Costs of Sustainable Forest Management in the Tropics
- State of Knowledge

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Thünen Working Paper 27

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Content

1 Introduction

1.1 Objective of the report

This report summarises existing knowledge on costs of sustainable forest management (SFM) in tropical and sub-tropical forests. First, the scope of forest-related cost studies and background information on definitions of and obstacles for SFM are given (Sections 1 and 2).

The main part of this report gives a review on existing studies about costs of SFM and answers the questions:

- What is known about costs of SFM? And who is researching in this field?
- How reliable are the existing estimates?
- Which research gaps still exist?

The different studies' findings are summarised and compared among each other. Furthermore, the coverage and reliability of the existing figures are evaluated.

The main question of this report "What are the costs of **sustainable forest management** in **tropical and sub-tropical primary forests**?" is not addressed and answered directly by any study. Therefore, studies which tackle part of the problem are included in the review. Section 1.2 gives an overview of the broad scope of forest-related cost studies. Under this scope the studies, which are reviewed in the following, are classified and the study review in this report (Section 3) is structured accordingly.

The report concludes on further research needed (Section 4).

1.2 Scope of forest-related cost studies

Cost studies are conducted at different scales and are related to different geographical regions of the world. This report concentrates on global or larger regional studies, rather than single site specific case studies. All cost studies are imperatively related to certain land use categories, e.g., 'forest land under sustainable forest management', 'forest land under protection', 'agricultural land use', etc. Cost studies on SFM focus mostly on the costs for the introduction of SFM on existing forest land. Opportunity cost studies of avoided deforestation, on the other hand, compare the net revenues from at least two different land use categories, mostly non-forest to forest land uses.

All land use categories can roughly be classified in forest and non-forest land uses. Forest land can be further classified in protected and not protected forest land. Protected forest land is often considered in cost studies as the alternative to deforestation. Here, no forest management and neither costs nor positive net revenues from the forest land are assumed, usually for reasons of simplicity. Unmanaged forest lands without protection status are usually not addressed by cost studies.

The production forest land (with any kind of forest product utilisation) can be classified in the categories sustainably and unsustainably managed forest land, in which the first is the main target object in this report (see Figure 1).

Non-forest land uses contain all land use forms not covered by forest land. The most important ones in the present context are different agricultural land uses and pastures, but also land for infrastructure and settlements can be addressed. In general, only profitable land use forms are considered as the next best land use option for the calculation of foregone profit.

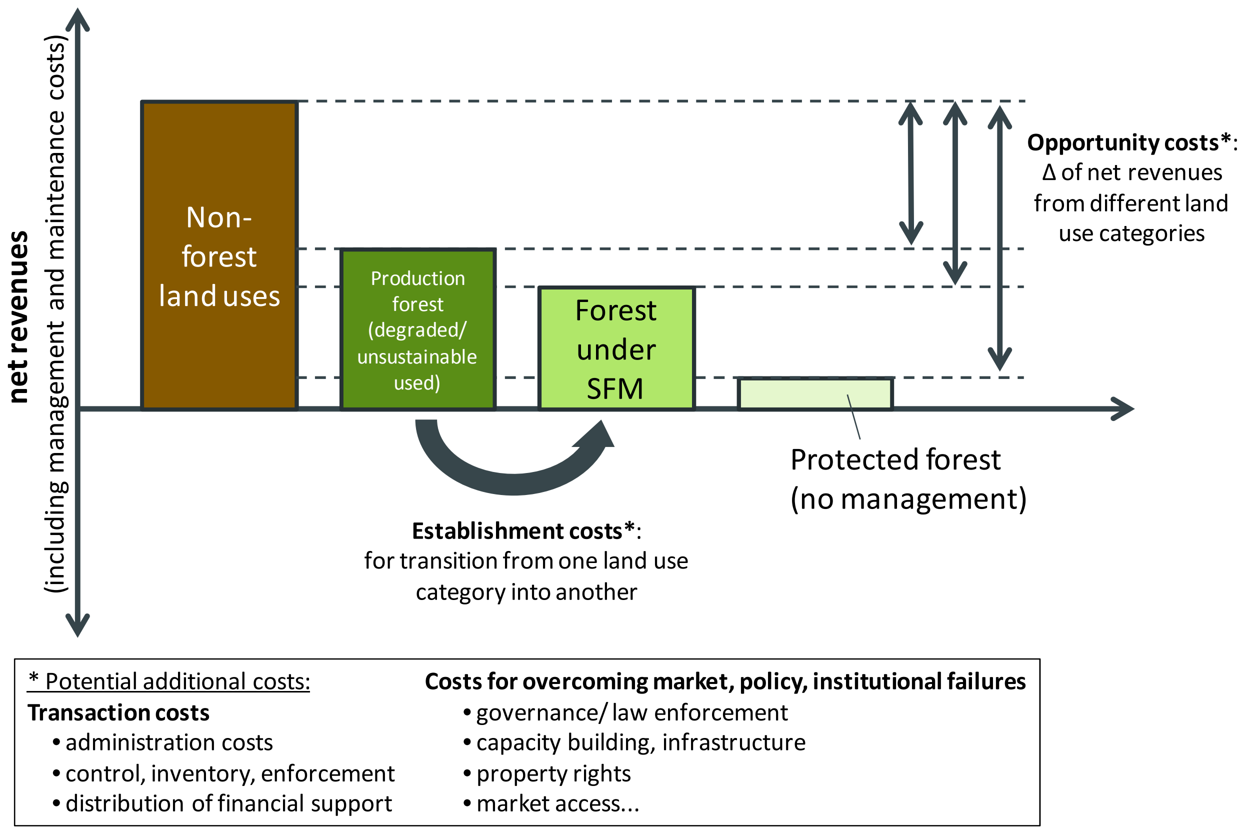

Figure 1: Scope of forest-related cost studies.

Each land use category is subject to input and output flows, which sum up to net revenues or net expenses related to the area considered. The area related revenues occur mainly from harvesting and commodity production (e.g., timber, crops, cattle), but could also result from payments for service production (e.g., recreation, biodiversity, carbon sequestration). The related expenses are mainly management and maintenance costs.

Most studies considering **costs of SFM** consider the conversion of unsustainably managed forest land in sustainably managed forest land and the maintenance of the latter status. They do not address opportunity costs of avoided deforestation (foregone profits of an alternative land use), but the different establishment costs, which occur when converting the existing forest land to the sustainable land use, e.g., costs for rehabilitation, introduction of management plans, for capacity building and inventories. If the introduction of SFM takes place by waiver on an alternative profitable land use, opportunity costs have to be added to the establishment costs of SFM. If, however, there is no alternative land use possible, e.g., due to legal restrictions, the opportunity costs of avoided deforestation are zero. Costs of SFM do not necessarily have to be negative, as positive net revenues might result from forest management, which exceed the invested establishment costs. The increase of revenues from forest management can also diminish the opportunity costs of avoided deforestation, i.e., the gap between net revenues from forest management and alternative land uses. This option, however, has not been considered by any of the investigated studies.

For considering opportunity costs of avoided deforestation, the deviance of net revenues from two land use categories has to be assessed and compared. Most studies consider the **opportunity costs of avoided deforestation** in the context of climate change. Here, the net revenues from the envisaged land use category, which in this context is a certain type of forest land use, is compared to the foregone net revenues from the next best land use alternative (mostly non-forest land, e.g., agriculture). The envisaged reference case is often defined as unmanaged protected forest land (without net revenues). This is mainly conducted for reasons of simplicity, and represents an overestimation of opportunity costs of avoided deforestation, when transferred to forest land under management. Some studies, however, directly consider the land use category of managed forest land as a reference, but without consideration of sustainability criteria. In this case net revenues from forest management have to be opposed to the net revenues from the foregone profits of the alternative land use. Usually, the net present values of all expected revenues and expenses in a certain time horizon are calculated, by a defined discount rate (Körner, 2010).

Studies on the avoidance of deforestation and forest degradation are mostly conducted before the context of climate change mitigation. Here, the forest protection is a means to avoid carbon emissions. Therefore, such studies often consider the abatement costs of carbon emissions and relate the opportunity costs of avoided deforestation to tonnes of carbon avoided, rather than to area directly. However, area related opportunity costs per area are inherent to those considerations.

Besides opportunity and establishment costs, further costs apply. Those costs might occur for administration, distribution of financial support or for control and inventory purposes (transaction costs), or might occur to overcome market, policy or institutional failures (see Figure 1). Those additional costs are only partly addressed by most studies, but are disclosed in this report when available.

Besides the private benefits for the land owner, public goods (ecosystem services) are associated to the existence and condition of any land use category, which might be related to public benefits for which potential payments (e.g., PES – payments for ecosystem services like REDD[1]) exist or are possible. Those payments would increase the net revenues from the respective land use category and will, thus, increase its profitability and change the related opportunity costs. Considered the other way around, the total opportunity costs of the next best land use option represent the maximum compensation payment for the land owner, to protect a forest area and its inherent ecosystem services, which might decrease in the case of PES payments. A review of studies assessing those public values is, however, not included in this report.

In this report, the review of cost studies on forest-related activities is subdivided in studies on:

• Costs of (S)FM	Considering establishment of SFM on existing forest land.	Section 3.1
• Opportunity costs of avoided deforestation	Considering forest land in comparison to non-forest land.	Section 3.2

[1] REDD = reducing emissions from deforestation and forest degradation

2 Background information

2.1 Sustainable forest management (SFM) – Definition

There is no commonly agreed-on definition for sustainable forest management (SFM), although several processes aimed to operationalise the concept of SFM (see Costa et al. (1999), Ch. 2.1).

The Ministerial Conference on the Protection of Forests in Europe (MCPFE) in 1993 defined SFM as:

> *"The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems."* (MCPFE, 1993).

The '**Forest Principles**' were adopted at **the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992** (UNCED, 1992). A result of the Forest Principles was the initiation of the **Montreal Process in 1994 as a 'Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests'**. According to the Montreal Process criteria for sustainable forest management were defined as follows:

> *"Maintenance of forest ecosystems health and vitality, of productive capacity of forest ecosystems, of forest contribution to global carbon cycles and of long-term multiple socioeconomic benefits to meet the needs of society, conservation of biological diversity and of soil and water resources"* (Costa et al., 1999; Montreal Process, 2009).

The United Nations Forum on Forests (UNFF) defined SFM for the **non–legally binding instrument (NLBI) on all types of forests in 2007** as follows:

> *"Sustainable forest management as a dynamic and evolving concept aims to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations."* (UNFF, 2007).

The International Tropical Timber Organisation (ITTO) defined SFM as:

> *"Sustainable forest management is the process of managing forests to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment."* (ITTO, 2014).

Under the **REDD+ framework of the United Nations Framework Convention on Climate Change (UNFCCC)** SFM is also addressed. The sustainable management of forests (SMF) is one of the five activities envisaged under the REDD+ system (REDD+ = "reducing emissions from deforestation and forest degradation and the conservation and enhancement of forest carbon stocks and the sustainable management of forests") (UNFCCC, 2011). However, a definition of SMF is not explicitly given.

2.2 Obstacles and recommendations for sustainable forest management

Douglas and Simula (2010) identify the main obstacles for SFM not being effective so far. They see the main obstacles in social and economic policy programmes (on trade, development, agricultural expansion), which do not directly address forest issues, but do have an indirect influence on the forest sector. Furthermore, they state, that for forest-related stakeholders (e.g., government forests, forest owners, local communities …) no (sufficient) incentives are given in opposition to competing self interests, like livelihood interests. Rather perverse incentives are existent, which oppose the objectives of SFM.

However, the authors do not see technology gaps or wrong management goals, as the main influencing obstacles for SFM.

UNFF (2003) see obstacles to SFM in market and policy failures, which decrease the profitability of SFM and in perverse incentives and higher profits in other economic sectors, which favour deforestation and forest degradation.

For reaching SFM, Costa et al. (1999) recommend to avoid false (institutional) incentives, which support non-sustainable use of forests and to give value to non-marketed forest goods and services. In timber production and carbon sequestration, also Pearce (2001), sees the greatest economic values of the forest.

3 Study review

3.1 Costs of sustainable forest management

Estimates on the global costs of sustainable forest management (SFM) are rare, and most existing studies are relying on rough assumptions and are outdated. An overview on the cost estimates for SFM by different studies is given in this chapter in two parts. Cost estimates and related studies are listed in Table 1a and 1b and the scope, methodologies and assumptions behind the cost estimates are summarised subsequently.

The first Table (1a) lists the oldest cost studies on SFM, originating from UNCED (1992) and UNDP (1996), about whose background assumptions only little is known. Information on the scope and assumptions behind these cost estimates are summarised subsequently to the table. These studies consider the global scope in their estimates and assume a short time period for introducing SFM. They result in much higher cost estimates than the studies described in the second part (listed in Table 1b). Table 1b lists the estimates by a study from the UNFCCC (2007, updated 2008), which is the most comprehensive and popular study on costs of SFM. This study is based on several pre-studies and literature cited, which are listed as well in Table 1b and are summarised subsequently to the table. Cost estimates from Whiteman (2006, 2007) are accentuated, as those are the origin of several other estimates.

Table 1a: Costs of establishing SFM on existing forest areas (compilation of cost studies part 1).

Billion USD/ year	Considered Scope	Study
31.25	Requirements for introducing SFM worldwide 1993-2000	**UNCED Earth Summit (1992)**
33	Above figure updated	**UNDP Pretoria Workshop (1996)** on “Financial Mechanisms and Sources of Finance for Sustainable Forestry” *(Costa et al. (1999))*
Above estimates extended for costs of deforestation:		
36-45	Depreciation of forest capital due to deforestation on 16.3 million ha/ a from 1993-2000	**Chandrasekharan (1996)** “Status of Financing for Sustainable Forestry Management Programmes” *(Joshi (1998))*

67.25	UNCED (1992) figure adjusted for depreciation of forest capital due to deforestation. Stop 50% deforestation until 2000, 100% by 2010	**IPF - Intergovernmental Panel on Forests (1996)** "International cooperation in financial assistance and technology transfer for sustainable forest management"
>70	UNDP (1996) figure adjusted for costs of deforestation of 16.3 million ha/ a 1993-2000	**IFF - Intergovernmental Forum on Forests (1998)** "Matters left pending on the need for financial resources" based on: **Chandrasekharan (1997)** "International cooperation and resource mobilization for sustainable forestry development"

UNCED (1992), UNDP (1996) AND UPDATES

Among the first global estimates on costs of SFM is the statement by the UNCED 1992, specifying the financial requirements for achieving SFM worldwide within the period 1993-2000 with 31.25 billion USD per year (Tomaselli, 2006). This financial need is including costs for institutional development (8%), resource development (32%), sustainable utilisation (57.6%) and assessment and monitoring (2.4%) (Chandrasekharan, 1997). The estimate has been revised up to 33 billion USD per year at the UNDP Workshop on "Financial Mechanisms and Sources of Finance for Sustainable Forestry" in Pretoria in 1996 (see Costa et al., 1999; Tomaselli, 2006, for an overview on the needs for financing SFM).

As these figures are neglecting economic, social and environmental costs due to deforestation, they have been accordingly adjusted up to 67.25 billion USD per year by IPF (1996), and 70 billion USD per year by Chandrasekharan (1997) and IFF (1998). Thereby, costs of deforestation take more than 50% of total cost estimate. The IPF (1996) estimates the costs of deforestation with 36 billion USD per year, assuming that 50% deforestation will be stopped by the year 2000, and only a minimum deforestation will be left by 2010. IPF assumes an offset of the depreciation of forest capital through investment in resource creation, rehabilitation and improved management, as well as further investment in forest industries, support services, market infrastructure, institutional capability, information generation and intensive forestry in high-yielding forest plantations/production forests. Chandrasekharan (1996, 1997) estimates the depreciation resulting from deforestation with 36-45 billion USD per year. Thereby, he considers the loss of growing-timber stock (disinvestment of forest capital), by assuming a deforestation of 16.3 million ha per year, with 113m^3 timber volume per hectare, at a price of 25 USD/ m^3 (Joshi, 1998). Those costs of deforestation are added to the cost estimates for introducing SFM by UNCED (1992) and UNDP (1996).

Table 1b: Costs of establishing SFM on existing forest areas (compilation of cost studies part 2).

Billion USD/ year	USD/ ha	Area [mio. ha]	Considered Scope	Study
8.2 **7.2** **1.0**	- 12 20*	652 602 50	Bring production forests in developing countries into SFM until 2030 of which: Tropical and sub-tropical *(estimate cited from Blaser, Robledo (2007))* Temperate and boreal *(estimate cited from Whitemann (2006))*	**UNFCCC (2007, updated 2008)** "Investment and financial flows to address climate change"
7.3 **1.0**	12 20*	602 50	Tropical and sub-tropical *(estimate adjusted from ITTO (1995))* Temperate and boreal *(estimate cited from Trines (2007))*	**Blaser, Robledo (2007)** "Initial analysis on the mitigation potential in the forestry sector"
2.2	6.25	350	Additional costs to bring tropical and sub-tropical production forests in developing ITTO countries into SFM 1995-2000 SFM priority actions only *(based on Leslie, Rice (1995))*	**ITTO (1995)** "Approach and Methodology for Estimating Resources and Costs Incurred in Achieving ITTO's Year 2000 Objective"
     2.2 **7.0**	 - -	 350 350	Bring tropical and sub-tropical production forests in developing ITTO countries into SFM 1995-2000 (extrapolation of data from 4 countries) SFM priority actions only All SFM actions	**Leslie, Reis (1995)** "Resources needed by producer countries to achieve sustainable management by the year 2000"
	20 *	-	Temperate and boreal *(estimate cited from Whitemann (2006))*	**Trines (2007)** "Final Report on Investment Flows and Finance Scheme in the Forestry Sector"
	20	-	**Value added** from forest management in dryland forests	**Whiteman (2006, 2007)** "Financing sustainable forestry in the tropics: a global overview"

*wrong citation from Whiteman (2006)

UNFCCC (2007) AND RELATED PRE-STUDIES

The most comprehensive and popular study on costs of SFM is made by the UNFCCC (2007, updated 2008), which is a compilation of results of different pre-studies and further literature reviewed (see Table 1b). The scope of the cost estimate for SFM by the UNFCCC (2007) covers production forests in all developing countries (Non-Annex I countries to the UNFCCC) under the assumption, that the area of production forest remains constant at the level of 2005 according to FAO FRA 2005 data (i.e., 602 million ha for tropical and sub-tropical forests and 50 million ha for temperate and boreal forests) (FAO, 2006). For the different world regions, different areas of production forests are respectively considered (see Table 2). The time horizon assumed for introducing SFM is 25 years (until 2030). Table 2 displays the UNFCCCs' estimates on the annual costs of SFM per world region. For the whole tropics 7.2 billion USD per year are calculated.

Table 2: Cost estimates for SFM in tropical and sub-tropical forests by world regions (according to Blaser and Robledo, 2007, p.23; UNFCCC, 2007, p. 83).

	Area of production forest 2005 [1000 ha]	Cost estimate for SFM [million USD/ a]
Eastern and Southern Africa	43,948	527
Northern Africa	46,129	554
Western and Central Africa	123,912	1,487
East Asia	125,369	1,505
South and Southeast Asia	120,046	1,440
Caribbean, Central America and Mexico	46,645	560
South America	96,459	1,158
Total tropics	602,185	7,231

The cost estimates by the UNFCCC (2007) are mainly based on two pre-studies by Blaser and Robledo (2007, Ch. 2.1 "What would it cost to bring tropical production forests under SFM in the year 2030?") and Trines (2007), which themselves refer to the studies ITTO (1995); Leslie and Reis (1995); and Whiteman (2006); Whiteman (2007) (see

b). Following back the assumptions made for the cost estimates, exposes a weak data background.

UNFCCC (2007) estimate the costs for **reaching SFM on existing areas of production forests** in developing countries. UNFCCC (2007) distinguish between sub-tropical and tropical production forests and temperate and boreal production forests, described in more detail in the following.

Tropical and sub-tropical forests

The costs for increasing the carbon stocks by SFM in sub-tropical and tropical production forests in Non-Annex I countries (7.2 billion USD/ a) are estimated by Blaser and Robledo (2007), who prepared a pre-study for the UNFCCC report. The costs are quoted with **12 USD/ ha** and are multiplied by the respective areas (compare Table 2). This figure has been cited by Blaser and Robledo (2007) from an estimate by the Expert Panel of ITTO (1995), and adjusted for inflation. The mentioned ITTO (1995) report estimates the costs for reaching SFM by the year 2000 in tropical production forests in ITTO member states with 6.25 USD/ ha (related to the area of about 350 million ha). Here, only priority actions for SFM are considered (i.e., reserve all areas likely to remain under forest cover, reserve those forest areas which must be totally protected, identify areas likely to be retained as multiple-use forests that will produce timber, apply a sustained yield that can be derived from multiple-use forests and use low impact logging methods and systems to all timber harvesting in multiple-use forests). The figure of 6.25 USD/ ha is based on calculations from Leslie and Reis (1995), which extrapolated data from four country submissions up to all ITTO member countries (see ITTO, 1995). Therefore, it can be assumed that the global cost estimates by the UNFCCC (2007, 2008) for SFM in all tropical and sub-tropical forests are based on economic data from four countries only.

Details on the kinds of costs included in the estimates are not given by UNFCCC (2007); (2008) and Blaser and Robledo (2007).

Temperate and boreal forests

For increasing carbon stocks through SFM in temperate and boreal production forests in developing (Non-Annex I) countries the UNFCCC (2007, 2008) refers to costs of **20 USD/ ha** (total of 1 billion USD/ a). For this figure they cite Whiteman (2006). It can, however, be assumed, that this citation is no direct citation but rather taken from the UNFCCC's pre-study by Blaser and Robledo (2007) as well. Blaser and Robledo (2007, p. 21) include the respective statement about the costs of SFM being 20 USD/ ha in their report, but cite it as a secondary citation by Trines (2007) who cited Whiteman (2006). The report by Trines (2007) is a pre-study for the UNFCCC 2007 report as well. Trines (2007) cites Whiteman (2006) as a direct citation (p. 43), saying Whiteman (2006) estimated the costs of SFM in dryland forests with 20 USD/ ha. However, Trines (2007) misinterprets Whiteman's statement at this point. Whiteman (2006) is giving no statement on costs for SFM. He estimates the value added for production in dryland forests under regular forest management with 20 USD/ ha (i.e., positive net revenues from forest management without referring to any sustainability criteria, nor to SFM establishment costs). The source, which is a conference presentation rather than a citable review study, furthermore does not include detailed information on the background of this estimate. In a personal communication with Adrian Whiteman, he confirms that this rough estimate on value added is not giving information on the costs of SFM. More information on the estimates by Whiteman will be given in the next sub-section.

Concluding one can say that the stated estimate of 20 USD/ ha, applied by Blaser and Robledo (2007); Simula (2008); Trines (2007) and UNFCCC (2007) for estimates of the global costs of SFM in temperate and boreal forests, is simply a mistaken citation.

WHITEMAN (2006)

In a presentation from Whiteman (2006, 2007) at the International Tropical Forest Investment Forum, he presents the value added from forest management and for harvesting in primary forests. Thereby, he compares dryland and moist tropical forests as average values over all developing countries (see Table 3).

Table 3: Value added from harvesting and forest management according to Whiteman (2006).

	Dryland forests	Moist tropical forests
Harvesting in primary forests (one-time) Value added [USD/ ha]	500	3,000
Forest management Value added [USD/ ha and year]	20	100

Although, we have no indication on the costs of SFM from this study, we have estimates on net revenues achievable from the land use category forest land. For the calculations Whiteman considers the value added per cubic metre of timber production. Therefore, the total value added in forestry (taken from national income accounts) is divided by the quantity of the total industrial round wood production (Whiteman 2013 personal communication). The considered cases result in an average value added of 50-100 USD/ m^3. The value added per cubic meter is multiplied by the timber production quantities per ha. For the **one-time harvesting** estimates in virgin forest or well-stocked secondary forest the average harvesting amount per ha at the time of harvest is assumed to be between 10 and 30 m^3/ ha. This results in an one-off net revenue between 500 and 3000 USD/ ha (see Table 3). For the estimates on **regular forest management** interventions the value added per cubic meter is multiplied by the average annual growth per ha and year (Whiteman 2013 personal communication). Here, annual net revenues between 20 and 100 USD/ ha are achievable (see Table 3).

Without discounting, accumulated revenues from regular forest management achieve the revenue from the one-time harvest after 25-30 years (considering net present values, the values equal after an even longer time period). By the calculations one can see that timber production from regular forest management interventions in developing countries is attributed a low level of value added and that it can hardly compete with one-time harvesting. Same holds for net revenues from commercially managed alternative land use forms (compare next Section Figure 3).

3.2 Opportunity costs of avoided deforestation

Most of the studies on the costs of forest-related activities have been conducted in the context of climate change mitigation. They were aiming at answering the question what forest-based climate change mitigation activities would cost, whereby, they basically focus on the climate change mitigation activity of avoided deforestation. Table 4 lists the most comprehensive cost studies on the opportunity costs of avoided deforestation on the global or larger regional scale. Among them the study by the UNFCCC (2007), which also considers the cost of SFM (see Section 3.1) and of afforestation and reforestation (not analysed in the present report).

The scope, methodologies and assumptions behind the opportunity cost estimates of the studies listed in Table 4 will be summarised one after the other in the following.

Table 4: Opportunity costs of avoided deforestation (compilation of cost studies).

Billion USD/ year	Considered Scope	Study
12.2	100% stop of deforestation and degradation from 2004 to 2030, in developing countries (12.9 million ha/ a)	**UNFCCC (2007, updated 2008)** "Investment and financial flows to address climate change" based on: **Blaser, Robledo (2007)** "Initial analysis on the mitigation potential in the forestry sector"
5 initially 3 - 6.5, 4 - 8	stop of 50% of global deforestation within 10 years stop of 46% of global deforestation within 30 years, 100% avoided deforestation in 8 countries (6.2 million ha/ a)	**Stern et al. (2006)** " The Economics of Climate Change" based on: **Grieg-Gran (2006, updated 2008)** "The Cost of Avoiding Deforestation"
(NPV) 247 115 138	stop deforestation in Brazil within 10 years stop of 100% (conserve 330 million ha) stop of 94% stop 100% outside protected areas	**Nepstad (2007)** "REDD. The costs and benefits of reducing carbon emissions from deforestation and forest degradation in the Brazilian"

17-33	stop of 50% of global deforestation until 2030 *(estimate is based on Opportunity Costs from Stern et al. (2006))*	**Eliasch (2008)** “Climate Change: Financing Global Forests”
  0.4-1.7 17.2-28	stop global deforestation 2005-2030 stop of 10% stop of 50%	**Kindermann et al. (2008)** “Global cost estimates of reducing carbon emissions through avoided deforestation”
  5 20 50	stop global deforestation until 2020 stop of 20% stop of 50% stop of 67%	**Boucher (2008)** “Out of the woods. A realistic role for tropical forests in curbing global warming”
25 30	stop of 90% of global deforestation stop of 94.6% of global deforestation *(estimate is based on Stern et al. (2006) and Naidoo, Iwamura (2007))*	**Strassburg et al. (2009)** “Reducing emissions from deforestation - The ‘‘combined incentives’’ mechanism and empirical simulations”

UNFCCC (2007, Ch. 4.4.7) and Blaser, Robledo (2007)

The scope of the UNFCCC (2007, updated 2008) study covers avoided deforestation in developing countries worldwide. The relevant areas for avoided deforestation are quantified according to FAO FRA 2005 data, which results in 12.9 million ha per year globally. It is assumed that all deforestation is avoided until 2030.

The forest area, considered as the envisaged reference area for the opportunity cost calculation, is assumed to be under conservation, i.e., no forest management is conducted and, therefore, no net revenues are opposed the opportunities. The study does not consider investment and maintenance costs of alternative land uses, administrative costs, transaction costs and upstream investment costs.

The UNFCCC (2007, updated 2008) estimates the opportunity costs of avoided deforestation in developing countries in total with 12.2 billion USD per year until 2030. For this purpose, the study considers the relevant area for avoided deforestation and forest degradation and the unit costs per ha for the relevant alternative land uses (opportunities). Those figures are differentiated for different geographical regions, in terms of the considered forest areas and the relevant drivers of deforestation. According to the different drivers of deforestation, different land use options are assumed to be relevant as the next best opportunities in the single regions.

The unit cost for the alternative land use options are multiplied by the respective areas, weighted by the relevant drivers in each region (see Figure 2).

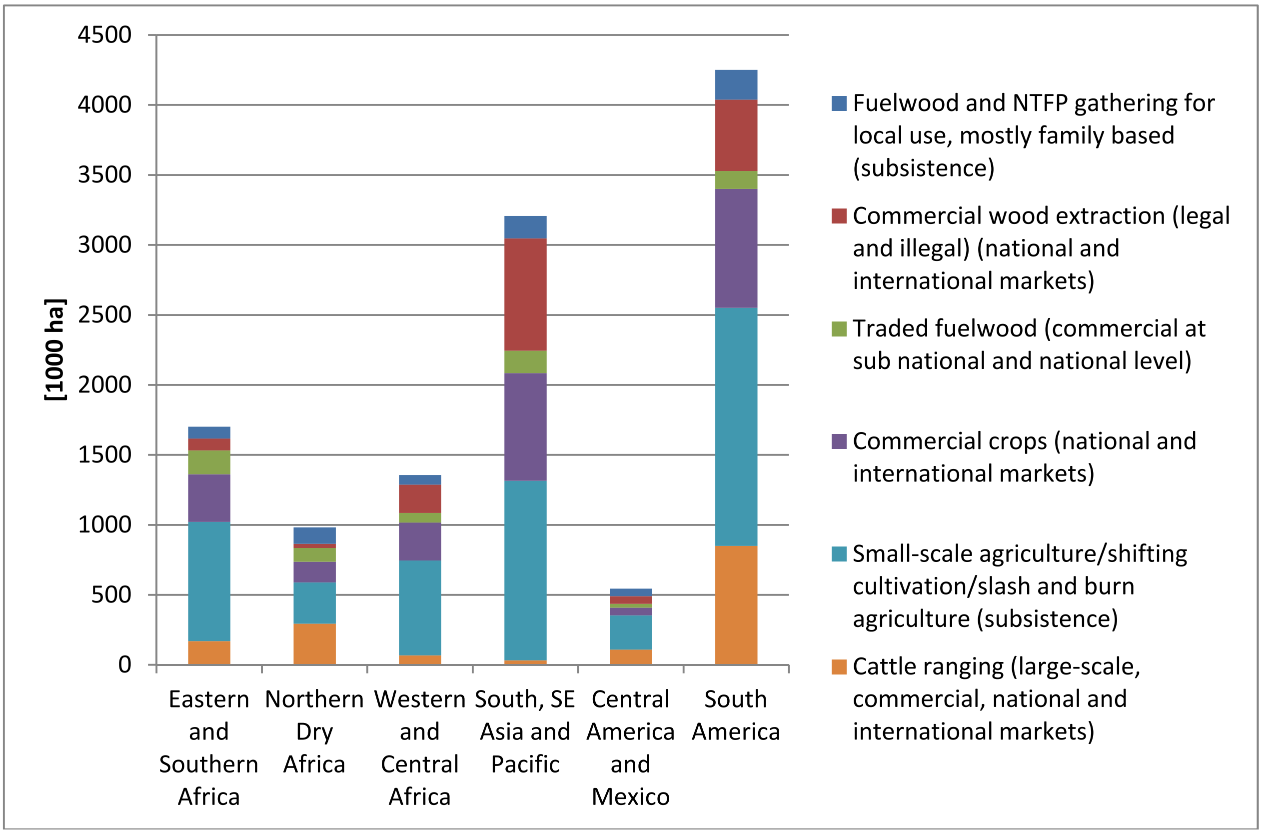

Figure 2: Area of deforestation and forest degradation per driver per world region (Blaser and Robledo, 2007, Chapter 1.2.2).

The unit costs of the alternative land uses (i.e., the net revenues from alternative land uses) are compiled from different data sources (mainly from Blaser and Robledo (2007)) and assigned to the different land use forms (see Figure 3). Blaser and Robledo (2007) distinguish six different land uses for the calculation of net revenues per ha and apply the average yields per main crops per region, multiplied by the average market prices for commercial and shadow values for subsistence agriculture respectively. Blaser and Robledo (2007) do not indicate, whether the unit costs are given per year or as net present values.

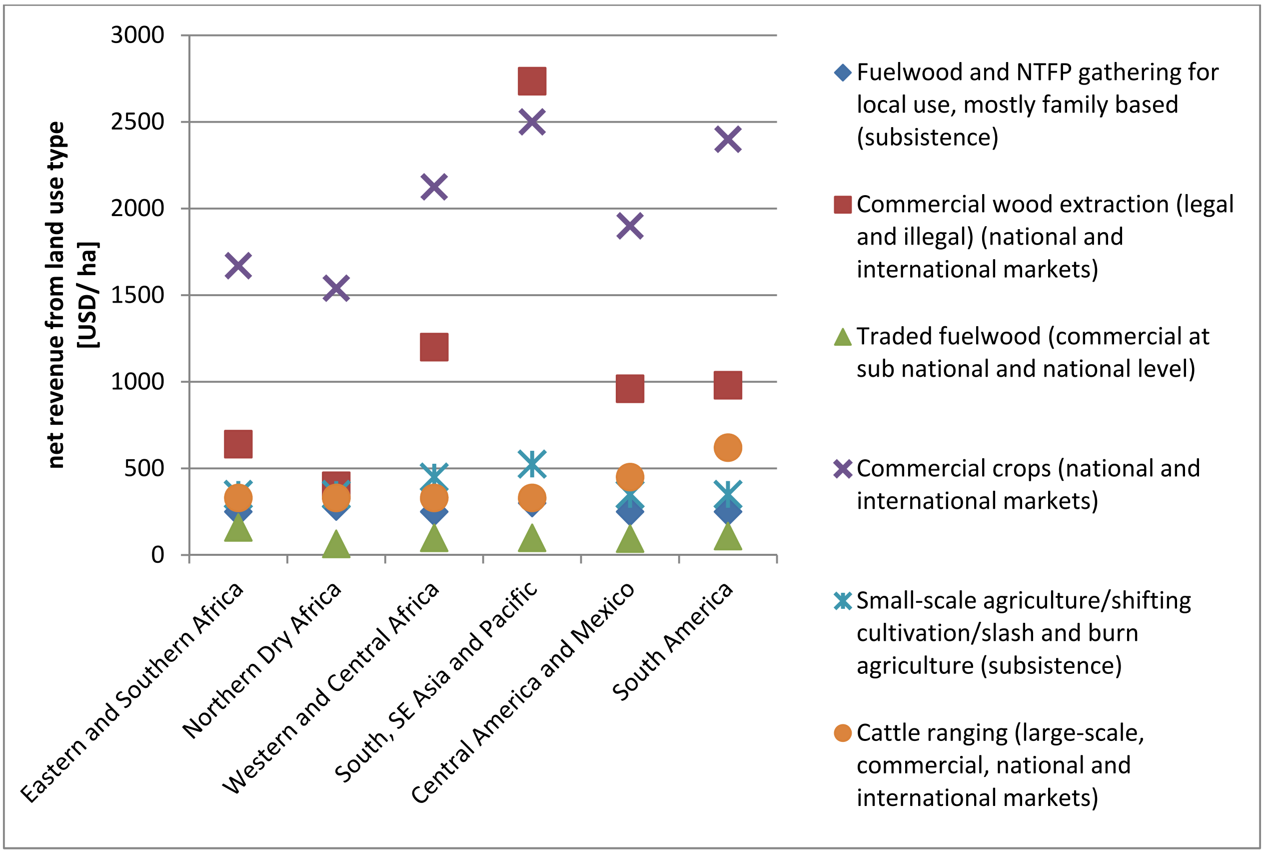

Figure 3: Average net revenues from alternative land uses per region according to Blaser and Robledo (2007, Chapter 1.2.2).

GRIEG-GRAN (2006, 2008) AND STERN (2006)

Grieg-Gran (2006, updated 2008) estimates the costs of avoided deforestation in 8 countries (Bolivia, Brazil, Cameroon, Democratic Republic of the Congo, Ghana, Indonesia, Malaysia and Papua New Guinea) under the assumption, that deforestation is completely avoided in these countries within 30 years without leakage. The considered area of avoided deforestation is 6.2 million ha per year, which sums up to 46% of the global deforestation area in the period 2000-2005 (according to FAO FRA 2005). The considered forest land is under conservation, i.e., no forest management and no revenues from forest management are considered. Hence, SFM is not considered.

For the calculation of the net revenues from the alternatives, both, the net revenues from the alternative land uses (usually agriculture) as well as the net revenues from the one-off harvest conducted at the time of deforestation, are considered. The net revenues from the one-off harvest are considered in three different scenarios (see Table 5).

Table 5: Opportunity costs of avoided deforestation according to Grieg-Gran (2006, 2008).

	Total opportunity costs of avoided deforestation [billion USD/ a]	
Scenarios for inclusion of revenues from one-off harvest	**2006 report**	**2008 update**
No revenues from one-off harvest	3	4
100% revenues from one-off harvest	6.5	8
Partly consideration of revenues from one-off harvest	5	6.6

The estimates from the updated 2008 report are about 1.5 billion USD higher than the estimates from the 2006 report. This increase is mainly caused by a significant increase in the returns to oil palm. Oil palm areas represent a large proportion of the considered next best land use types.

The net revenues per ha from different land use alternatives are based mainly on local level estimates from the considered countries and differ between net present values of 3 and 3,340 USD/ ha (see Figure 4). The calculation is conducted in net present values by a 10% discount rate over a 30 year period.

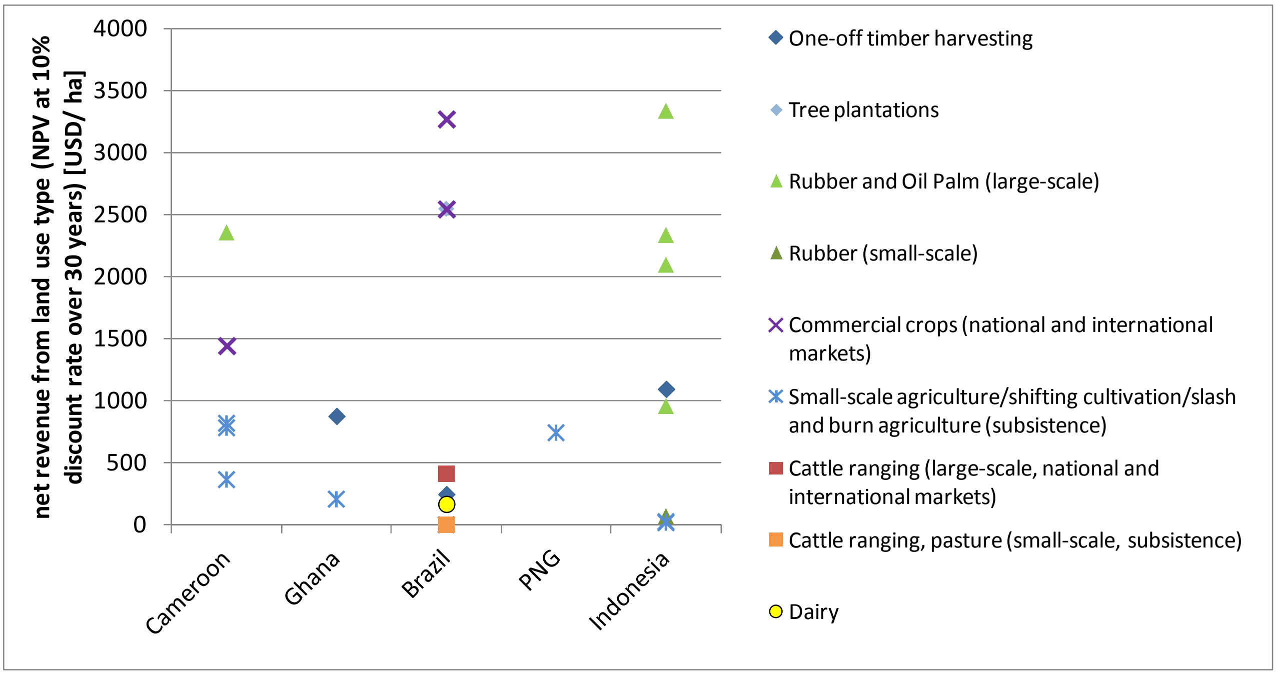

Figure 4: Net revenues from alternative land uses per country according to Grieg-Gran (2008) (different revenues possible per land use option).

Grieg-Gran also includes some considerations on transaction costs for administration and monitoring of payment schemes to avoid deforestation. The average costs for administering a payment scheme are specified with 4-9 USD/ ha, resulting in net present values between 232,920 and 524,070 USD for the total of the eight countries considered (10% discount rate over a 30 year period).

The Grieg-Gran Report from 2006 was prepared for the Stern-Report (2006). Stern (2006) concludes that the annual costs for avoiding 50% of global deforestation would be 5 billion USD per year initially, but would rise over time, as the marginal costs would increase.

NEPSTAD ET AL. (2007)

Nepstad et al. (2007) estimate the costs of forest conservation in Brazil, by calculating opportunity costs of the most important and profitable land uses soy and cattle and opposing them to net revenues from forest management. They apply three spatially explicit models for mapping land rents in Brazil as net present values by a 5% discount rate in a 30 year time horizon. They calculate opportunity costs of avoided deforestation for the whole Brazilian Amazon forest, including protected areas. Conserving all of the Brazilian forest (330 million ha of forest land) results in 247.3 billion USD. Permitting a land use change on 6% of the most profitable land (opportunity costs >10 USD/ tonne of carbon), the total costs of conserving the remaining 94% of forest are reduced by more than half to 114.6 billion USD.

Nepstad et al. (2007) oppose the net present values of timber production to the net present values of agricultural land, which is mostly neglected by other studies. Thereby, the total opportunity costs of avoided deforestation are reduced by about 4%.

ELIASCH (2008)

Eliasch (2008) estimates the abatement costs of reducing 50% of global deforestation until 2030 with 17-33 billion USD per year if carbon trading is conducted. The report considers opportunity costs of avoided deforestation (foregone profits from timber and agricultural commodity sales) as well as costs occurring from forest protection policy and administration (costs for capacity building and policy implementation). The Eliasch-Report is based on the opportunity cost estimates by Grieg-Gran (2008) and Stern (2006) but does not adopt their methodology where it is assumed that each landholder is paid a different price according to the opportunity cost of avoided deforestation for his particular plot of land. Eliasch (2008) rather assumes that the landholders are all paid at the same rate, i.e., the balance point of supply and demand for carbon credits. By this method, he includes rents, which the forest credit sellers receive by supplying their credits below the marginal cost of the last unit of abatement. No individual assessment on land values were conducted for the report.

Kindermann et al. (2008) and Boucher (2008)

Kindermann et al. (2008) and Boucher (2008) both estimate the costs of reducing emissions from deforestation on the basis of marginal cost curves. They apply three economic models of global land use (DIMA, GCOMAP and GTM) for calculating supply curves of emission reduction, which simulate the land use development, depending on economic assumptions on demographic, technological and trade development. All models include land values for different land use types as present values. Details on the model inherent land values and applied interest rates are not on hand. Kindermann et al. (2008) and Boucher (2008) calculate marginal cost curves on the basis of these models by applying carbon prices as incentives to reduce deforestation. Kindermann et al. (2008) assess the time period 2005 to 2030 and their results show annual costs of 0.4-1.7 billion USD per year for reducing 10% of global deforestation and 1.5-2.7 billion USD per year for reducing 50% of global deforestation. Transaction costs and cost to overcome other institutional barriers are not considered.

Boucher (2008) comes to similar results of costs of 5, 20 and 50 billion USD per year to stop 20%, 50% and 67% of global deforestation until the year 2020 respectively.

Strassburg et al. (2009)

Strassburg et al. (2009) estimate global costs of reducing emissions from deforestation on the basis of incentives paid per tonne of carbon emissions avoided. The calculations are based on two databases providing opportunity costs of alternative land uses to deforestation, i.e., Stern (2006) and Naidooa and Iwamura (2007). The first approach applies the net returns per ha for alternative land uses of 8 countries from Grieg-Gran (2008); Stern (2006) and extrapolates them up to all deforesting countries. The second approach applies a global map of economic rents from agricultural land from Naidooa and Iwamura (2007). Naidooa and Iwamura (2007) provide a spatial explicit map of gross rents from land uses, containing actual crop distributions, crop productivities, livestock densities and producer prices. Strassburg et al. (2009) apply a profit margin of 15% to the data to get net revenues per ha.

They conclude that a global emission reduction of 94.5% would be realisable at 29.6 billion USD per year, including 20.9 billion USD per year for incentive payments, 1.1 billion USD per year for transaction costs and 7.6 billion USD per year for forest management and protection costs. Respectively 90% emission reduction could be reached at 25 billion USD per year.

4 Conclusion

4.1 What is known about costs of sustainable forest management? – further need for research?

Two categories of global estimates on the 'costs of sustainable forest management in the tropics' exist, which either estimate the costs for introducing SFM on existing forest land or estimate the opportunity costs of avoided deforestation. However, only few studies exist on the global or larger regional scale, which are mostly of unsatisfying precision and data quality. Most studies apply relevant areas from FAO statistics, while economic returns per ha are usually taken from smaller scale assessments and statistics, which are extrapolated respectively to the considered scope.

The most comprehensive study, which estimates the **costs for introducing SFM** on existing forest land in developing countries worldwide has been published by the UNFCCC (2007, updated 2008). This study does not contain own data acquisitions or calculations, but is compiled out of findings of other studies. The results of the study are cost estimates of 12 USD/ ha for introducing SFM in tropical and sub-tropical forests and 20 USD/ ha in temperate and boreal forests. Those figures, however, are hardly reliable. The primary figure is extrapolated from data of four countries only, while the latter figure is a wrong citation and not applicable at all. Former estimates on the need for financial requirements for financing SFM exist, prepared by UNCED and UNPD. However, the calculations are outdated (related to actions before 2000) and only little is apparent on the assumptions and data quality behind the estimates.

Further research is needed on estimating the costs for introducing SFM on existing forest land, as the existing studies do not provide satisfactory information on the costs of establishment of SFM (costs for implementation, management, capacity building) and on net returns achievable from management of forest land in the tropics. Furthermore, a differentiation by the status of the forests' condition (from untouched to degraded forests at the fringe of forest definition) needs to be conducted.

Several **opportunity cost studies of avoided deforestation** exist on different scales, of which the larger scale studies (UNFCCC 2007 and Stern 2006) apply data compilations on returns per ha of foregone land uses, which they differentiate according to countries or continents. Furthermore, they define the extent of relevant areas of avoided deforestation according to the next best land use options. Most other studies consider abatement costs of emissions from deforestation and are based on opportunity cost databases and models. They are sensitive to assumptions on considered area, time span and discount rates.

The existing global estimates on opportunity costs of avoided deforestation are rough, as they scale up few regional figures to large areas. However, the existing estimates are operational at the global level and the applied methods are comprehensible. The existing global estimates can easily be updated by new areal data, time spans or discount rates, if desired. The methods are transferable to finer scales as well and might be complemented by additional data on net returns per ha of alternative land uses, determined at finer scales. However, such fine scale databases on net returns of different land uses do not comprehensively exist. Spatial heterogeneity does not allow downscaling, and new assessments need to be conducted if finer scale data is desired.

Data on the net returns from SFM/ forest management in the tropics, which need to be offset the opportunity costs from alternative land uses, are almost completely lacking. Only two studies consider revenues from forest management at all, of which Whiteman (2006) gives only rough estimations on an average global value added and Nepstad et al. (2007) gives estimations without disclosing the assumptions behind. Here, comprehensive data on forest growth in tropical and sub-tropical forests is lacking, which differs due to spatial heterogeneity.

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