbed forest	0%	65%	10%	1%	4%	1%	15%	2%	0%	0%	0%	1%	1%
Rubber agroforest	0%	6%	55%	2%	0%	10%	23%	1%	0%	0%	0%	1%	0%
Coffee-based agroforest	0%	1%	0%	17%	0%	0%	0%	0%	0%	0%	0%	1%	0%
Acacia plantation													
Rubber	0%	4%	26%	4%	1%	50%	10%	1%	1%	0%	1%	2%	0%
Oil palm	0%	3%	0%	13%	0%	0%	70%	0%	0%	0%	0%	15%	0%
Coconut-betel nut	0%	11%	1%	14%	0%	1%	1%	51%	3%	0%	0%	16%	0%
Shrub	0%	15%	7%	10%	2%	4%	7%	11%	22%	1%	1%	14%	3%
Grass													
Other crops	0%	19%	1%	28%	0%	0%	0%	27%	4%	0%	16%	4%	0%
Rice field	0%	6%	10%	1%	1%	1%	11%	1%	0%	0%	0%	67%	1%
Cleared land	0%	6%	16%	11%	1%	6%	15%	34%	1%	1%	0%	3%	6%

Annex 9. Land-use change trajectories in Tanjung Jabung Barat, 2000–2009

2000-2009	Undisturbed forest	Disturbed forest	Rubber agroforest	Coffee-based agroforest	Acacia plantation	Rubber	Oil palm	Coconut-betel nut	Shrub	Grass	Other crops	Rice field	Cleared land
Undisturbed forest	42,118	5,732	306	983	1,148	445	1,181	979	1,931	98	54	74	179
Disturbed forest	-	50,821	6,617	9,103	28,915	11,190	30,148	13,003	18,168	8,767	1,143	2,120	3,107
Rubber agroforest	-	5,137	4,356	664	4,012	7,756	25,283	1,626	2,246	696	563	853	644
Coffee-based agroforest	-	220	418	12,993	881	375	1,446	2,839	725	198	13	124	86
Acacia plantation	-	658	377	173	4,138	444	824	330	897	651	28	40	99
Rubber	-	2,379	1,802	288	1,322	5,172	9,046	1,086	1,098	328	255	253	232
Oil palm	-	2,078	1,409	301	2,985	2,789	31,308	888	1,684	560	513	605	636
Coconut-betel nut	-	227	602	1,448	952	555	1,796	26,138	865	375	119	114	148
Shrub	-	193	124	886	828	77	373	1,371	513	66	20	85	36
Grass	-	15	47	29	19	81	124	297	32	66	4	6	6
Other crops	-	21	232	2	50	198	541	3	1,062	11	84	1	117
Rice field	-	370	708	2,753	472	607	1,333	6,417	1,050	133	125	657	223
Cleared land	-	334	185	63	278	122	449	340	835	38	7	48	89

Annex 10. Percentage of area changes in Tanjung Jabung Barat, 2000–2009

2000-2009 (%2009)	Undisturbed forest	Disturbed forest	Rubber agroforest	Coffee-based agroforest	Acacia plantation	Rubber	Oil palm	Coconut-betel nut	Shrub	Grass	Other crops	Rice field	Cleared land
Undisturbed forest	75%	10%	1%	2%	2%	1%	2%	2%	3%	0%	0%	0%	0%
Disturbed forest	0%	27%	4%	5%	15%	6%	16%	7%	10%	5%	1%	1%	2%
Rubber agroforest	0%	9%	8%	1%	7%	14%	46%	3%	4%	1%	1%	2%	1%
Coffee-based agroforest	0%	1%	2%	64%	4%	2%	7%	14%	4%	1%	0%	1%	0%
Acacia plantation	0%	8%	4%	2%	47%	5%	9%	4%	10%	7%	0%	0%	1%
Rubber	0%	10%	8%	1%	6%	22%	38%	5%	5%	1%	1%	1%	1%
Oil palm	0%	4%	3%	1%	6%	6%	68%	2%	4%	1%	1%	1%	1%
Coconut-betel nut	0%	1%	2%	4%	3%	2%	5%	78%	3%	1%	0%	0%	0%
Shrub	0%	4%	3%	19%	18%	2%	8%	29%	11%	1%	0%	2%	1%
Grass	0%	2%	6%	4%	3%	11%	17%	40%	4%	9%	1%	1%	1%
Other crops	0%	1%	10%	0%	2%	8%	23%	0%	45%	0%	4%	0%	5%
Rice field	0%	2%	5%	18%	3%	4%	9%	43%	7%	1%	1%	4%	1%
Cleared land	0%	11%	6%	2%	10%	4%	15%	12%	29%	1%	0%	2%	3%

Annex 11. Time-averaged carbon stock on other land-cover types in Tanjung Jabung Barat based on other data sources

No.	Land cover	Time-averaged carbon stock (Mg ha^{-1})	Standard deviation	Data source
1.	Undisturbed forest	261.52	69.24	RaCSA project
2.	Logged-over forest: high density	192.81	143.25	ICRAF Database+IPOC 2010
3.	Logged-over forest: low density	129.97	73.44	ICRAF Database+IPOC 2010
4.	Undisturbed swamp forest	193.20	48.58	PanECO project
5.	Logged-over swamp forest	141.30	126.41	IPOC 2010
6.	Undisturbed swamp forest on peat	193.20	48.58	PanECO project
7.	Logged-over swamp forest on peat	141.30	126.41	PanECO project
8.	Undisturbed mangrove	142.60	20.00	Murdiyarso et al, 2009
9.	Logged-over mangrove	57.50	4.47	This study
10	Rubber agroforest	69.00	49.18	ICRAF Database
11	Coffee-based agroforestry	27.9	10.79	ICRAF Database
12	Acacia plantation	57.90	32.49	This study
13	Rubber monoculture	40.50	24.92	IPOC 2010
14	Oil palm monoculture	40	-	IPOC 2010
15	Coconut and betel nut	31.80	7.48	IPOC 2010*
16	Shrub	43.00	34.07	IPOC 2010, ICRAF Database
17	Grass	3.35	0.86	CCI Project, IPOC 2010
18	Other crops	9.50	4.30	IPOC 2010
19	Rice field	0.99	0.57	ICRAF Database
20	Cleared land	3.35	0.86	ICRAF Database
21	Settlement	4.14		
22	Rubber agroforest on peat	58.00	29.70	This study
23	Coffee based agroforestry on peat	26.0	5.0	This study
24	Acacia plantation on peat	51.60		This study
25	Rubber monoculture on peat	40.50	24.92	IPOC 2010
26	Oil palm monoculture on peat	38.6		IPOC 2010
27	Coconut and betel nut on peat	31.8	20.51	IPOC 2010
28	Shrub on peat	43.00	34.07	CCI Project
29	Other crops on peat	9.50	4.30	IPOC 2010
30	Rice field on peat	0.99	0.57	ICRAF Database
31	Grass on peat	3.56	0.66	IPOC
32	Cleared land on peat	3.35	0.86	CCI Project, IPOC 2010
33	Settlement on peat	4.14		

Annex 12. Aboveground carbon stock of each land-use system

No	Land-use system	Aboveground carbon stock (ton/ha)
1.	Undisturbed forest	261.52
2.	Logged-over forest: high density	192.81
3.	Logged-over forest: low density	129.97
4.	Undisturbed swamp forest	193.20
5.	Logged-over swamp forest	141.30
6.	Undisturbed swamp forest on peat	193.20
7.	Logged-over swamp forest on peat	141.30
8.	Undisturbed mangrove	142.60
9.	Logged-over mangrove	57.50
10.	Rubber agroforest	58.00
11.	Coffee-based agroforest	26.00
12.	Acacia plantation	57.90
13.	Rubber monoculture	40.50
14.	Oil palm monoculture	40.00
15.	Coconut-betel nut agroforest	31.80
16.	Shrub	43.00
17.	Other crops	9.50
18.	Rice field	0.99
19.	Grass	3.35
20.	Cleared land	3.90
21.	Settlement	4.14
22.	Rubber agroforest on peat	58.00
23.	Coffee-based agroforest on peat	26.00
24.	Acacia plantation on peat	51.60
25.	Rubber monoculture on peat	40.50
26.	Oil palm monoculture on peat	38.60
27.	Coconut –betel nut agroforest on peat	31.80
28.	Shrub on peat	43.00
29.	Other crops on peat	9.50
30.	Rice field on peat	0.99
31.	Grass on peat	3.35
32.	Cleared land on peat	3.90
33.	Settlement on peat	4.14

Annex 13. Assumptions used for large-scale management system

No	Variable	Unit	Land-use system		
			Logging	Acacia plantation	Large-scale oil palm
1	Commodity		Meranti	*Acacia mangium*	FFB
2	Area	Ha	45 000	12 274	3000
3	Price				
	Private	Rp/kg	1 597 655 *	472 420 *	1350
	Social	Rp/kg	1 987 242 *	417 910 *	1438
4	Productivity	Kg/ha/year	17 **	84 **	14 000
5	1st Year production	Year	1	7	2

Note:
* (Rp/m^3)
**(m^3/ha/year)

Annex 14. Assumptions used for smallholder management system

No	Variable	Unit	Land-use system								
			Smallholder Oil Palm on Mineral	**Smallholder Oil Palm on Peat**	**Rubber Monoculture on Mineral**	**Rubber Agro forest**	**Rubber Monoculture on Peat**	**Coconut Monoculture**	**Coffee Agroforest**	**Betel Agroforest**	***Jelutung* Monoculture**
1	Commodity		FFB	FFB	Rubber	Rubber	Rubber	Copra	Coffee	Betel nut	Latex
2	Area	Ha	1	1	1	1	1	1	1	1	1
3	Price										
	Private	Rp/kg	1,350	1,182	16,000	16,000	16,000	4,000	16,500	3,500	3,500
	Social	Rp/kg	1,438	1,438	24,000	24,000	24,000	4,000	16,500	3,500	3,500
4	Productivity	Kg/ha/year	13,000	9,000	718	371	525	1,438	683	1,003	4,471
5	1st Year production	Year	3	3	9	10	9	6	3	4	10

Annex 15. Assumptions used for crop management system

No.	Variable	Unit	Land-use system			
			Irrigated paddy	**Dryland paddy**	**Tidal paddy**	**Maize**
1	Commodity		Rice	Rice	Rice	Maize
2	Area	Ha	1	1	1	1
3	Price					
	Private	Rp/kg	6000	6000	6000	2000
	Social	Rp/kg	6000	6000	6000	2000
4	Productivity	Kg/ha/year	5000	2000	4000	4000
5	1st Year production	Year				

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