CDM Forest Sink model

Version 2.01

A USER GUIDELINE

Waterloo, M.J., Wichink Kruit, R.J. and Spiertz, P.H.

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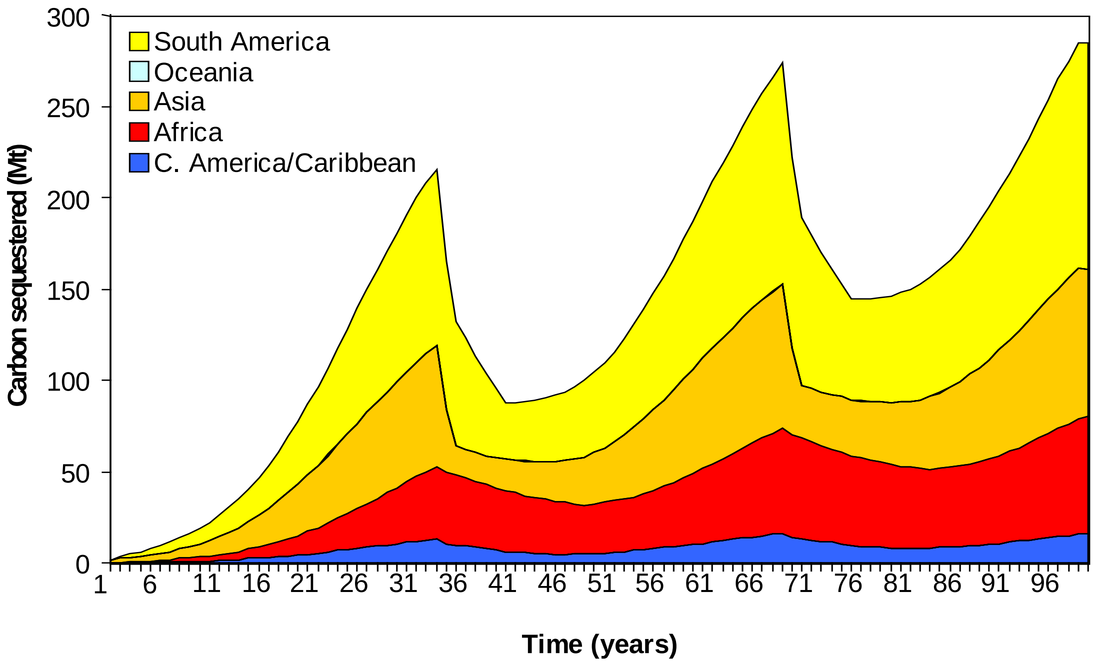

Department of Water & Environment
Droevendaalsesteeg 3, Building 101
P.O. Box 47, 6700 AA Wageningen
The Netherlands

For further information contact:

Dr. Maarten J. Waterloo
Vrije Universiteit Amsterdam
Faculty of Earth and Life Sciences
Phone: +31 20 4447319 (work), +31 20 4123617 (home)
e-mail: watm@geo.vu.nl

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1 Introduction

Alterra developed the Clean Development Mechanism Forest Sink Model (CDMFSM) at the request of the Dutch Ministries of Agriculture, Nature and the Environment (LNV) and of Housing, Spatial Planning and the Environment (VROM). The development of this model was part of a study to investigate the potential carbon sink capacity and costs of afforestation, reforestation and forest conservation projects under CDM for a selected number of developing countries (Waterloo et al., 2000).

In the study, a set of criteria was developed that could be applied to forest sink projects in order for these to be eligible for receiving Certified Emission Reductions (CERs) under CDM. The model allows inclusion or exclusion of these criteria and shows their effect on the carbon sink potentials and associated costs of projects in each country. The potentials are expressed in Mt C, whereas costs are expressed in US dollars per tonne C.

Version 2.0 of the model has an extended country list (69 developing countries included) as compared to Version 1.0 and provides regional overviews for Central America/Caribbean, Africa, Asia, Oceania and South America. In addition, the country information has been updated, the af-reforestation calculations now use a growth model and a “project success rate” factor has been incorporated to estimate potentials and costs taking into account that a certain percentage of projects will fail.

2 Calculation methods and data sources

2.1 Definitions

For the purpose of this study, forests are defined in the sense of their biomass (FAO, 1999). Values for the average biomass of forests for each country have been published by the FAO (1995, 1999, 2001). It is assumed that deforestation involves a complete removal of the forest biomass (i.e. conversion to pasture or some other low-biomass vegetation cover). Afforestation or reforestation is defined as a gradual change from pasture (or some other form of low-biomass vegetation type) to forest on land that has been without forest prior to 1990. Forest conservation projects are defined as projects, which protect existing natural forest from deforestation, thus keeping the biomass at a level equal to that of undisturbed forest. This implies that there is no timber extraction from these forests (e.g. National Park status).

In reality, afforestation/reforestation can occur on land that already has a significant tree cover and the intensity of deforestation may range from low impact activities (shifting cultivation) to high impact activities such as permanent conversion to pasture.

Hence, with the definitions presently used, the estimates given for carbon sequestration must be considered as high impact changes (i.e. conversion to pasture or reforestation of pasture). The actual sink capacity must therefore be considered lower, depending on the type of deforestation and the biomass of the vegetation on deforested lands.

The definition of agro-forestry includes a change from an agricultural practise to a combination of agriculture and forestry. If we ignore the changes in carbon stocks caused by changes in the agricultural crop management practises in this system, it may be viewed as "very low intensity" plantation forestry, with associated low biomass accumulation rates.

2.2 Area assumptions for the calculation of C fixation

The forest carbon sink potential of a country is strongly dependent on the land area that is available for af-/reforestation projects, or on the natural forest area for conservation projects. As such there is a need for realistic estimates of the area available to projects for a proper estimation of the carbon sequestration potentials. CDMFSM was developed to calculate the sink potential, as well as "actual" sequestration rates, by CDM projects using different sets of criteria. A schematic diagram of how potential and actual project available areas are assessed in this spreadsheet model is given in Figure 1 at the end of this section.

2.2.1 Af-/reforestation projects

There is no information readiliy available for the current selection of countries on the actual area being available (and physically) suitable for *af-/reforestation* projects. As such, we followed the assumptions of Nilsson and Schopfhauser (1995) that 3-4% of the agricultural land (source: FAOSTAT database) would be potentially available and physically suitable for such projects. The actual percentages used for countries in different regions are given in Table 1.

Table 1. Fraction of agricultural land in tropical regions that would be available and physically suitable for af-forestation or reforestation projects (Nilsson and Schopfhauser, 1995).

Region	Available and suitable land / total agricultural land
Tropical Latin America	0.030
Tropical Africa	0.036
Tropical Asia	0.040

The potential area (85.7 Mha) is affected by the selection of criteria (**Figure 2**), with the exception of the additionality criterion. Additionality requires that a project needs to demonstrate that it is additional to the "business as usual" in order to receive credits. To account for this criterion, it is assumed that the current planting rate (FAO, 2001) may be taken as a baseline value (i.e. 4.1 Mha y^{-1}). However, a significant part of the current planting is on land that was deforested after 1990. In view of the fact that such land cannot be used for CDM af-/reforest projects, this area should not be taken fully into account in the baseline. The model therefore defines a factor ($0<F_a<1$) by which the current country annual planting rate is multiplied to define the baseline planting rate on the area available for CDM projects. At present, this value is set to 0.35 as a default.

The potential area to be reforested annualy, taking additionality into account, can be expressed as a percentage of the current annual planting rate. For instance, if the percentage is set at 100%, the planting rate becomes double the current annual country planting rate. The sum of the area planted annualy is checked against the potential available area for af-/reforestation and cannot exceed this area. If the potential area is filled, the annual planting rate for CDM projects becomes zero. A plot of the total area planted over 100 years is shown in **Figure 1**.

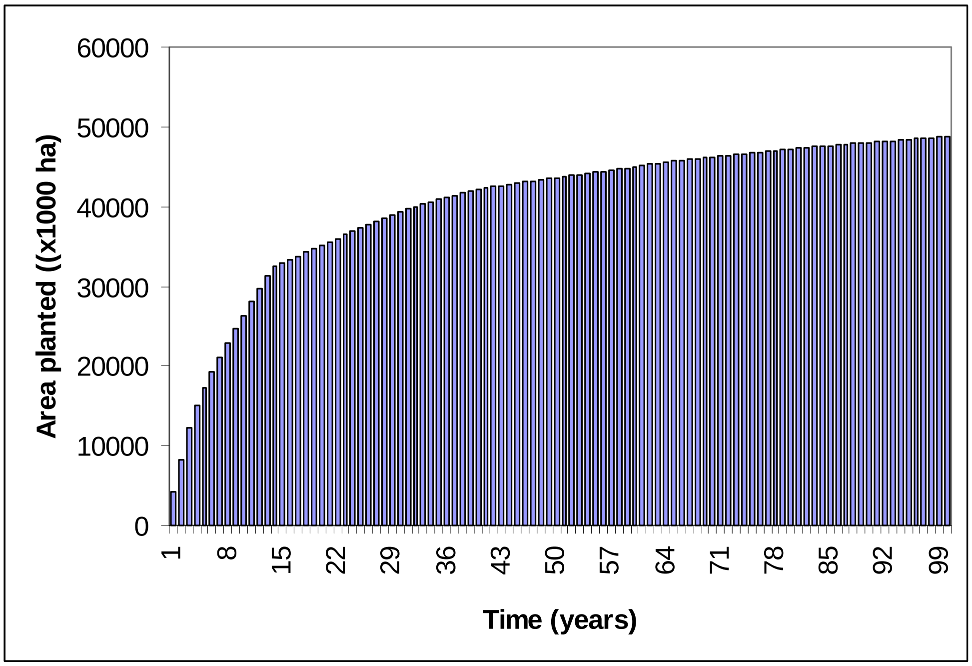

Figure 1. Plot of the total area planted assuming a 100% increase in the current planting rate due to CDM projects and no criteria applied.

2.2.2 Forest conservation projects

In principle, the maximum area available for *forest conservation* projects could be represented by the area presently under forest cover (FAO, 2001). However, conservation projects should be aiming at reducing ongoing deforestation for additionality reasons. This implies that the area for such conservation projects is actually limited to current deforestation rates, assuming that this represents a maximum that could be used in (future) baseline scenarios. To arrive at an estimation for the obtainable reduction in the deforestation rate, we made the assumption that the reduction would be dependent on the country's Gross National Product (***GNP***), the deforestation rate (***DFR***) and the population density (***PD***, defining pressures on the land). The assumed potential reduction (in % of deforestation rate) was calculated according to:

$$\frac{GNP * 100}{DFR * PD}$$

and set to a maximum of 20%. An overview of the countries, their GNP, deforestation rates, population density and the calculated efficiency of slowing down deforestation is given in Table 2. The baseline scenarios are described in the next section.

Table 2. Country's GNP (FAO, 2001), Annual deforestation rates (between 1990 and 2000; FAO, 2001), population density (FAO, 2001) and assumptions on the efficiency of slowing down deforestation in a CDM programme.

Country/region	GNP (US$)	Deforestation (x 1000 ha yr^{-1})	Pop. Density (km^{-2})	Assumed reduction (%)
C. America/Caribbean	1902	-313	85	0.9
Africa Developing	732	-4746	59	3.2
Asia Developing	1000	-601	185	0.6
Oceania Developing	1392	-119	20	4.7
South America	4995	-3711	18	1.8
Total/average	**2004**	**-9490**	**74**	**2.2**
Angola	1409	-124	10	4.5
Argentina	8755	-285	13	9.2
Bangladesh	352	17	975	0.0
Belize	2547	-36	10	20.0
Benin	381	-70	53	0.4
Bhutan	420	0	40	0.0
Bolivia	912	-161	8	3.0
Botswana	3307	-118	3	20.0
Brazil	4514	-2309	20	0.4
Burundi	141	-15	256	0.1
Cambodia	303	-56	62	0.3
Cameroon	587	-222	32	0.3
Central African Republic	341	-30	6	8.0
Chile	4478	-20	20	20.0
China	668	1806	137	0.0
Colombia	1910	-190	36	1.1
Congo	633	-17	8	17.7
Costa Rica	2610	-16	71	9.3
Cote d'Ivore	727	-265	46	0.2
Cuba	1500	28	102	0.0
Democratic Republic of Congo	114	-532	22	0.0
Ecuador	1390	-137	43	0.9
El Salvador	1684	-7	297	3.2
Equatorial Guinea	892	-11	16	20.0
Fiji	2340	-2	44	20.0
French Guyana	27437	0	2	0.0
Gabon	3985	-10	5	20.0
Gambia	342	4	127	0.0
Ghana	384	-120	87	0.1
Guatemala	1350	-54	103	1.0
Guinea	552	-35	30	2.1
Guinea Bissau	232	-22	42	1.0
Guyana	766	-49	4	14.5
Honduras	723	-59	56	0.9
India	392	38	336	0.0
Indonesia	1096	-1312	116	0.0
Kenya	330	-93	52	0.3
Laos	414	-53	23	1.4
Madagaskar	229	-117	27	0.3
Macedonia	1053	0	79	0.0
Malawi	163	-71	113	0.1
Malaysia	4469	-237	66	1.1
Mexico	3304	0	51	0.0
Mongolia	391	-60	2	15.3
Mozambique	131	-64	25	0.3
Myanmar	1000	-517	69	0.1
Nepal	200	-78	158	0.1
New Caledonia	1500	0	12	0.0
Nicaragua	408	-117	41	0.3
Nigeria	239	-398	120	0.0
Panama	2993	-52	38	6.1
Papua New Guinea	931	-113	10	3.2
Paraguay	1946	-123	14	4.7
Peru	2310	-269	19	1.8
Philippines	1170	-89	250	0.2

Rwanda	207	-15	293	0.2
Senegal	554	-45	48	1.0
Sierra Leone	150	-36	66	0.3
Solomon Islands	797	-4	15	20.0
South Africa	3377	-8	33	20.0
Sudan	255	-959	12	0.1
Surinam	940	0	3	0.0
Thailand	2821	-112	119	0.8
Tanzania	183	-91	37	0.2
Uganda	326	-91	106	0.1
Uruguay	6076	50	19	0.0
Venezuela	3499	-218	30	2.2
Vietnam	299	52	242	0.0
Zambia	387	-851	12	0.2
Zimbabwe	656	-320	30	0.3
Total/average	**1715**	**-135.5**	**68**	**3.8**

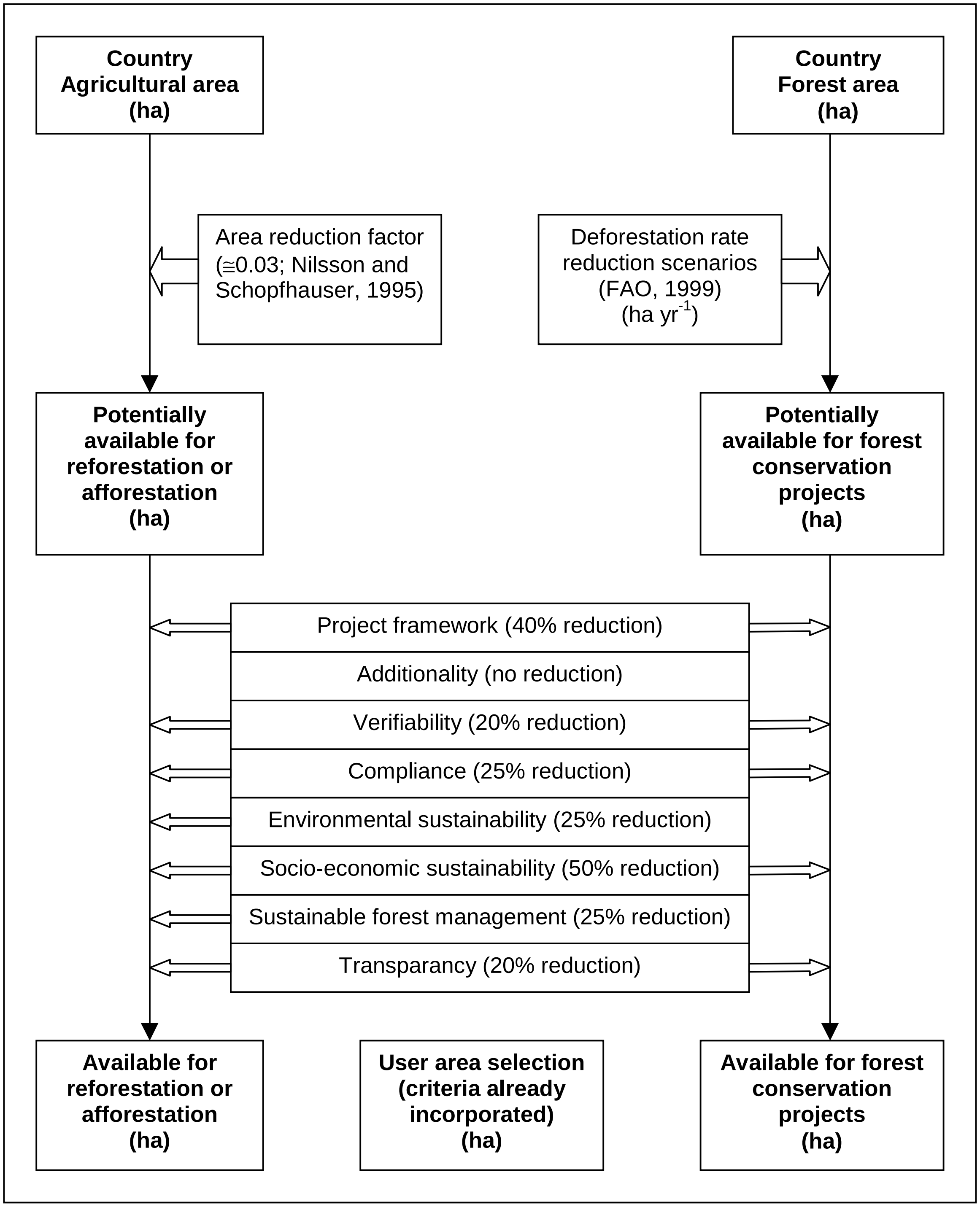

Figure 2. Schematic overview of the assessment of the potential area available to projects and the influence of criteria.

2.3 Forest conservation scenarios

There are many possibilities for formulating combinations of baseline scenarios and project implementation schemes for forest conservation simulation studies and it is difficult to say which would be the most realistic. We have composed five more or less realistic scenarios. To explain the differences between the five scenarios, we added two figures (see end of section) and a description of their characteristics. The first figure (Figure 2) shows the annual forest area conserved for the five scenarios. In Figure 3, the total forest area saved is displayed for the 5 scenarios. The scenarios are described below and examples of their implementation are included for further illustration. The case of Angola will be used as an example for each scenario. The 1990-2000 deforestation rate is used as the Business as Usual (BAU_0) baseline for Angola (FAO, 2001) and amounts to 124,000 ha yr^{-1}. The deforestation rate reduction target for this country is set to 4.5% of BAU_0 (see Table 2). All calculations cover a period of 100 years maximum.

Forest conservation 1:
In this scenario, a fixed percentage of the initial deforestation rate (i.e. the 1990-1995 deforestation rate; FAO, 1999), and therefore a fixed forest area, is conserved each year relative to the BAU_0 baseline assumption. The accumulated forest area conserved shows a linear increase in time. The conservation target is set to zero when there is no additional forest left to conserve anymore due to progressing deforestation in a country. Inclusion of project criteria results in lower annual conservation rates. The green lines in Figures 2 and 3 display the area conserved in this scenario.

For Angola, the cumulative area conserved by conservation projects amounts to 5,600 ha in the first year, 11,200 ha in the second year, etc. The baseline remains at 124,000 ha yr^{-1}, but goes to zero when deforestation has progressed such that there is no forest left to deforest/protect in the country anymore.

Forest conservation 2:
This scenario is basically the same as Forest conservation 1, but with a single forest conservation activity in the first year and no additional conservation activities in consecutive years. As such, this scenario simulates a typical project activity, in which a certain area is selected for conservation in the first year and protected in consecutive years without adding new conservation areas. The forest area conserved drops to zero after the first year and the total forest area saved remains constant in time. This scenario is displayed by the turquoise line in Figure 2 and 3.

In the case of Angola, there would be a single forest conservation activity in the first year, protecting 5,600 ha of forest over the 100-year period.

Forest conservation 3:
This scenario is the most ambitious scenario, in that it aims toward a maximum reduction in the deforestation rates in time. In this scenario the actual deforestation rate decreases by a fixed percentage each year relative to the BAU_0 baseline scenario. The forest area protected increases on an annual basis until the deforestation rate becomes zero. The total forest area protected increases almost exponentially relative to the BAU_0 scenario, but will eventually become linear. This scenario is displayed by the blue line in Figure 2 and 3.

In the case of Angola, the area protected amounts to 5,600 ha in the first year. After the first year, the deforestation rate has been reduced by 5,600 ha yr^{-1} and equals 124,000-5,600=118,400 ha. In the second year, an area the size of another 5,600 ha plus the 4.5% of the remaining deforestation rate has to be protected (i.e. 5,600+0.045*118,400=5,328 ha), in addition to the 5,600 ha protected in the first year. The baseline is kept constant at BAU_0 (124,000 ha yr^{-1}).

Forest conservation 4:
In this scenario the actual deforestation rate decreases by a fixed percentage each year, but the BAU scenario is redefined every year. Relative to the BAU_x scenario (where BAU_x is the deforestation rate of the previous year), the forest area saved per year decreases each year. The total forest area saved relative to the BAU_x scenario increases, but is levelling (becomes constant) in time, because the forest area saved per year approaches zero. This scenario is displayed by the brown line in Figure 2 and 3.

With an initial deforestation rate of 124,000 ha yr^{-1} in Angola, this means that in the first year 5,600 ha of forest is protected. We then assume that the deforestation rate has decreased to 124,000 – 5,600 = 118,400 ha yr^{-1} and the baseline scenario is adjusted accordingly. In the second year, 4.5% of the new baseline (= 5,328 ha) is protected and the baseline is reduced to 118,400-5,328 = 113,072 ha yr^{-1}. This process continues until deforestation reaches zero and the total area conserved in time is thus equal to the initial deforestation rate (124,000 ha in this case).

Forest conservation 5:

In this scenario the actual deforestation rate decreases by a fixed percentage each year as in scenario 4, but the BAU scenario is redefined after every commitment period (5 years). Relative to the BAU_x scenario (where BAU_x is now the deforestation rate at the end of the former commitment period), the forest area saved per year increases within a commitment period. After this commitment period the BAU scenario is redefined and the forest area saved per year becomes the forest area saved per year relative to the new BAU scenario. On long term the forest area saved per year approaches zero. The total forest area saved increases in time and becomes constant on the long term. The increase of the total area saved is largest at the end of each commitment period. This scenario is displayed by the orange line in Figure 2 and 3.

For Angola, this means that the first five years, the baseline is set at 124,000 ha yr^{-1} and the area protected annually ranges from 5,600 ha in the first year to 25,700 ha in the 5th year. The baseline is then adjusted to 124,000-4,700=119,300 ha yr^{-1} and the area protected annually ranges from 4,500 ha in the 6th year to 20,400 ha in the 10th year. The new baseline then becomes 119,300-3,700=115,600 ha yr^{-1} and the process continues until the deforestation rate becomes zero.

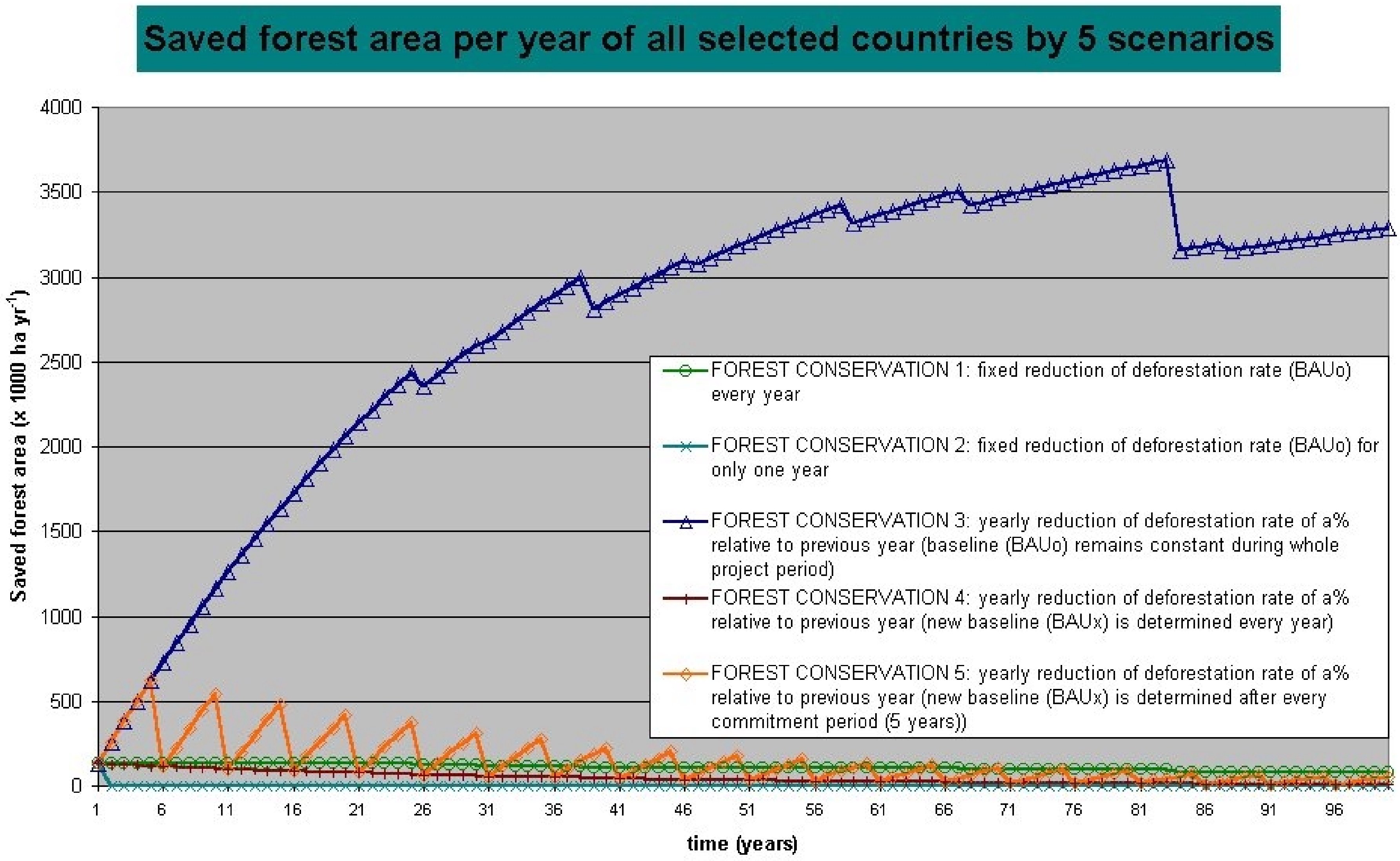

Figure 3. Five scenarios of forest conservation displayed as the saved forest area per year as a function of time.

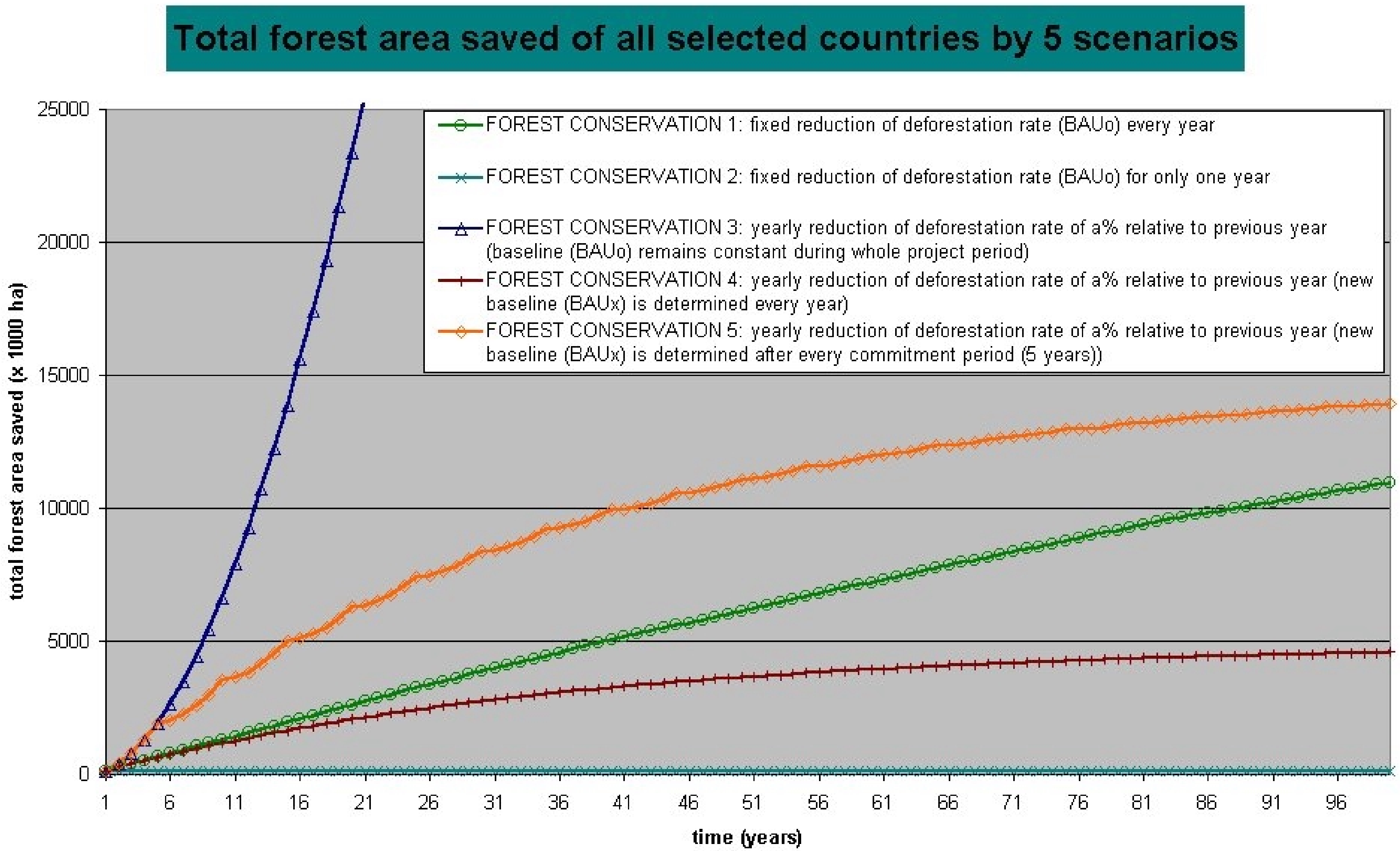

Figure 4. Five scenarios of forest conservation displayed as the total forest area saved as a function of time.

2.4 Influence of criteria on available areas

The area available for af-/reforestation or for forest conservation projects is not static, but is influenced by the adoption of certain criteria in a project. The adoption of criteria has a negative impact on the slowing down of the deforestation rate because only a fraction of the potential area can then be used for CDM projects. For example, sustainable forestry may not be feasible on all available land and adopting this criterion in a project will therefore have a negative effect on the available area. A similar reasoning can be made for other criteria and these criteria all tend to have negative impacts on the available area. Specific weights for area reduction have been assigned to each of the criteria, based on experience from the Dutch FACE projects. Our calculations are such that adoption of a criterion will result in a reduced area equal to multiplication by the weight factor assigned to that criterion. The area reduction factors are given in Tabel 3.

Table 3. Area reductions per criterion.

Project criteria	Area reduction factor (%)	Remarks
Project framework	40	
Additionality	0	Implemented separately in baselines
Verifiability	20	
Compliance	25	
Environmental sustainability	50	0% for forest conservation
Socio-economic sustainability	25	
Sustainable forest management	25	0% for forest conservation
Transparancy	20	

As additionality is a key-element of any CDM project, we suppose that all CDM project initiatives will have to comply with this criterion to be eligible and it can therefore not be switched off in the spreadsheet model. Projects that would not comply with this criterion would not pass the identification phase. Additionality has been included using baseline planting rates for af-/reforestation.

Per definition, existing natural forests satisfy the criteria of environmental sustainability and sustainable forest management. We therefore assume these two criteria to have no impact on the potential project area in case of forest conservation projects. This means that these two criteria are always set to zero (although not explicitly visible for the user in the model) for forest conservation projects.

Criteria only influence the potentially available project area when the option of using potential areas is selected. If you opt to define your own area for the simulations, we assume that the criteria have been taken into account during selection of the area and there is therefore no need for further reduction of the area through criteria.

2.5 Project success rates and sink potentials

The Country Credit Ratings list published by the Institutional Investors Magazine (2001) has been used as a measure of the success rates of projects. When this factor is selected, the potential sink is multiplied by the credit rating (its value ranges between 0.95 for Switzerland to 0.078 for Afghanistan) to account for failed projects (which do not receive CERs). The area and total costs are not affected. However, when this factor is selected, the cost per ton C sequestered increases inversely with the value of the credit rating.

2.6 Carbon sequestration and emission calculations

This section describes the procedures for carbon sequestration calculations. All values of Carbon sequestration, emission or stocks are given in units of C. Units of CO_2 and associated costs can also be provided by setting a parameter in the parameter sheet to 3.67 (i.e. the ratio of the molecular weights of CO_2 and C).

Af-/reforestation:

The biomass increase in a plantation usually follows an S-curve. The biomass remains low in the first few years after planting, then increases more rapidly finally levels off to a maximum value when the plantation matures. Normally, the plantation is logged before reaching maturity and the site replanted. The time between planting and logging is called the rotation period T (in years). A growth model has been implemented in this version of CDMFSM. The biomass at a certain point in the rotation is calculated according to the logistic equation (Cooper, 1983):

$$B(t) = \frac{B_m}{1 + be^{-rt}}$$

where $B(t)$ is the biomass at time t, B_m the asymptotic maximum biomass, r the intrinsic growth rate (calculated somewhat arbitrarily as $\sqrt{T}$ to obtain realistic curves for both short and long rotation periods). The shape parameter b is calculated as:

$$b = \frac{B_m - B0}{B_m}$$

The asymptotic maximum biomass for commercial plantations was assumed to be double the country biomass provided by the FAO (2000). The course of $B(t)$ over time using a rotation length of 35 years is shown in **Figure 5**.

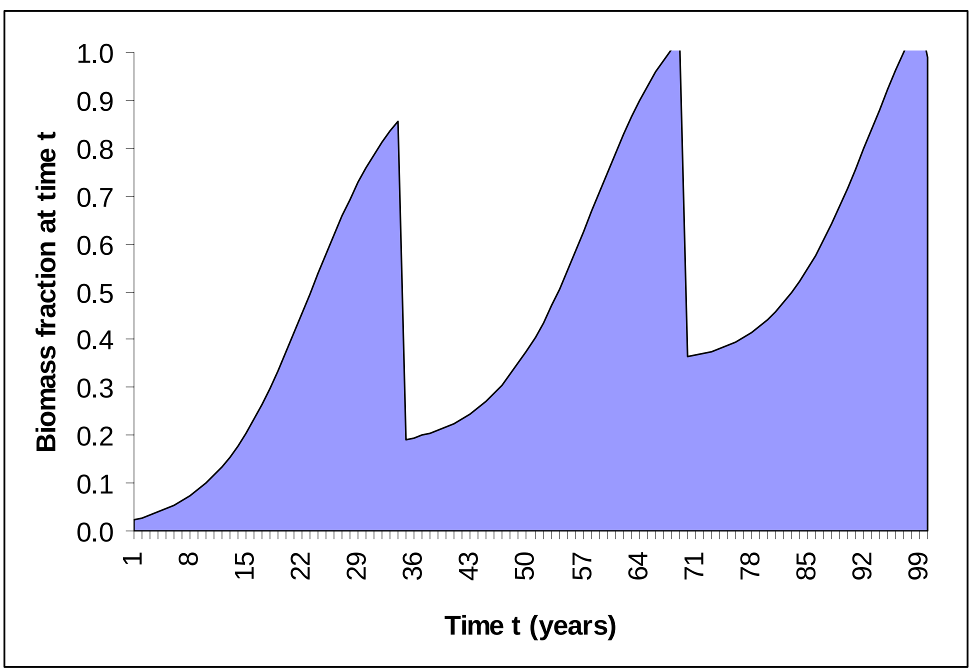

Figure 5. Plot of the ratio of the biomass at time t (=$B(t)$) to the maximum biomass (B_m) over a 100-year period using a rotation length of 35 years.

The carbon sink (F_C , Mt y^{-1}) resulting can be calculated from:

$$F_C = \Delta A_{ref} * B(t) * CC * K_{soil} * K_{CO_2}$$

where:
- ΔA_{ref} is the size of the afforested or reforested area (ha),
- K_{soil} is a correction factor for losses of carbon from the soil and litter layer (1.3; Nilsson and Schopfhauser, 1995),
- K_{CO_2} is a conversion factor to account for the conversion from C units to CO_2 units ($\boldsymbol{K}_{CO2}$ =3.67),
- $B(t)$ is biomass at time t (Cooper, 1983) and
- CC is the fraction of carbon in the biomass (assumed to be 0.5; IPCC/OECD/IEA, 1996),

For the calculation of the carbon sequestration over periods longer than the rotation length, a factor (set at 0.20 by default) was used to account for the return of carbon to the atmosphere after harvesting. As such, 20% of the carbon stored at the end of the rotation is assumed to be permanently sequestered and is added to the sequestration in the next rotation.

Calculations were made for three budget periods, i.e. for the first commitment period (2000-2008, with or without banking) and for longer periods, being from 2000-2050 and 2000-2100. The calculations all started for the year 2000.

Forest conservation:

The C emissions as a consequence of deforestation can have been calculated as:

$$E_C = BMS * CC * \Delta A_{def} * K_{soil} * K_{CO2}$$

where:
- E_C is the C emission (Mt yr^{-1}) as a result of deforestation,
- ***BMS*** is the forest biomass (ton ha^{-1}; FAO, 1995),
- ***CC*** is the fraction of carbon in the biomass (assumed to be 0.5; IPCC/OECD/IEA, 1996),
- ΔA_{def} represents the size of the deforested area (ha),
- K_{soil} is a correction factor for losses of carbon from the soil and litter layer (1.3; Nilsson and Schopfhauser, 1995) and
- K_{CO2} is a conversion factor to account for the conversion from C units to CO_2 units (K_{CO2} =1 or 3.67).

In case of forest conservation a part of ΔA_{def} will be saved. How large this part of ΔA_{def} will be, is dependent of the scenario chosen.

2.7 Cost calculation procedures

The cost calculation procedure is represented schematically in Figure 4 (see end of this Chapter). Three kinds of costs can be distinguished for sink projects within CDM. These are:

a) operational costs
b) transaction costs
c) certification costs

The distinction made between costs for forest conservation and af-/reforestation projects is based on the assumption that for forest conservation the environmental sustainability and sustainable forest management have no amount in the (operational and transaction) costs, because they are naturally 'present'. Though the operational costs and the transaction costs are calculated on the basis of af-/reforestation projects, the forest conservation project costs per ton CO_2 are lower than the af-/reforestation project costs per ton CO_2.

2.7.1 Operational costs

The operational costs are the costs of project implementation, including promotion, nurseries, technical assistance, training and overhead. The operational costs (***OC***) of the FACE and Noel Kempf projects were related to the Gross National Products (***GNP***) of the host countries using linear regression. This resulted in the following equation, which was used to calculate the basic operational costs for projects in different countries:

$$\boldsymbol{OC = 0.36 + 0.00019 * GNP} \qquad \mathbf{n=6,\ r^2=0.94}$$

The operational costs are influenced by adoption of criteria in CDM projects. Factors relating the increase in costs to adoption of a certain criterion are given in Table 4.

Table 4. Project criteria and their weight factors influencing operational costs

Project criteria	Operational costs factors	
Project framework	0.525	
Additionality	0.000	
Verifiability	0.095	
Compliance	0.090	
Environmental sustainability	0.060	0.000 for forest conservation
Socio-economic sustainability	0.055	
Sustainable forest management	0.090	0.000 for forest conservation
Transparancy	0.085	
Total factor	1.000	0.850 for forest conservation

2.7.2 Transaction costs

Transaction costs represent the running costs of projects and include the expenses made for preparation, certification and sale. The preparation cost for the FACE projects were the costs relating to the launch of the Face Foundation, the development of the contracts and the (internal) monitoring system MONIS, identification of the project countries as well as the projects themselves. Our present estimates are based on the transaction costs (***TC***) of the two FACE projects only and were also related to ***GNP***:

$$\boldsymbol{TC = 0.07 + 0.00096 * GNP} \qquad \mathbf{n=2,\ r^2=1.00}$$

The transaction costs are also influenced by the adoption of criteria in CDM projects. Their weight factors are given in Table 5.

Table 5. Weight factors used to calculate the influence of adoption of criteria on the transaction costs.

Project criteria	Transaction costs	
Project framework	0.055	
Additionality	0.020	
Verifiability	0.345	
Compliance	0.230	
Environmental sustainability	0.050	0.000 for forest conservation
Socio-economic sustainability	0.045	
Sustainable forest management	0.050	0.000 for forest conservation
Transparancy	0.205	
Total factor	1.000	0.900 for forest conservation

2.7.3 Certification costs

Certification costs depend partly on the level of uncertainty that is required for a project. Certification costs include a) monitoring (remote sensing, field work and reporting), b) costs incurred by the certifying agency, and c) in the case of the FACE projects, supervision by Face Foundation. If a low uncertainty level is needed, more sample plots will be required, which increases the costs. One way of dealing with the uncertainties is by creating a buffer, which accounts for these uncertainties. In the spreadsheet model, the level of precision can be given. The relation for the increase of certification costs (***CC)*** with the desired precision level (***P***) was obtained from Powell (1999) with Noel Kempf project data. Relations between certification costs and gross national product were established for five precision levels, being 5, 10, 20, 25 and 30% and the respective equations relating the certification costs to host country ***GNP*** are given below.

$$CC = 0.89 + 0.00032*GNP, \quad P = 5\%$$
$$CC = 0.63 + 0.00022*GNP, \quad P = 10\%$$
$$CC = 0.58 + 0.00021*GNP, \quad P = 20\%$$
$$CC = 0.58 + 0.00021*GNP, \quad P = 25\%$$
$$CC = 0.57 + 0.00020*GNP, \quad P = 30\%$$

Unlike the operation and transaction costs, the certification costs are not influenced by adoption of the criteria in projects

2.7.4 Projection of present costs estimates to the future

The cost calculations for the different periods were based on the present costs of setting up a CDM project. For long-term financial projections a discount rate is normally used to correct for inflation, etc. This rate is usually set to a value of around 5%. Applying this discount rate would increase the cost estimates presented in this report by a factor of 1.8 (i.e. 1.05 to the power of 12) for the first commitment period and 11.5 and 131.5 for the 50- and 100-year periods, respectively.

The projects currently under investigation have not yet provided financial returns on the investment and may only start doing so after the first commitment period when plantations are mature. Projected cost estimates over longer periods will have to be corrected with income generated by the projects through future sale of timber, non-forest timber products, eco-tourism, etc. As the returns on the investment are presumably close to 100% for af-/reforestation projects, and perhaps a bit less for forest conservation projects, the present price level may be a fair indication for the costs of CDM sink projects in the near future (i.e. first commitment period).

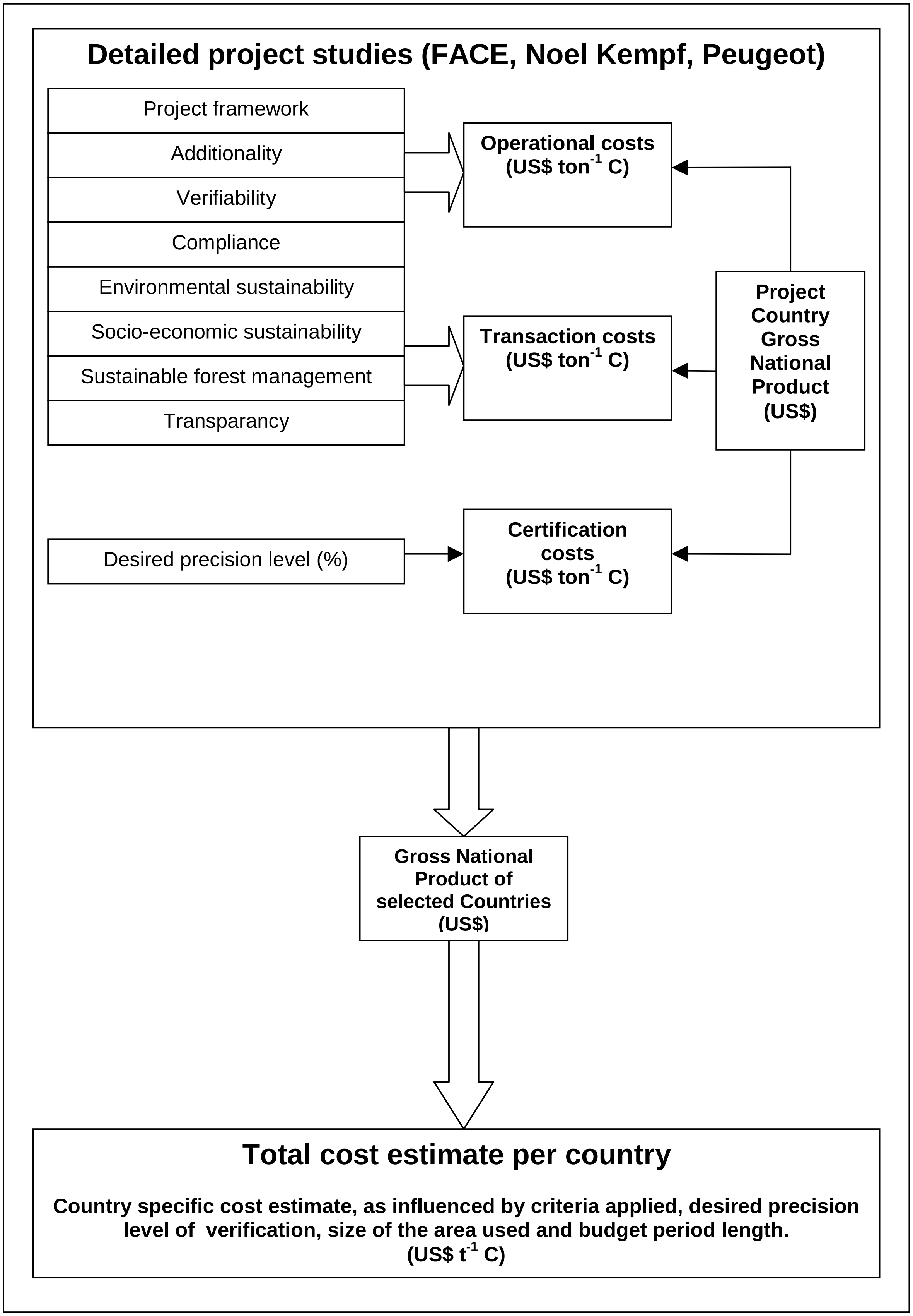

Figure 6. Schematic overview of the calculation procedure of the costs per ton carbon.

3 How to use the CDM Forest Sink model (CDMFSM)?

1. Go through the worksheets from left ("**select. parameters**") to right ("**costs per scenario 2008-2012**").

2. Select settings for the parameters used in the calculations in worksheet "**select. Parameters**". You can change the following parameters:

   a) *project area for af-/reforestation projects within CDM:*
      - The potential area is set at between 3-4% of the total agricultural area in a country (Nilsson and Schopfhauser, 1995) and is affected by the in- or exclusion of criteria.
      - You can also define your own project area. Switching criteria on or off does not affect the defined area in this case. It does affect the costs, however.

   b) *forest conservation area for CDM projects:*
      - The potential area targeted for forest conservation is expressed as a percentage of the deforestation rate. The percentages used are rather arbitrary and range between 5-25%, depending on expert judgement of the country forest area and population pressure. The weighted average of the country deforestation reductions yields a reduction of about 11% in the deforestation rate.
      - You can also define your own deforestation rate reduction percentage.

   c) *start of budget period for the first commitment period (2008-2012):*
      - Within CDM, it may be possible to include carbon fixation in projects started after a.d. 2000 in the first commitment period (2008-2012) fixation totals.

   d) *criteria to include in a project:*
      - Costs of carbon sequestration potential are always influenced by the adoption of criteria. A factor of 0 implies that a criterion will not be taken into account, a factor of 1 counts the criterion according to the FACE project experience, whereas a factor of 2 doubles the weight of a criterion, etc.
      - When potential area calculations are used (see above), the factor entered affects the area deemed suitable for CDM projects (exponentially). A zero factor will not affect the potential area, a value of one decreases the potential area based on experience gained in the FACE projects, whereas higher values reduce the potential area even further.
      - As additionality is a key requirement for a project to be eligible under CDM, this factor is set to 1.0.
      - Certification costs form part of the total project costs. Certification costs mainly depend on the certification precision required and size of the project area. The certification precision should be defined here (for the FACE projects a buffer of 25% was used) and costs increase when a higher precision level is desired.

3. Results of the calculations with the selected settings for the different parameters are returned in the worksheet named "**results table**".

4. Results are also visually displayed in the following graphs:
   - "**saved forest area per year**"
   - "**CO2 sequestration 2008-2012**"
   - "**CO2 sequestration 2000-2050**"
   - "**CO2 sequestration 2000-2100**"
   - "**costs per ton CO2 per country**"
   - **"costs per scenario 2008-2012"**

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