INITIAL ANALYSIS ON THE MITIGATION POTENTIAL IN THE FORESTRY SECTOR

Prepared for the UNFCCC Secretariat

Prepared by
Jürgen Blaser
Carmenza Robledo

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Content

Introduction

The task given the UNFCCC Secretariat to the consultants on July 27 by was to estimate the potential and cost requirements for mitigation options to offset current level of emissions from the forestry sector in 2030 i.e. 5,8 GtCO2. The work was conducted between July 27 and August 1, 2007.

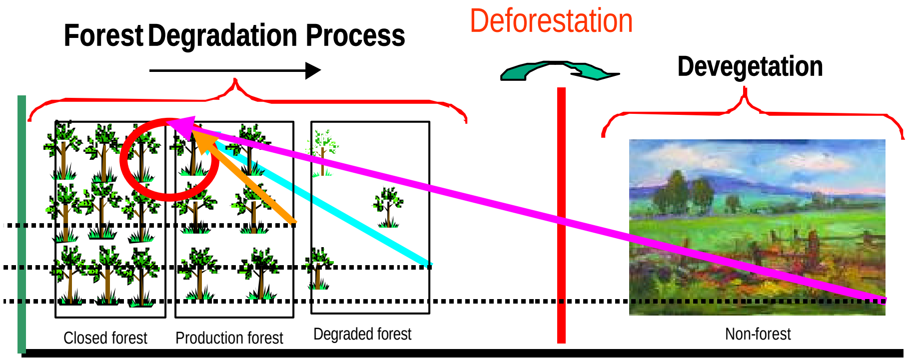
In this document three out of the four mitigation options in forestry were considered (see graphic 1):

- Reducing emissions from deforestation and forest degradation
- Forest management
- Forest restoration

Afforestation and reforestation as the only eligible mitigation option has not been tackled in this report (see report of Evelyne Trines)[1].

The following graphic summarizes the conceptual approach proposed by the consultants to tackle GHG mitigation options in forestry. Only A/R CDM is an eligible option in the Kyoto Protocol, other options are put forward for consideration for a post 2012-regime.

Graphic 1: Mitigation opportunities in the forestry sector



------ Sustainable use of existing forest:
→Emission reduction: Considered in REDD

------ Sustainable use of existing forest:
→Emission reduction: Considered in REDD

------ Forest Restoration and Rehabilitation:
→Emission reduction + carbon sequestration. Not considered yet

------ Plantations & Agroforestry:
→Carbon sequestration: Included in A/R CDM

.... Initial carbon stocks

1. REDD: Minimum Investments Required for Reducing GHG Emissions from Deforestation and Forest Degradation by 2030

The present chapter contains an approach to estimate the potential and cost requirements with regard to reducing emissions from deforestation and forest degradation (REDD) as one of the three main mitigation options in the forestry sector. For a complete understanding of the potential of the entire sector, this document should be read in combination with the specific comments provided by the authors on the dialogue paper.

[1] Elements that could not been taken into account for the present report but that are also of importance in the overall context of mitigation options in forests are: how to treat reduced impact logging? How to treat “pioneer agroforestry”? How to treat synergies between REDD and adaptation?

This chapter presents an attempt to calculate the lowest investment flows that will be required to reduce emissions from deforestation and forest degradation by 2030. The general approach was to clarify how much money will be needed to compensate the loss if DD (Degradation and Deforestation) do not happen (the opportunity cost), considering the major direct drivers in the most important regions where REDD can be applied as a future mitigation option.

The first section summarizes the main findings. The second section presents the rational used in the calculation and the corresponding tables. Final results depend completely of the assumptions and default values presented in the rational. This rational can be refined at a later stage, if required.

For a full understanding of the chapter the following considerations should be borne in mind:

- Only compensation prices for the opportunity cost of direct drivers of DD have been calculated and no investment or maintenance costs of alternative land-use have been taken into consideration. Most importantly, the ***figures proposed in this document <u>cannot</u> be understood as expressing the FULL cost of reducing emissions from deforestation and/or forest degradation***. The reason is that the effective cost of this reductions will be highly affected by future UNFCCC decisions on REDD in the post 2012 regime. As this regime and its implementation arrangements have not yet been defined, a realistic calculation of the full costs of REDD can not be done at the moment. Once an agreement is found in the COP administrative and transaction costs for REDD will need to be calculated.

- Data of benefits per direct driver are based on FAO data, ITTO data, scientific literature; project work and expert judgement (see section two for detailed references). The estimates are based on business as usual under the current development scenario and market values up to the year 2030. Dollar figures are in today's real prices in US$ (data base allowed assessments between 2000 and 2005). Figures are based on one year, time horizon 2005-2030 (25 years).

- Recurrent benefits are estimated on an annual basis over a time span of 25 years, keeping actual prices. In the case of logging and NTFP gathering, the calculation is done, considering a single or repeated interventions (increasing degradation), distributed over 25 years.

- The minimum investment flow required for reducing emissions from deforestation and forest degradation is equal to the opportunity cost of converting forest into other land uses.

- The rate of deforestation used here is 12.9 million hectares per year (according to FAO 2006), which is the total of net loss of forests of those countries that have a negative forest area dynamic (see also explanation in section 2). Other figures on DD are also those published in FRA (Forest Resource Assessment carried 2005, FAO 2006).

- The data on carbon per hectare is based on *Marklund and Schoene* (2006). They used the basic data of FRA 2005.

- Emissions from deforestation in the 1990s are 5.8 $GtCO_2$/yr as estimated in the IPCC, AR4 (AR4 WGIII-Mitigation to Climate Change, 2007)

- Deforestation and forest degradation are relevant in particular for tropical and subtropical non-Annex I countries. For this reason Annex I countries will not be estimated in detail in the calculations presented in REDD. Data for these countries are presented in table 8 “other countries” using average values.

1.1. Main findings

The following are the main findings according to the calculations made by the authors:

- If emissions from deforestation and forest degradation are to be reduced to zero by 2030 a **minimum investment of 12. 2 billion US$[2] per year** would be necessary to compensate the opportunity costs of DD.

- An average price of 2.8 US$/tCO2 will cover the opportunity cost of DD of 8.5 million of ha yearly. This would represent a emission reduction of ~GtC 3.76 tCO2/year (65% of the emissions). For this scenario the price of 2.80 US$/tCO2 will also allow to improve livelihood conditions in many regions. Such an improvement depends on various factors:

    - the administration and transaction costs of REDD activities
    - the specific conditions of each region (socio-economic, institutional, access to infrastructure etc.).

  A more detailed analysis is recommended to analyse the impacts of different carbon prices on the development path of each region.

- If using this average price then investments of 10.4 billion US$ yearly will be needed.[3] According to the analysis, this average price will be higher than the opportunity costs of the following DD drivers: cattle ranching (large scale), small scale agriculture/ shifting cultivation, fuelwood and NTFP gathering and fuel-wood/charcoal (traded).

- Costs of REDD will depend not only on the opportunity cost of converting or degrading forests, but also on the requirements of the REDD-activity in a future climate regime. As this regime has not been agreed yet, presenting an estimation on full costs of REDD, (including administrative costs, costs for monitoring, etc) seem to be premature.

- Opportunity costs vary significantly among regions (even among countries) and over time. Underlying drivers for deforestation (e.g. structural changes in land tenure or in agricultural or forest policies) also have a great impact on opportunity costs. The figures presented here can therefore only be understood as indicative.

- The potential for REDD needs to be understood as **complementary** to the other mitigation alternatives in forestry, mainly afforestation and reforestation and forest management. Furthermore, it will be highly relevant to include the sequestration potential of forest restoration in a future mitigation regime. Activities in agroforestry and bio-energy although considered in other sectors (i.e. agriculture and energy) have considerable implications on forest dependent livelihood and in the overall forestry sector. The relationship among these activities and the overall forest sector still need to be analysed in detail

- In some cases, deforestation will convert forest into another use with a high content of living biomass (e.g. conversion in palm oil, rubber, pulp, cocoa plantations, or

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[2] 1 Billion USD = 1000 Million USD

[3] Considering C content in forest as 449 tCO2/ha as an average for the calculation

woody bioenergy plantations). This kind of deforestation has, however, a high impact on biodiversity conservation and on livelihoods. However, from the perspective of the GHG emissions this deforestation can be partially neutralised through the sequestration effect in the plantation.

1.2. Calculation and its rational

This section presents all the estimates per region and at the global level, as well as the rationale and explanation for each single table. The purpose is to make the method of calculation fully transparent to facilitate any future discussion on these figures.

1.2.1. General explanation of the variables

Seven variables were included:
1. Categories of direct deforestation and degradation drivers
2. Estimate of the share of deforestation/degradation driver
3. Total areas of DD in Million ha
4. Estimate of benefits from land-use change/degradation per main direct DD driver
5. Lowest investment required to compensate the opportunity costs (in Million US$ per year)
6. Lowest C compensation prices per tCO_2 per year
7. Lowest C compensation prices per tC per year

The text below explains the rational used in determining or calculating the values of each variable. For the regional tables an additional explanation of variables 2 and 4 is included.

1 Categories of direct deforestation and degradation drivers

Opportunity costs are defined for the three major direct drivers of DD as follows:

- Commercial Agriculture (national and international markets)
  - Commercial crops
  - Cattle ranging (large scale)
- Subsistence farming
  - Small scale agriculture/shifting cultivation/swidden agriculture
  - Fuel-wood and NTFP gathering for local use, mostly family based
- Wood extraction
  - Commercial (legal and illegal) for national and international markets
  - Traded fuel-wood (commercial at sub-national and national level)

It is understood that deforestation usually results from a combination of factors; direct and underlying causes of DD interact in complex and variable ways. To simplify the calculations in this exercise, however, the separation of the main direct drivers seems to be the most appropriate approach. Infrastructure development (e.g. roads, dams), urban development and mining have not been listed. Mining is also a direct driver, but generally limited in area and locality specific. Emissions by fire (without conversion) have not been considered in the calculations.

2 Estimate of the share of deforestation/degradation driver

Estimates are based on the fact that there are different direct drivers for DD in each country where DD occurs. The different drivers have different underlying causes; nevertheless there are general patterns that remain more or less similar in all regions. Commercial agriculture is more important in regions where investment capital is relatively readily available (e.g. Latin America, certain SE-Asian countries). Commercial livestock ranching is more widespread in Latin and Central America, while it is not practiced at a similar scale in SE Asia. Subsistence farming, which includes small-scale farming and livestock breading of settlers at the forest fringes, shifting cultivation and swidden agriculture occurs in all the tropical regions, forest-rich and forest-poor; its relative importance in all the regions is closely linked with the increasing population and macro-economic characteristics in a given country. This kind of farming leads to a permanent or time bound land-use change while the category titled "fuelwood and NTFP gathering" can lead to carbon stock loss through gradual forest degradation. Wood extraction occurs in all the regions, forest-rich and forest-poor, however timber (including commercial logging) is of importance only in forest-rich countries. Unsustainable wood extraction (which is the general case in all tropical regions) leads to forest degradation, and is also an underlying cause for deforestation. SE-Asia, which has the most timber-rich forests, is more prone to carbon stock loss through timber extraction than Africa and tropical America. Commercial fuelwood is a phenomenon in many smaller, forest-poor countries with rapid development of urban centres. All these characteristics have been taken into account when estimating the share of each driver. The estimates made in the tables below are based on ITTO (2006); Forner et al (2006); Kaimowitz and Angelsen (2001); Moutinho and Schwartzman (2005); Chomitz and Kumari (1998); Chomitz, K. (2006) and Geist and Lambin (2002) and expert judgement.

3 Total areas of DD in Million ha

The data used are those from the Forest Resource Assessment 2005 - FRA 2005 (FAO 2006). The total net change in forest area in the period 2000–2005 is estimated at -7.3 million hectares per year. Compared to the 1990s, the current annual net loss is 18 percent lower and equals a loss of 0.18 percent of the remaining forest area each year during this period. For the FRA 2005 assessment, countries were not requested to provide information on each of the four components of net change, as most countries do not have such information. This, however, makes estimation of the deforestation rate difficult and no attempt has been made to do so at the country level. Rather, an estimate of the global deforestation rate has been made as follows: **The total net loss for countries with a negative change in forest area was 13.1 million hectares per year for 1990–2000 and 12.9 million hectares per year for 2000–2005.** This would indicate that annual deforestation rates were at least at this level. Taking these considerations into account the global deforestation rate was estimated at **12.9 million hectares** per year during the period 1990–2005, with few signs of a significant decrease over time. Consequently, the hectare figure of DD by main direct driver has been based on the 12.9 million ha figure, as a conservative approach.

4 Estimate of benefits from land-use change/degradation per main direct DD driver

The USD figures have been estimated as follows:

- For commercial agriculture: Benefits are estimated based on the commercial value as product harvested multiplied by an average market value. Calculation basis where average yield as average market price assessments for the main crops in each region. Main source was FAOSTAT for Agriculture and Nutrition, but also other sources have been taken into account (UNCTAD, base calculations for the Stern Report by Grieg-Gran, M. (2006) and other sources. The dollar figure indicated is the average price of the main or the three main commercially traded crops per region.

- For subsistence farming: benefits are calculated using an average amount of product harvested multiplied by a shadow value in form of the price in the inland market. This is based on work of bilateral development agencies, principally SDC and DfID. This was not possible to do in detail for all the regions. Estimation figures were therefore also based on general poverty assessment figures taking as a reference value 1 USD per day. The average size of a forest fringe farming is estimated generally to 1.5 ha. (Millenium Ecosystem Assessment Report 2005).

- Wood extraction: Commercial benefits are calculated as wood harvested multiplied by an average market price. Degradation patterns (mainly wood extraction) have been calculated on yield loss over a 25 years period of time. E.g. unsustainable extraction in a given forest (in two interventions) can be 80 m3/ha average price of a cubic meter of timber 200 USD, occurring over 25 years: (80x200) / 25 = 640 USD. Data basis: ITTO Market News Bulletin (www.itto.or.jp), FAO Forest Stat.; ITTO (2006).

5. Lowest investment required to compensate the opportunity costs (in Million USD per year)

In the regional tables this variable was estimated for each driver as the result of multiplying the area of deforestation per driver (3) by the benefits per ha (4). This determines the income that won't be received if this area is not deforested/degraded (opportunity cost per drivers in each region).

For the global estimates this variable was calculated adding the regional values per driver as estimated in tables 2 – 8.

6. Lowest C compensation prices per tCO_2 per year

This variable was calculated dividing the total benefits per year (all regions) of each driver by a constant value of tCO2/ha.

The constant value of tCO2/ha (315 tCO_2/ha) is based on FAO data for above and below ground biomass only as a conservative approach. This figure is calculated as the average of the figures indicated for Western and Central Africa, Eastern and Southern Africa, South East Asia, East Asia, Caribbean and Central America and South America as presented by Marklund and Schoene (2006). This approach facilitates also monitoring C over time with a higher certainty.

7. Lowest C compensation prices per tC per year

This variable was calculated dividing the total benefits per year (all regions) of each driver by a constant value of tC/ha.

The constant value of tC/ha (86 tCO_2/ha) is based on FAO data for above and below ground biomass only as a conservative approach. This figure is calculated as the average of the figures indicated for Western and Central Africa, Eastern and Southern Africa, South East Asia, East Asia, Caribbean and Central America and South America as presented by Marklund and Schoene (2006). This approach facilitates also monitoring C over time with a higher certainty.

1.2.2. Global estimates

Table 1 present the global results for all variables. Data on rates of deforestation for each driver has been estimated based on the total area of DD (3) as the addition of the values in the regional tables in relation to a total DD of 12.9 millions of ha.

Data on global benefits per driver (**(USD/ha^{-1})** has been estimated dividing the total benefits of each driver as the addition of the values per region by the area of DD per driver.

Table 1. Minimum investment flows for REDD based on opportunity cost of forest conversion per conversion category in the most important regions for deforestation and forest degradation

1	2	3	4	5	6	7
Main direct drivers	**Rate of DD (% of total)**	**Area of DD (Million ha^{-1})**	**Global benefits (USD/ ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**	**Lowest C compensation prices per tCO2 per year (bases: 315 tCO2/ha)**	**Lowest C compensation prices per tC per year (bases: 86tC/ha)**
1. Commercial agriculture						
1.1 Commercial crops	20	2.6	2247	5774.18	7.13	26.13
1.2 Cattle ranching (large scale)	12	1.6	498	801.35	1.58	5.79
2. Subsistence farming						
2.1 Small scale agriculture/shifting cultivation	42	5.5	392	2148.13	1.24	4.56
2.2 Fuel-wood and NTFP gathering	6	0.75	263	196.95	0.83	3.05
3. Wood extraction						
3.1 Commercial (legal and illegal)	14	1.8	1751	3187.4	5.56	20.36
3.2 Fuel-wood/charcoal (traded)	5	0.70	123	85.96	0.39	1.43
Total	**100**	**12.9**		**12193.97**	16.74	61.32
Average					**2.79**	**10.22**

Table 1b: GHG emissions reductions per scenario

Region	DD Reduced (million of ha^{-1})	Carbon factor (tCO2/ha)	Total reduction per region (in GtCO2/year)
Scenario 1: zero emissions by 2030			
Eastern and Souther Africa	1,7	292,8	0,50
Northen Dry Africa	0,98	120,78	0,12
Western and Central Africa	1,36	724,68	0,99
South SE Asia and Pacific	3,21	442,86	1,42
Central America and Mexico	0,55	563,64	0,31
South America	4,25	512,4	2,18
Other regions	0,86	329,4	0,28
Total	**12,9**		**5,79**
Scenario 2: emission reduction to be expected at a carbon price of USD 2.8 tCO2			
Eastern and Souther Africa	1,28	292,8	0,37
Northen Dry Africa	0,8	120,78	0,10
Western and Central Africa	0,88	724,68	0,64
South SE Asia and Pacific	1,64	442,86	0,73
Central America and Mexico	0,44	563,64	0,25
South America	2,89	512,4	1,48
Other regions	0,6	329,4	0,20
Total	**8,53**		**3,76**

Table 1b shows the proportion of emission reductions that can be expected yearly and per regions. Carbon factors were calculated for all carbon pools excluding COS from data provided by Marklund and Schoener, 2006.

1.2.3. Estimates per region

Social-economic conditions, agricultural land-use and forest use are different region by region and country by country. Global estimates alone will not suffice and a country-by-country analysis is not a feasible approach at this moment, nevertheless needed for future, more in-depth analysis[4].

For the present analysis, the six regions that are net forest carbon emitters have been considered according to FRA 2005. The figures correspond to the net loss of forest (in thousand of hectares) for countries with a negative change in forest area according to FRA 2005. Since this change takes into account afforestation and natural forest increase in each of the countries in the region, the absolute deforestation area might be even higher. However, the fact that in many countries there is no full assessment available on the fate of deforested areas (some of them might naturally grow back into forests through secondary succession immediately after clearing), the proposed figure can be assessed as relatively solid.

The regions considered in the calculations are:

Regions	Area of DD('000 ha)
▪ Eastern and Southern Africa	1702
▪ Northern Africa (Dry Africa)	982
▪ Western and Central Africa	1356
▪ South, SE Asia and Pacific	3207
▪ Central America and Mexico	545
▪ South America, tropical and subtropical	4251
▪ *Other countries outside the regions*	*857*
Total of all regions considered	**12,900**
Total DD in the six tropical regions assessed	12,043

[4] Some pilot projects on REDD have been initiated in various developing countries and will produce relevant information in a short period of time

I. Eastern and Southern Africa[5]

The estimates for Eastern and Southern Africa are presented in table 2

Table 2. Minimum investment flows for REDD based on opportunity cost of forest conversion per conversion category in Eastern and Southern Africa

1	2	3	4	5
Main direct drivers (1)	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.2	0.34	1670	567.80
1.2 Cattle ranching (large scale)	0.1	0.17	330	56.10
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.5	0.85	350	297.50
2.2 Fuel-wood and NTFP gathering	0.05	0.09	250	21.25
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.05	0.09	640	54.40
3.2 Fuel-wood/charcoal (traded)	0.1	0.17	160	27.20
Total	**1**	**1.7**		**1024.25**

Data in table 2 was estimated based on the remarks in Box 1:

Box 1: Remarks in regard to table 2: Eastern and Southern Africa

Main direct drivers	**% of total DD**		**Benefits (USD/ha^{-1})**	
	Remarks	Value	Remarks	Value
1. Commercial Agriculture				
1.1 Commercial crops	Variety of situations due to different climatic and socio-economic conditions. Most of the countries forest-poor, deforestation mostly on heavily degraded forest land	20	Commodity prices of a variety of commodities, including cotton, pulp, tobacco, sugar cane, sweet potato, cassava. Compiled from FAOSTAT, highest prices taken	1670
1.2 Cattle ranching (large scale)	Only in few countries of relative importance	10	Bovine meat data, compiled from FAOSAT	330
2. Subsistance farming				
2.1 Small scale agriculture/shifting cultivation	Heavy population pressure on remaining forests due to poverty	50	Expert judgment, based on project work and shadow pricing, 1 USD per day	350
2.2 Fuel-wood and NTFP gathering	Fuelwood is the most important energy source, NTFPs additional income source	5	Based on shadow prices for charcoal fuelwood, medicinal plants and other NTFPs	250
3. Wood extraction				
3.1 Commercial non-sustainable (legal and illegal)	A region with few commercial timber harvesting and relatively low value timber stocks	5	30 m3 valued 200 USD, and service wood of undefined quantify, all mainly local markets (expert judgment)	640
3.2 Fuelwood/Charcoal (traded)	Commercial fuelwood market mostly informal	10	Basis: 100 m3 x 2 over 25 years, 20 USD per m3 (FAOFORSTAT)	160

[5] In this region mining is an important driver of deforestation, thought not very important in total area, but through its indirect impacts. However, as mining has not been considered in this calculations, the data of mining as driver in easttern and southern Africa has been included in the other drivers

II. Northern Dry Africa

The estimates for Northern Dry Africa are presented in table 3.

Table 3. Minimum investment flows for REDD based on opportunity cost of forest conversion according to the direct drivers in Northern Dry Africa

1	2	3	4	5
Main direct drivers	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.15	0.15	1540	226.38
1.2 Cattle ranching (large scale)	0.3	0.29	330	97.02
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.3	0.29	350	102.90
2.2 Fuel-wood and NTFP gathering	0.12	0.12	280	32.93
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.03	0.03	400	11.76
3.2 Fuel-wood/charcoal (traded)	0.1	0.10	65	6.37
Total	**1**	**0.98**		**477.36**

Data in table 3 was estimated based on the remarks in Box 2:

Box 2. Remarks in regard to table 3: Northern Dry Africa

Main direct drivers	**Share of total DD**		**Benefits (USD/ha^{-1})**	
	Remarks	Value (%)	Remarks	Value
1. Commercial Agriculture				
1.1 Commercial crops	Area where the main tropical cash crops are on their growth limit. Mainly cotton, in future maybe jatropha	15	Cotton, sorghum, groundnuts, medium prices, FAO AgriSTAT, highest prices chosen	1540
1.2 Cattle ranching (large scale)	Traditional extensive livestock grazing over wide areas	30	Extensive, FAOSTAT	330
2. Subsistance farming				
2.1 Small scale agriculture/shifting cultivation	Forest-fringe areas are the only interested areas for cultiviation	30	Same basis as for East Africa	350
2.2 Fuel-wood and NTFP gathering	Fuelwood main energy source, NTFP for fodder	12	Shadow prices for NTFP, in particular fodder and fuelwood	280
3. Wood extraction				
3.1 Commercial non-sustainable (legal and illegal)	A region without major timber stocks	3	1 m3 per ha valued 350 USD and a certain amount of service wood	400
3.2 Fuelwood/Charcoal (traded)	Commercial fuelwood market mostly informal	10	Basis: 40 m3 X 2 over 25 years, 20 USD per m3 (FAOFORSTAT)	65

III. Western and Central Africa

The estimates for Western and Central Africa are presented in table 4.

Table 4. Minimum investment flows for REDD based on opportunity cost of forest conversion according to the direct drivers in Western and Central Africa

1	1	3	4	5
Main direct drivers	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.2	0.27	2125	578.00
1.2 Cattle ranching (large scale)	0.05	0.07	330	22.44
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.5	0.68	450	306.00
2.2 Fuel-wood and NTFP gathering	0.05	0.07	250	17.00
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.15	0.20	1200	244.80
3.2 Fuel-wood/charcoal (traded)	0.05	0.07	100	6.80
Total	**1**	**1.36**		**1175.04**

Data in table 4 was estimated based on the remarks in Box 3:

Box 3: Remarks in regard to table 4: Western and Central Africa

Main direct drivers	Share of total DD		Benefits (USD/ha^{-1})	
	Remarks	Value (%)	Remarks	Value
1. Commercial Agriculture				
1.1 Commercial crops	Traditional expansion zone for commercial crops since colonial times; still forest land reserves available for expansion	20	Cocoa, palm oil, sugar cane, rubber, cassava and others, FAO AgriSTAT, medium of 3 highest priced crops chosen	2120
1.2 Cattle ranching (large scale)	In the more semi-arid areas with savannah like forest areas (carbon stock poor)	5	In selected countries and semi-arid areas, same figures as in table 2	330
2. Subsistance farming				
2.1 Small scale agriculture/shifting cultivation	Pressure in forest-fringe areas high due to opening-up of closed forest areas by roads; pressure will increase over the next 25 years	50	Many of small-scale agriculture is market driven (source: Swiss funded project work and Grien-Gran (2006)	450
2.2 Fuelwood and NTFP gathering	NTFP gathering (including fauna and flora) of increasing importance	5	In particular charcoal and NTFP forest products harvesting; ITTO (2006)	250
3. Wood extraction				
3.1 Commercial non-sustainable (legal and illegal)	Area with heavy pressure on unsustainable logging, increasing efforts on forest management	15	50 m3 in 2 intervals of forest degradation, 300 USD per m3	1200
3.2 Fuelwood/Charcoal (traded)	Charcoal becomes more and more a formal business on unsustainable basis	5	Basis: 100 m3 x 2 over 25 years, 12 USD per m3 (FAOFORSTAT)	100

IV. South, SE Asia and Pacific

The estimates for South, SE Asia and Pacific are presented in table 5.

Table 5. Minimum investment flows for REDD based on opportunity cost of forest conversion according to the direct drivers in South, SE Asia and Pacific

1	2	3	4	5
Main direct drivers	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.24	0.77	2500	1926.00
1.2 Cattle ranching (large scale)	0.01	0.03	330	10.59
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.4	1.28	525	674.10
2.2 Fuel-wood and NTFP gathering	0.05	0.16	300	48.15
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.25	0.80	2735	2194.84
3.2 Fuel-wood/charcoal (traded)	0.05	0.16	100	16.05
Total	**1**	**3.21**		**4869.73**

Data in table 5 was estimated based on the remarks in Box 4:

Box 4: With regard to table 5: South, SE Asia and Pacific

Main direct drivers	**Share of total DD**		**Benefits (USD/ha^{-1})**	
	Remarks	Value	Remarks	Value
1. Commercial Agriculture		(%)		
1.1 Commercial crops	Commercial crop areas expanding due to high investment interests	24	Palm oil, soybean, rubber, pulp, cobra, groundnut, pineapple: medium of 3 highest priced crops chosen	2500
1.2 Cattle ranching (large scale)	Still marginal, but demand for land might increase considering the ever increasing demand for bovine meat in Asia	1	Figure estimate from a pantropical assessment (FAOSTAT, ILRI documentation)	330
2. Subsistance farming				
2.1 Small scale agriculture/shifting cultivation	Different situations in the least development and more developed countries in Asia. High pressure on forest-fringe areas in Mekong region	40	A mix of small-scale agriculture with market access and shifting cultivation, basis: 1.5 USD income per day (CIFOR)	525
2.2 Fuel-wood and NTFP gathering	NTFP gathering of importance in some regions a a major degradation driver	5	Unsustainable high priced NTFP gathering as a main degradation driver in some regions (CIFOR)	300
3. Wood extraction				
3.1 Commercial non-sustainable (legal and illegal)	The area where non-sustainable harvesting of wood can lead to important loss of carbon stocks (high % of commercially interesting timber species. Wood extraction is a main driver of DD	25	In many Asian countries highly stocked dipterocarp forests, high degradation potential with high market prices: 180 m3 x 2 per 190 USD , calculated over 25 years (ITTO 2006)	2735
3.2 Fuelwood/Charcoal (traded)	Mainly in least development countries	5	As in table 4	100

V. Central America and Mexico

The estimates for Central America and Mexico are presented in table 6.

Table 6. Minimum investment flows for REDD based on opportunity cost of forest conversion according to the direct drivers in Central America and Mexico

1	2	3	4	5
Main direct drivers	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.1	0.06	1900	104.50
1.2 Cattle ranching (large scale)	0.2	0.11	450	49.50
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.45	0.25	350	86.63
2.2 Fuel-wood and NTFP gathering	0.1	0.06	250	13.75
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.1	0.06	960	52.80
3.2 Fuel-wood/charcoal (traded)	0.05	0.03	95	2.61
Total	**1**	**0.55**		**309.79**

Data in table 6 was estimated based on the remarks in Box 5:

Box 5: With regard to table 6: Central America and Mexico

Main direct drivers	**Share of total DD**		**Benefits (USD/ha^{-1})**	
	Remarks	Value (%)	Remarks	Value
1. Commercial Agriculture				
1.1 Commercial crops	Limited expansion of commercial crops in forest-fringe areas	10	Banana, tree crops, sugar cane, palm oil, FAOSTAT	1900
1.2 Cattle ranching (large scale)	Traditionally a main DD driver, limited expansion possible if meat market increases as predicted	20	Based on a relative market price of 1.5 USD per kg; potentially higher valued than in South America	450
2. Subsistance farming				
2.1 Small scale agriculture/shifting cultivation	Main driver in forest-fringe areas, but mainly in secondary forest zones	45	Based on the USD 1 per day income assessment on 1 ha of productive area	350
2.2 Fuel-wood and NTFP gathering	Fuelwood main energy source in rural areas	10	Shadow market price of fuelwood as basis for fuelwood gathering	250
3. Wood extraction				
3.1 Commercial non-sustainable (legal and illegal)	In some of the countries also an underlying cause of deforestation	10	40 m3 in 2 intervals of forest degradation, 300 USD per m3	960
3.2 Fuelwood/Charcoal (traded)	Develops into a formal market in many of the countries	5	Basis: 80 m3 x 2 over 25 years, 15 USD per m3 (FAOFORSTAT)	95

VI. South America

The estimates for South America are presented in table 7.

Table 7. Minimum investment flows for REDD based on opportunity cost of forest conversion according to the direct drivers in South America

1	2	3	4	5
Main direct drivers	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.2	0.85	2400	2040.00
1.2 Cattle ranching (large scale)	0.2	0.85	620	527.00
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.4	1.70	350	595.00
2.2 Fuel-wood and NTFP gathering	0.05	0.21	250	53.125
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.12	0.51	980	499.80
3.2 Fuel-wood/charcoal (traded)	0.03	0.13	110	14.03
Total	**1**	**4.25**		**3728.95**

Data in table 7 was estimated based on the remarks in Box 6:

Box 6: With regard to table 7: South America

Main direct drivers	**Share of total DD**		**Benefits (USD/ha^{-1})**	
	References	Value (%)	References	Value
1. Commercial Agriculture				
1.1 Commercial crops	In some of the countries high potential for capital intensive conversion	20	Soy bean, palm oil, pulp	2400
1.2 Cattle ranching (large scale)	Was a main driver in the past, might become important in the forest-fringe regions if global meat demand increase as predicted	20	Difficult to estimate dollar figures for extensive cattle ranching (estimates vary between 10 and 660 USD)	620
2. Subsistance farming				
2.1 Small scale agriculture/shifting cultivation	Colonialization of forest-fringe areas still a major driver of DD	40	Based on the USD 1 per day income assessment on 1 ha of productive area	350
2.2 Fuel-wood and NTFP gathering	NTFP gathering might increase over time as degradation driver	5	Shadow market price of fuelwood as basis for fuelwood gathering	250
3. Wood extraction				
3.1 Commercial non-sustainable (legal and illegal)	With more access to forest, there is a considerable higher potential for degradation of carbon stock loss in future	12	35 m3 in 2 intervals of forest degradation, 250 USD per m3	980
3.2 Fuelwood/Charcoal (traded)	Potential to grow into formal markets (bioenergy)	3	Basis: 90 m3 x 2 over 25 years, 15 USD per m3 (FAOFORSTAT)	110

VII. Other countries

These are countries with a net loss of forest, which are located outside the regions considered (e.g. Mongolia, Russia Federation, Australia). The estimates for other countries are presented in table 8

Table 8. Minimum investment flows for REDD based on opportunity cost of forest conversion according to the direct drivers in other countries (e.g. Mongolia, Russian Federation)

1	2	3	4	5
Main direct drivers	**Share of total DD**	**Area of DD (Million ha)**	**Benefits (USD/ha^{-1})**	**Lowest investment required to compensate the opportunity costs (in Million USD per year)**
1. Commercial agriculture				
1.1 Commercial crops	0.15	0.13	2500	322.50
1.2 Cattle ranching (large scale)	0.1	0.09	450	38.70
2. Subsistence farming				
2.1 Small scale agriculture/shifting cultivation	0.5	0.43	200	86.00
2.2 Fuel-wood and NTFP gathering	0.05	0.04	250	10.75
3. Wood extraction				
3.1 Commercial (legal and illegal)	0.15	0.13	1000	129.00
3.2 Fuel-wood/charcoal (traded)	0.05	0.04	300	12.90
Total	**1**	**0.86**		**599.85**

Data in table 8 was calculated based on general estimates on a global assessment

2. FOREST MANAGEMENT

2.1. What would it cost to bring tropical production forests under (sustainable forest management, in costs per ha) in the year 2030?

The basic assumption is that the production forest area remains the same as today in the year 2030. The basis for the cost estimates is the ITTO Expert panel report on estimating the costs to achieve the ITTO Year 2000 Objective on Sustainable Forest Management (can be obtained in ITTO, www.itto.or.jp) ; this report was produced in 1995, based on a analysis using Criteria and Indicators for SFM. The report estimated the costs for all tropical production forests in ITTO member countries (about 350 million ha), to US$ 6.25. Considering present values 2007 (5% devaluation factor), this would correspond to about 12 US$ per ha. That figure is used to estimate the costs to bring tropical production forests under SFM by the year 2030.

For non-annex tropical and subtropical countries, the cost estimate for achieving (sustainable) forest management would therefore be around 7.3 billion US$. For developing, non-annex 1 countries with temperate and boreal forests that have potential to increase carbon stocks through forest management, the amount of 20 US$ per ha as indicated by Whiteman (cited in TRINES might be appropriate. An additional 1 billion US$ can be estimated as cost of forest management for these countries.

2.2. What is the additional C-sequestration potential of forest management?

Global forest vegetation stores 283 GtC in its biomass and an additional 39 GtC as deadwood, for a total of 322 GtC. Total carbon content of forest including soils to a depth of 1 m is 798 GtC (FAO 2006 figures, in FRA 2005).

Unsustainable forest management degrades living biomass and reduces the carbon stocks in forests. Sustainable forest management (SFM) keeps carbon stocks at an optimal level and uses at an optimum the elastic capacity of a given forest ecosystem. The elastic capacity describes the dynamic forest processes within a range of changing vertical forest structure, species composition, biodiversity, carbon stocks and productivity normally associated with the natural forest type expected at a given site.

Under managed forests we understand here that a natural forest that is managed for sustainable timber and non-wood harvesting (e.g. through integrated harvesting and silvicultural treatments), wildlife management and other uses have resulted in changes of forest structure and species composition. All major goods and service functions, including the maintenance of carbon stocks, are maintained intact.

Through sustainable forest management, additional carbon sequestration can be reached, first through planned silvicultural management, based on optimization of yield and increase of faster growing, light demanding species. Forest restoration is another very important carbon sequestration strategy that could be addressed through forest management, but also through REDD (see main document on Forest Management, sent 1.8.2007). In addition forest management can reduce GHG emissions through reduced impact logging and other measures, including improvements in transport.

We estimate here only the sequestration potential that comes from the optimization of the elastic capacity of a given forest ecosystem. Basis is an increased growth (in m3) of timber per region. Each forest ecosystem has its own growth characteristics. Estimates per region are based on silvicultural experiences in natural forest management. Sources are different documents of ITTO, in particular ITTO (2006) and Yield prediction tables of FAO (FAO-For-STAT). In the estimate 1tC = 2 m3 of wood.

Two approaches to estimate the sequestration potential of forest management are proposed. The first one, based on FAO global figures, as presented by TRINES, includes all tropical areas. Nevertheless, the total production forest area is rather on the upper side. The second approach, more conservative, uses figures from ITTO, is closer to a reality in tropical countries. Indeed, the area includes only classified production forest areas that potentially is or will be used for forest management.

<u>Estimate for Non tropical countries:</u>

Additional potential in developing countries outside the tropics and in countries in transition: 287.7 MtC/yr in 2030 (Trines report, from IPCC)

In summary:

- ✓ Total carbon sequestration potential in tropical countries from forest management in 2030: between 1.1 and 1.5 GtC (the first figure based on ITTO for highly productive tropical forests; the second figure based on FAO for the entire tropical region)

- ✓ Total carbon sequestration potential in developing non tropical and countries in transition: 0.3 GtC

- ✓ No calculation is presented for Annex-1 countries, as it is supposed that the majority of their production forests are managed in a sustainable way and that there is only low potential for additional carbon sequestration through forest management.

- **Total costs to bring the production forest under (sustainable forest management): 8 billion US$**
- **Total carbon sequestration potential from forest management in tropical and non-annex 1: 1.8 GtC**
- **Cost per tC for SFM: 8 billion US$ / 1.8 GtC = 4.4 US$ per TC or 1.2 US$ per tCO2**

Table 9: Approach 1: Proposed summary of production forests (source for production forest areas FAO 2006, extract from Trines report, 2007)

	Area of production forest (x1000 ha)	Cost estimate for SFM (US$ per ha)	Global estimate of carbon in biomass (tC per ha)*	Forest managed area at a 25-years rotation basis 2005-2030 ('000 ha)	Additional annual growth potential through SFM (m3 per ha and yr)	Increased sequestration potential per ha through FM*** tC	C additional sequestration potential in the year 2030 (Mt C)
Total Eastern and Southern Africa	43,948	527 million	63.5	1.758	2.8	1.4	62
Total Northern Africa	46,129	554 million	26.0	1.845	0.5	0.25	12
Total Western and Central Africa	123,912	1487 million	155.0	4.956	5.8	2.9	359
Total East Asia	125,369	1505 million	37.3	5.015	3.5	1.75	219
Total South and Southeast Asia	120,046	1440 million	77.0	4.802	7	3.5	420
Total Caribbean, Central America & Mexico	46,645	560 million	119.4	1.866	6	3	140
Total South America	96,459	1158 million	110.0	3.858	5.5	2.75	265
Tropics	**602,185**	**7231 million**	**84**	**24.100**	**4.4**	**2.2**	**1477**

*Source: Marklund and Schoene, 2006

***: Expert estimation on the basis of ITTO, 2006 and FAO, 2006.

Table 10: Approach 2: Table using figures of production forests (only natural forests) from ITTO (ITTO 2006)**

	Total area of production forests (only natural forests)	Area with Forest Management Plans	Additional costs to bring the production forest under SFM by 2030*	tC of additional sequestration of C through SFM	C additional sequestration potential in the year 2030

	('000 ha)	('000 ha)	('000 USD)	(tC per year)	(Gt C in 2030)
Africa	70.461	10.016	845.000	2.9	0.20
Asia and Pacific	97.377	55.060	1.169.000	3.5	0.34
Tropical America	184.727	31.174	2.217.000	2.875	0.53
TOTAL	**352.565**	**96.250**	**4.232.000**		**1.08**

* Based on 12 USD per ha (ITTO Expert Panel report 1995, in today's value)

** 33 tropical timber producing countries, covering about 90% of the humid tropical forest area

3. FOREST RESTORATION

What is missing in the actually discussed approaches in forest and climate mitigation is the entire field of restoration, which is indeed probably the most promising option in forestry for restoring carbon stocks. Restoration is a combination of planting trees and human induced natural regeneration within a degraded forest area[6] but that has lost most of its carbon stock. Forest restoration hence is a strategy applied in degraded primary forest areas. Forest restoration aims to enhance and accelerate natural processes of forest regeneration (including carbon stocks) in order to regain the elastic capacity of the forest ecosystem.

Forest Restoration is an issue in ALL non-annex 1 countries where REDD is also considered.

Forest restoration potential: about 850 million ha (see table below).

- Considering an average carbon stock of 30 t C/ha in living carbon pools (above and below ground biomass) in degraded forests this would total to 25 Gt of carbon pantropical
- Fully stocked, these 850 million ha would amount to 57 GtC
- Hence the maximum potential to restore carbon stocks from forest restoration would amount to 32 GtC
- Taking a price of USD of 12 per t of carbon, as today paid by CDM A/R, there would be an additional potential of about USD 38 billion which has not been included in the A/R CDM for the first commitment period. Nevertheless, this activity should be considered for a post-2012 forest mitigation regime.

Table 11: Estimated Extent of Degraded Forest Landscapes by Category in Tropical Asia, Tropical America and Tropical Africa (million ha) in Year 2000*.

	ASIA 17 COUNTRIES	**TROP. AMERICA** 23 COUNTRIES	**AFRICA** 37 COUNTRIES	**TOTAL**
Degraded primary and secondary forest	145	180	175	500
Degraded forest land	125	155	70	350
Total	270	335	245	850

Source: Blaser and Sabogal (2002): ITTO Guidelines for Forest Restoration and Secondary Forest Management

*Authors' estimates. Based on FAO (1982, 1990, 1995, 2001); Sips (1997); Wadsworth (1997); WRI-World Bank (2000). In tropical America, about 38 million ha are classified as secondary forests (second-growth forests). For the other regions it is not possible to distinguish between degraded primary forests and secondary forests

Forest restoration can be included as a separate activity or integrated in REDD. In the present document we include forest degradation in analysing the opportunity cost in REDD. It means that the potential emission reduction was considering in this first chapter. The tables presented in this third chapter refer to the sequestration potential of restoration activities. To understand this difference and to consequently promote restoration as a sequestration activity will promote a more effective mitigation path while improvement of livelihood and conservation of biological diversity.

Linking REDD, A/R, Forest Restoration and Forest Management is indeed the most promising strategy to address the forest mitigation option!

[6] Forest degradation: The reduction of the capacity of a forest to produce goods and services. 'Capacity' includes the maintenance of ecosystem structure, functions and carbon stocks

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