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Institute for Economics

Integration of harvested wood products into accounting approaches of the carbon dioxide cycle in the forestry sector

by

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Preface

The UN Framework Convention on Climate Change aims at stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent anthropogenic interference with the climate system. In the Kyoto Protocol, the Conference of the Parties, beside other decisions, agreed on accepting sinks from removals of carbon dioxide from the atmosphere by activities connected to land use, land use change and forestry.

The international community is still discussing the option to include carbon sequestration in increasing harvested wood product stocks into these sinks. This paper analyses the potential role of harvested wood products in the German situation and compares carbon accounting systems in the forestry sector for German conditions in comparison to conditions in the Netherlands and in Sweden. It presents an extended version of the accounting system 'Stock Change Approach' that takes into account some shortcomings of the original with regard to international trade.

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1. Introduction

1.1 Development of the Negotiation Process

The Kyoto Protocol allows Annex I countries to meet parts of their greenhouse gas reduction target by removing carbon from the atmosphere through defined activities in the Land Use, Land Use Change and Forestry (LULUCF) sector such as afforestation, reforestation and selected management options.

Long-term wood products store a considerable amount of carbon. Though the carbon is released again to the atmosphere after the end of a product's life span, CO_2 emissions are also delayed like in Kyoto-forests thus offering time for cleaner technologies to evolve. Since the mid-nineties, there is ongoing debate to possibly include the carbon sinks in wood products in the acknowledged sinks of the Kyoto Protocol.

In 1995, an approach for estimating the net carbon emissions from forest harvesting and wood products was developed by the IPCC Expert Group on Land Use Change and Forestry. After reviewing this draft approach at a second expert meeting on this subject which was held in Brazil 1996, it was forwarded later that year to the IPCC-Plenary (IPCC12, Mexico City). However, the IPCC deferred a decision on a greenhouse gas inventory module related to harvested wood products. It requested that the SBSTA be consulted on the matter because of the broader policy implications. The SBSTA welcomed this decision and asked IPCC for an evaluation of the importance of harvested wood products as carbon sinks.

An IPCC Expert meeting to evaluate different approaches for estimating the fate of forest harvesting and wood products was held in Dakar, Senegal, 5-6 May 1998 (IPCC/OECD/IEA 1998). Further refinements were added at the 'Harvested Wood Products Workshop' in New Zealand, in February 2001 (McFARLANE & FORD-ROBERTSON, 2001).

In Marrakesh, at the Conference of the Parties (COP7) in October/November 2001, SBSTA 15 took the decision that any changes to the treatment of harvested wood shall be in accordance with future decisions of the COP. Annex I countries are invited to provide, by 15 January 2003, submissions on the implications of harvested wood products accounting, including views on different approaches and methodologies, for consideration at its 18th session.

Besides various ongoing national activities, the evaluation of the approaches is part of the objectives of the COST E21-action 'Contribution of Forests and Forestry to Mitigate Greenhouse Effects' of the EU (LAITAT ET AL. 2000). The action is to last until December 2003.

1.2 Prerequisites for Accounting of Carbon in Wood Products; the German Example

Following the discussions so far (IPCC/OECD/IEA 1995, LULUCF2/paper/0112 of 9.1.2001), there is a recommendation to accept carbon sequestration in wood products in case a country is able to proof that existing stocks of long term products are actually increasing.

For Germany, this proof can be established not only from national statistics, but also from the FAO forest product database. During 1991 to 2000 the stocks of sawnwood, wood based panels and other industrial roundwood increased on an average by net 5.3 Mio m^3 per year and the stocks of paper and paperboard by net 0.1 Mio t per year (calculations include decreases of stocks by inherited emissions according to BFH-estimates). Per capita consumption increased by 10% in the case of sawnwood and by 27% in the case of wood based panels.

The yearly average increases in stocks correspond to surplus carbon sequestration of 1.32 Mt in wooden products and 0.6 Mt C in paper and paperboard, in total 1.92 Mt C per year.

2. Accounting of Carbon Fluxes in the Forestry Sector With Special Emphasis on Harvested Wood Products

The current methods for carbon accounting in the forestry sector (IPCC-default approach) are explained in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC/OECD/IEA 1995).

In the Dakar workshop (IPCC/OECD/IEA 1998), three different methodological approaches for estimating the emissions and removals of carbon from forest harvesting and wood products were evaluated:

- Stock-change approach
- Production approach
- Atmospheric-flow approach = Flow consumption approach

'Globally, all three proposed approaches are scientifically and technically similar. Technical differences among the approaches affect accounting of national emissions or stock changes. This factor has implications for national policies, and possibly for reporting under the Kyoto Protocol. This consideration may ultimately influence which approach is chosen for further development ' (IPCC/OECD/IEA 1998).

COP 7 invited parties to discuss these approaches and to respond, comment and eventually present further refinements until 15 January 2003. The Federal Research Centre for Forestry and Forest Products (BFH) evaluated the approaches and developed an extended version of the stock change approach in order to overcome some of its major constraints.

2.1 Description of Approaches

IPCC-approach following the revised 1996 Guidelines (IPCC/OECD/IEA 1995)
The approach makes up the balance of primary net production in the forests, the changes in soil carbon in agriculture and forestry, changes in land-use from forest- and grasslands and changes in woody biomass stocks by harvest. Total logging (slash and harvested wood) is treated as emissions in the year of harvest. This is based on the assumption that new products replace old ones and hence, that product pools are stable.

Proposed approaches (Dakar-Meeting, IPCC/OECD/IEA 1998)
Changes in forest stocks are basically treated like in the IPCC-approach. The approaches differ in the treatment of harvested wood. All approaches may be applied at different levels of complexity, i.e. tiered methods, depending on data availability and availability of expertise.

Flow Consumption (FC) approach = Atmospheric Flow approach
The FC-approach makes up the balance of changes in forest stocks, emissions from consumed fuelwood and short term products, waste from product production (no secondary use) and inherited emissions of long term products consumed. Since the focus is on consumption, imports and exports are taken into account.

Flow Production (FP) approach
The FP-approach makes up the balance of changes in forest stocks, emissions from fuelwood and short term products produced, waste product production (no secondary use) and inherited emissions of long term products produced taking into consideration only domestically produced wood.

Stock Change (SC) approach
The SC-approach makes up the balance of changes in forest stocks, logging and the difference from changes in the stocks of consumed long term products. Emissions of total logging are attributed to the producer country. Since the focus is on consumption of long term products, imports and exports in this category only are taken into account.

Proposed Approach of the Federal Research Centre for Forestry and Forest Products (BFH) = **Stock Change/Trade (SC/T)** approach (see Annex I for a detailed description)

Approach SC/T basically corresponds to the SC-approach, but adds the complete trade dimension in form of the foreign trade balance. Thus, the amount of total available material for production (logging + foreign trade balance + outflow from the stock of long term products) is known. After subtraction of new long term products consumed all emissions during the production process are attributed to the country where they occur.

2.2 Results of Approaches

In order to illustrate the differences between the approaches, the calculations are presented for the German forestry sector reflecting the state in 1991 (Annex II). In a next step, the balances of the approaches are compared for different situations of the forestry sector in 4 countries:

- Gabon (high deforestation rate)
- the Netherlands (high import rate, low self-sufficiency rate)
- Sweden (high export rates)
- Germany (medium import rate, high self-sufficiency rate).

The year 1990 is selected as base year in the Guidelines; exceptions are accepted if reasonable. Germany selected 1991 as base year because the impacts of re-unification and forest damages by storms in the year 1990 distorted prevailing conditions. Inherited emissions from long-term products cover the years 1961 to 1989 or 1990, respectively, following the time series available in the FAO Forest Products statistics which go further back in time than most national statistics and provide a common database for all countries.

Tab. 1 presents the overall results of all approaches: IPCC Standard-Approach (IPCC), Flow Consumption (FC), Flow Production (FP), Stock Change (SC) and Stock Change/Trade (SC/T) for 4 selected countries. Data for Gabon, the Netherlands and Sweden (in light grey) are cited from NABUURS & SIKKEMA (1998, 2001) and are based on the FAO-Forest Products database. Also the foreign trade balance for the Netherlands and Sweden (in dark grey) which is needed in approach SC/T is derived from the FAO-database (details in Annex III, 1.). All data for Germany are derived from national statistics and calculations of the BFH.

Country	**IPCC**	**FC**	**FP**	**SC**	**SC/T**
	Mt C				
Gabon	-9.7	-9.1	-9.1	-9.7	
the Netherlands	0.3	-0.6	0.5	1.3	-0.3
Sweden	9.7	18.1	16.6	11.5	16.5
Germany	8.7	6.5	9.4*	11.6	9.5

Tab. 1. Balances of the approaches to account for carbon emissions/removals in the forestry sector in Gabon, the Netherlands, Sweden and Germany. Balances in Mt C, negative values indicate C-sources.

* the balance for Germany does not include inherited emissions from exported products

In **Gabon** the effects of the proposed approaches are largely superimposed by carbon stock changes due to deforestation. Differences in comparison to the IPCC-approach are comparatively small. Therefore, Gabon is no longer considered in the following sections.

In the **Netherlands** the forest sector is either source or sink depending on the approach selected. In the approaches FC and SC/T the import of short term product results in turning the sector into a net source.

In **Sweden** the forest sector is a sink on considerably varying level depending on the selected approach. Sweden benefits in the FC approach from the fact that comparatively few inhabitants consume few products.

In **Germany** the forest sector is also a sink, the differences between the results of the approaches are comparatively low.

2.3 Discussion of Approaches

The main difference between the approaches is whether or not a distinction is made in the accounting of emissions of domestically grown and traded wood. Also, there are some differences in the treatment of short term and long term products.

All approaches explicitly considering harvested wood products, that is all approaches except the IPCC standard, are considerably sensitive to the estimation of products' life spans (Annex III, 2.).

A special case is bio-energy if the wood used is not officially declared and traded as fuelwood (Annex IV). All approaches offer incentives for the use of bio-energy by reduction of fossil fuels in the energy chapter. Still, when traded wood residues or recycling materials are concerned, only the FC and SC/T approaches account correctly for emissions when and where they occur.

The **IPCC** approach defines total domestic harvest as emissions and ignores trade flows. Consequently, emissions are overestimated in net exporting countries such as Sweden and in countries with increasing stocks of long term products, thus reducing the balance. Emissions from imported wood products are not accounted for. The approach offers incentives for sustainable forest management and use of bio-energy.

The **FC** approach favours producer countries (exporters such as Sweden) with low consumption within the country and disadvantages countries with low forest cover and high imports such as the Netherlands. There is no incentive for recycling.
Explicit identification of all emission sources within the forestry sector is vital for the accuracy of the approach. Emissions of any domestic wood used as fuel within forest industries, which is not declared as a product or connected to a commodity such as waste like in the Swedish forestry sector, are not accounted for (Annex IV).

The **FP** approach does not account for international trade. There are incentives for the production (including recycling) of long term products. Like in the FC approach, explicit identification of emission sources is vital for the accuracy of the approach. Emissions of any domestic wood used as fuel within forest industries, which is not declared as a product, are not accounted for.
There are incentives for sustainable forest management, use of long term products and use of bio-energy. The approach is rejected by the majority of countries that responded up to now (UNFCCC/SBSTA 2001), because the accounting of emissions

of all products produced regardless of trade effects is not consistent with the principle of counting emissions where and when they occur. Further, countries doubt that it is feasible to correctly account emissions from produced long term products in trade partner countries. Therefore, this approach is not discussed in detail.

The **SC** approach offers incentives for sustainable forest management, use of long term products and of bio-energy. Export countries such as Sweden are disadvantaged, because emissions of exported wood are accounted for in the producing countries. Thus, emissions are not consistently captured in the place of their origin. Net-importing countries such as the Netherlands are enabled to build up sinks in long term products in a short term. Recycling leads to positive effects, if long term products are produced.

The **SC/T** approach intends to adjust biases resulting from foreign trade. Recycling results in positive effects, if long term products are produced. Exports reduce emissions, thus they also have positive effects on the result. Imports have opposite effects, except in cases when they are transformed into long term products. Thus, emissions are accounted for, where they occur as long as trade takes place between Annex I countries.
The approach favours countries with high increases to the stocks of long term products. There are incentives for importing countries for sustainable forest management.

In conclusion, the main advantages or disadvantages of the approaches are:
- IPCC: incomplete accounting, emissions are not accounted for where they occur
- FC : risk of double counting of emissions, risk of incomplete accounting
- FP : emissions are not accounted for where they occur, risk of incomplete
- accounting
- SC : complete accounting, emissions are not accounted for where they occur
- SC/T: complete accounting, emissions are accounted for where they occur.

2.4 Preference for the (Extended) Stock Change Approach

Before the meeting of SBSTA 15, the SC approach was favoured by most of the Annex I - countries, though some issues were mentioned as being critical like
1. advantages for importing countries,
2. incentives for imports of not sustainable produced wood from non Annex I-countries and
3. sensitivity to variations in the levels of imports/exports (UNFCCC/SBSTA 2001).

to 1. advantages for import countries
The SC-approach assumes that total logging except consumed long term products are emissions in the year of harvest, this includes products for export. Thus, emissions from imported products are not accounted for in the import country.
In contrast to SC, approach SC/T counts emissions where they occur, so there is no advantage for any trade partner.

to 2. incentives for imports of unsustainably produced wood from non-Annex-I-countries
The SC approach 'rewards' imports of any type since it does not account for emissions from imported short term products or produced short term products from imported wood and imports of long term products increase the sink.
Approach SC/T treats imported wood like in-country grown wood, thus there is no incentive.

to 3. sensitiveness with regard to variations in yearly import/export-rates
All approaches respond sensitive to yearly variations in the foreign trade balance, thus accurate accounting of emissions is important in order to avoid imbalances between countries.
The SC approach favours import countries, thus countries which are net importers in one year and net exporters in the other may profit or not. Approach SC/T does not have this disadvantage because emissions are accounted for correctly when and where they occur.

NABUURS & SIKKEMA (2001) conclude in their evaluation of the approaches, that 'the stock change method seems to be a suitable method, combining precise accounting and simplicity. This method is also an incentive for the use of wood in long-life products and bioenergy, and for sustainable management.' Still, they point out that the SC approach is 'not accurate per country because carbon emissions are accounted partly in another country as where they actually take place'.

This disadvantage is amended in approach SC/T. Approach SC/T adds some complexity to the stock change approach by including the foreign trade balance as parameter, but this parameter is comparatively easy to obtain on an approved level of data quality from the FAO Forest Products database.

The strength of the SC/T approach is, that it captures all fibres available for production within a country.

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List of Abbreviations

BFH	Bundesforschungsanstalt für Forst- und Holzwirtschaft, Federal Research Centre for Forestry and Forest Products
CDM	Clean Development Mechanism
COP	Conference of the Parties
FAO	Food and Agriculture Organization of the United Nations
FC	Flow Consumption approach
FP	Flow Production approach
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change, and Forestry
Mt	Mega tons
SBSTA	Subsidiary Board for Scientific and Technological Advice
SC	Stock Change approach
UNFCCC	United Nations Framework Convention on Climate Change

Annex I: Proposal BFH: Stock Change/Trade Approach

In the BFH proposal, the only explicit carbon sink is the (positive) change in forest stock (Fig. 1). Thus, the credit of carbon sequestration is always attributed to the country where the timber is grown. The sink is a flow item. It solely includes the carbon quantity sequestered in one year. A sink can be preserved only by withholding carbon in the forest stock or by transferring it to the long term product stock.

The amount of carbon remaining in the forest stock is determined by the quantity of the removals. The amount of carbon stored in the product stock is dependent on the production of wood products and their life spans. Total available basic material for production is provided by forest harvest, foreign trade, and domestic recycling of wooden products. These three input items are flow items as well.

Removals, net imports and domestic recycling material are potential sources of carbon. Together they may exceed the forest sink of a country, depending on the respective foreign trade balance and recycling volume. Wood and wood fibres in long term commodities lead to a delay of the source effect. Only short term commodities are assumed to be decomposed or burned in the respective year. For accounting of the carbon release of harvested wood and wood products in a given year, the amount of short term products has to be determined by subtracting the amount of long term commodities consumed from total available material. The influx to the long term commodity stock can be estimated on base of official production and trade statistics and on assumptions about the input of semi-finished products in final products and their life spans. Wood and wood fibres not processed to long term commodities are used for short term commodities. The corresponding volume of carbon is taken into account as a source of carbon. Each country is debited with the release of carbon in it’s own borders.

Like in all other approaches, the calculations of the BFH proposal are based on statistical data for semi-finished products as provided by FAO. This is due to problems obtaining statistical data for finished products and it may cause an under- or over-estimation of the emissions of the country in question.

Proposal for Accounting of Harvested Wood Products in National Greenhouse Gas Inventories in Mio t C

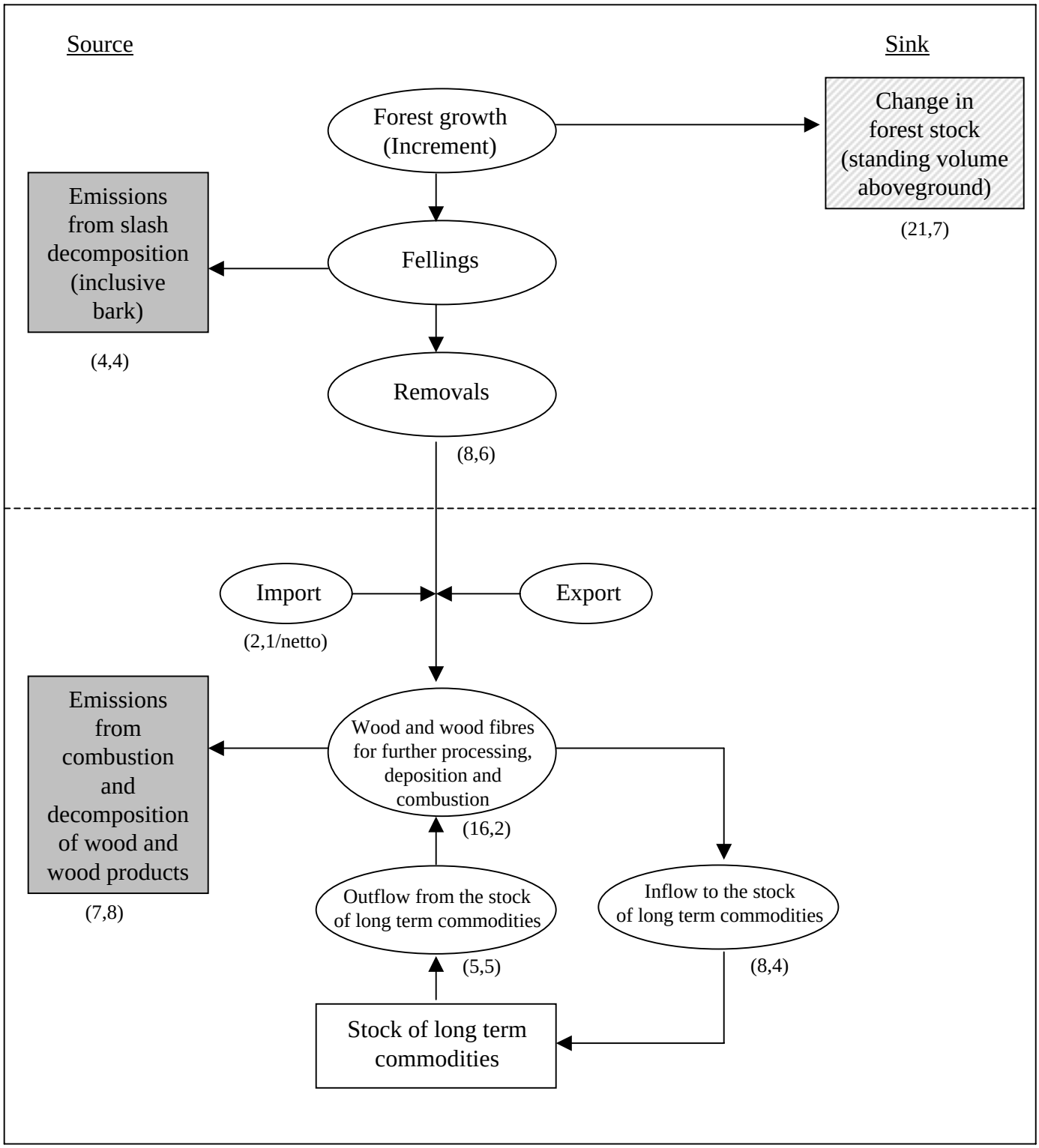

Fig. 1. Foreign trade balance containing round-wood, waste-wood and waste-paper as well as the commodities sawn-wood, wood based panels, pulp, paper and paperboard and other semi finished products. Figures in parentheses: Values for the Federal Republic of Germany 1991 in Mio t C.

Annex II: Results for Germany 1991

The following listing presents all approaches and their relevant parameters for German conditions of the forestry sector in 1991. Data is given in Mt C based on statistics and calculations by the BFH.

IPCC-Approach:

C sink from forests:	21.7
- slash	4.4
- logging	8.6
	8.7 Mt C

Flow Consumption-Approach:

C sink from forests:	21.7
- slash	4.4
- consumed commodities< 5yrs	4.0
- waste produced commodities	0.8
- inherited emissions consumed comm.	5.5
- consumed fuelwood	0.5
	6.5 Mt C

Flow Production-Approach:

C sink from forests:	21.7
- slash	4.4
- produced commodities< 5yrs	6.9 (4.0 + 2.9 export)
- inherited emissions produced comm.	5.5 + ? export
- consumed fuelwood	0.5
	9.4 Mt C **–** inh. em. export comm.

Stock Change-Approach:

C sink from forests:	21.7
- slash	4.4
- logging	8.6
+ consumed commodities> 5 yrs	8.4
- inherited emissions consumed comm.	5.5
	11.6 Mt C

Stock Change/Trade Approach :

C sink from forests:	21.7
- slash	4.4
- logging	8.6
- net imports	2.1
+ consumed commodities> 5 yrs	8.4
- inherited emissions consumed comm.	5.5
	9.5 Mt C

Annex III: Detailed Aspects Related to the Approaches

1. Foreign Trade Balance

Approach SC/T needs as one of the basic parameters the foreign trade balance expressed in t C.

The calculation of the foreign trade balance for Germany is based on EUROSTAT-trade data using conversion factors for product groups which were estimated fairly detailed by BFH for in-country conditions. Such country-specific data is not available for Sweden and the Netherlands.

For international comparability and verification purposes, a common database for all Annex I-countries is required. Such a database is provided by the FAO-Forest Products database which is internationally acknowledged as being a reliable data source. Still, differences between national and FAO-statistics may occur due to the application of divergent conversion factors.

This section analyses the comparability of country-specific data and FAO-data on basis of the German example in order to check the magnitude of eventual discrepancies if FAO-data is used to calculate the foreign trade balance for Sweden and the Netherlands.

EUROSTAT provides the amount of traded product groups in t (fresh) and traded $-amounts, FAO provides data in m^3 respectively metric t. In both cases carbon content is calculated by conversion to $t_{dm.}$ The EUROSTAT-Data were analysed for the years 1991 and 1999. The same calculations were applied to the FAO- database:

	EUROSTAT	FAO	EUROSTAT	FAO
	1991		1999	
Foreign Trade Balance in wood products in 1000 t_{dm}	4,238	4,587	1,360	1,274
Carbon content in Mt	2.1	2.3	0.7	0.6

Tab. A1. Foreign trade balances in wood products in Germany based on EUROSTAT- and FAO-data.

Compared to EUROSTAT, the FAO-database underestimates in 1991 particularly the export of industrial roundwood (by 199,000 t_{dm}) and overestimates the import of sawnwood (by 232,000 t_{dm}). This causes a difference in the foreign trade balance of about 200,000 t C. FAO overestimates county-specific data by + 10%.
In 1999, the FAO-database also underestimates the export of industrial roundwood/chips and particles/ wood residues (by 350,000 t_{dm}), but corresponds to EUROSTAT in the case of sawnwood. A further analysis is not possible to date, because EUROSTAT gives preliminary data for semi-finished products in 1999. With regard to the overall result the difference between the two statistics is only 100,000 t C. In 1999, FAO underestimates country-specific data by –14%.

In summary, the level of the foreign trade balances in wood products in these databases is comparable. Thus, the foreign trade balances for Sweden and the Netherlands have been calculated likewise on basis of the FAO-database in order to apply approach SC/T.

The results of approach SC/T for Sweden and the Netherlands combining data from NABUURS & SIKKEMA (1998) for the year 1990 and the respective foreign trade balances are as follows:

Sweden

C sink from forests	27.2
- slash	6.4
- logging	11.1
+ net exports	5.0
+ consumed commodities>5 yrs	2.1
- inherited emissions consumed comm.	0.3
balance	**16.5 Mt C**

the Netherlands

C sink from forests	0.8
- slash	0.2
- logging	0.3
- net imports	1.6
+ consumed commodities>5 yrs	1.4
- inh. emissions cons. comm.	0.4
balance	**-0.3 Mt C**

These results are input for Tab. 1.

2. Effects of Conversion Factors on Carbon Balances, the Swedish Example

Various conversion factors are needed to calculate the C-content of product groups and their gradual outflow of the stocks of products over time. The basic factors are:

- specific weight
- share of long term versus short term commodities and
- product life spans.

This section analyses the effects of altering conversion factors using the Swedish case as example. Following the Stock Change approach, the balances of the forestry sectors in Sweden and Germany indicate a C-sink in the same order of magnitude. The basic conditions are quite divergent and also the assumptions concerning the conversion factors according to NABUURS & SIKKEMA (1998) for Sweden and BFH for Germany vary in parts considerably (Tab. A2). The German conversion factors were applied to the Swedish data in order to examine the impacts on the country's balance (Tab. A3+4).

	proportion >5yrs		specific weight g/cm^3		life span yrs		disposal/yr	
	S	D	S	D	S	D	S	D
sawnwood	0.8	0.8	0.44	0.5	**200**	**60%:50** **25%:15** **15%:10**	0.005	0.012 0.0167 0.015
panels	0.9	0.95	0.52	0.75	**100**	**45%:50** **45%:15** **10%:10**	0.01	0.009 0.03 0.01
other ind. roundwood	0.7	0.5	0.6	0.5	**50**	**10**	0.02	0.05
paper+pb	**0.6**	**0.1**	1.0	0.9	**200**	**10**	**0.005**	**0.1**

Tab A2. Conversion factors wood into long term products / inherited emissions for Sweden and Germany. Major differences are highlighted in bold print.

Remark: life spans > 40 years underestimate inherited emissions, since FAO-Data are only available since 1961.

net biomass into long-term use (t C)

	S-original conversion	S-German factors
sawnwood	1,060,400	1,205,000
wood based panels	350,298	280,688
other ind. roundwood	31,500	18,750
paper+paperboard	643,200	107,200
Sum	**2,085,398**	**1,611,638**

inherited emissions (t C) in 1990

	S-original conversion	S-German factors
sawnwood	119,521	666,059
wood based panels	68,441	257,503
other ind. roundwood	53,130	16,875
paper+paperboard	68,405	95,450
Sum	**309,497**	**1,035,887**

Tab. A3. Use of German conversion factors on Swedish 1990-data.

The effects on the balance are considerable:

	S 1990, original conversion factors	S 1990, German conversion factors
	Mt C	Mt C
C sink in forest	27.2	27.2
- slash	6.4	6.4
- logging	11.1	11.1
+ long term products	2.1	1.6
- inherited emissions	0.3	1.0
balance	**11.5**	**10.3**

Tab. A4. Balances of the stock change approach for Sweden
left: calculated with conversion factors following NABUURS AND SIKKEMA (1998)
right: calculated with conversion factors according to German conditions (BFH)

Conclusions:

- Changes in the share of long term products in total products, specific weights, life spans and recorded traded quantities per product category may effect the balance of each approach to a considerable amount.
- A targeted selection of conversion factors offers opportunities for directing the balance during the first commitment period. In the longer run, the effects will drop out, if measures are taken that conversion factors may not be easily changed.
- Conversion factors are based on assumptions, not on reliable statistics. Thus, there is a need for agreement on basic assumptions.
- In cases when product life spans exceed the accounting period of statistics, inherited emissions of long term products are underestimated.

Annex IV: Emissions from the Production Processes

Following the philosophy of the IPCC-Guidelines, it is essential to count emissions when and where they occur. Following emissions occur within a country during wood processing:

- oxidisation/combustion of waste from production
- oxidisation/combustion of short term products
- oxidisation/combustion of long term products
- burning of fuelwood.

These items are covered in the Flow Consumption approach. Approach SC/T follows a more general perspective. The available wood and wood fibres for further processing, deposition and combustion are balanced by the inflow to the stock of long term commodities and the difference are emissions from combustion and decomposition of wood and wood products.

In contrast to FC, approach SC/T is able to reflect recycling into new long term products. Thus, a comparison of emissions calculated by the two approaches should result in lower emission rates following approach SC/T compared to FC:

Country	Emissions Approach SC/T (Mt C)	Emissions Approach FC (Mt C)
NL	0.9	1.2
S	4.3	2.7
D	7.8	10.8

Tab. A5. Emissions calculated by approach Stock Change/Trade and the Flow Consumption approach in the Netherlands, Sweden and Germany.
Data for NL and S from NABUURS & SIKKEMA (1998) for the year 1990, for D from calculations of the BFH for the year 1991.

For Germany, FC sums up emissions of 10.8 Mt C; SC/T results in 7.8 Mt C; the difference may be attributed to recycling processes. The BFH-institutes for Economy and for Wood Technology estimate a total of 5.5 Mt_{dm} available recycling material, which corresponds to about 2.7 Mt C.

Also for the Netherlands the balance of material fluxes results in lower emissions than accounting of single parameters, indicating recycling processes.

In contrast, for Sweden FC calculates 2.7 Mt C emissions; approach SC/T results in significantly higher emissions of 4.3 Mt C. It is well known that the Swedish forest industries operate with high recycling rates, but this does not show up in the above comparison.
This difference might be due to the high proportion of wood used for energy production which is neither counted as commodity (no declared fuelwood for the markets) nor related to a commodity like waste from production. If a forest industry uses own harvested wood for energy and heat production, the timber is included in harvest statistics, but not in product statistics. For example, according to the Swedish National Energy Administration ET:2001, the amount of wood residues used for production of electricity in forest industries was 3.38 Mt_{dm} in 2000 corresponding to about 1.7 Mt C (black liquor not included). For the same year, the FAO database

states an C-equivalent of 1.27 Mt for fuelwood consumption; fuelwood being defined as wood in the rough to be used as fuel for purposes such as cooking, heating or power production. Given that the private sector also uses fuelwood, there is a considerable lack in the basic data concerning bio-energy. Since the FC-approach refers to harvested wood product related data only without considering total harvest, roundwood and recycling material for bio-energy use within forest industries is not completely counted.

The Swedish case shows, that the Flow-approaches (FC and FP), which do not include the parameter 'logging' underestimate emissions from forest harvest if wood is used as fuel within forest industries.