INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories

Evaluating Approaches for Estimating Net Emissions of Carbon Dioxide from Forest Harvesting and Wood Products

by
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Meeting Report

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Executive summary

The size and management of biotic carbon pools affect atmospheric CO_2 concentrations. An important carbon pool is harvested wood products. Wood products include industrial roundwood, woodfuel, and wood commodities such as sawnwood, particle board, plywood, pulp and paper, and the like. An IPCC expert meeting in Dakar, Senegal examined a range of approaches for estimating the emissions and removals of CO_2 from forest harvesting and wood products, and compared these approaches with the one in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.

In the current IPCC default approach, all CO_2 emissions and removals associated with forest harvesting and the oxidation of wood products are accounted for by the country in which the wood was grown and in the year of harvesting. This approach is inaccurate because there is the underlying assumption that there is no change in the size of the wood-products pool. The products pool may be increasing globally by about 140 Tg C/yr. The amount of carbon sequestered annually in wood products is projected to increase and is currently equal to about 2% of global CO_2 emissions from fossil fuels.

The magnitude of the inaccuracies in the default approach would vary widely country by country. For some countries the effect could be significant.

The meeting identified three approaches for estimating the emissions and removals of CO_2 from forest harvesting and wood products:

Stock-change approach - This estimates net changes in carbon stocks in the forest and wood-products pool. Changes in carbon stock in forests are accounted for in the country in which the wood is grown, referred to as the producing country. Changes in the products pool are accounted for in the country where the products are used, referred to as the consuming country. These stock changes are counted within national boundaries, *where* and *when* they occur.

Production approach - This also estimates the net changes in carbon stocks in the forests and the wood-products pool, but attributes both to the producing country. This approach inventories domestically produced stocks only and does not provide a complete inventory of national stocks. Stock changes are counted *when*, but not *where* they occur if wood products are traded

Atmospheric-flow approach - This accounts for net emissions or removals of carbon to/from the atmosphere within national boundaries, *where* and *when* emissions and removals occur. Removals of carbon from the atmosphere due to forest growth is accounted for in the producing country, while emissions of carbon to the atmosphere from oxidation of harvested wood products are accounted for in the consuming country.

The meeting identified and applied scientific, technical and policy-relevant criteria for evaluating the three approaches. These criteria relate to the *feasibility* and *accuracy* of the approaches, and to their *relevance to national policies* and *the reporting needs of the UNFCCC and Kyoto Protocol.*

In terms of feasibility, all three approaches offer a range of tiered methods, ranging from a default method based on currently available data, to a second or third tier method relying on national statistics of varying levels of detail. The current IPCC default approach can be considered the simplest form of the stock-change and production approaches, given the default assumption that the change in wood-product pool is negligible. But, even the simplest form of the atmospheric-flow approach differs from the IPCC default approach because emissions associated with traded roundwood are allocated to the consuming country.

The meeting noted that the FAO maintains a database containing information on production, imports and exports of wood products. This information is sufficient for the simpler tiered methods of all approaches, although the FAO data on the production of fuelwood and charcoal are likely uncertain because these products are often informally gathered. The FAO data are insufficient for higher tiered methods. The meeting identified various data sources for high tiered methods, including production data for intermediate and finished products, surveys of housing and their wood content, waste statistics, and range of other scientific studies.

The meeting further noted that the uncertainty in changes in carbon stocks, emissions, and removals in the land-use change and forestry (LUCF) sector is probably large, and likely be much greater than the uncertainty associated with forest harvesting and wood products. For some countries, the uncertainty of stock changes and emissions and removals from forest harvesting and wood products could be relatively low because formal harvesting of wood is an economic activity, and data for such activities are often well tracked. For the data-poor countries, the uncertainty in estimates from forest harvesting and wood products may be considerably greater.

The meeting found that, from a scientific perspective, globally, the results from the three approaches will be the same. At national scales, however, scientific differences among the three approaches do exist. One difference is that system boundaries differ among the three approaches. Another difference among the three approaches is how imports and exports are accounted for; this has implications for the assignment of national responsibility and for policy.

A major difference between the approaches is in the accounting of carbon emissions, removals, or stock changes *where* and *when* they occur. The *atmospheric-flow* approach accounts for when and where emissions occur. The *stock-change* approach accounts for when and where stock-changes occur. The *production* approach accounts for *when* stock changes occur, but not necessarily *where* - if wood products are exported, the stock changes continue to be attributed to the producing country.

The issue of *when* and *where* has implications for managing forest resources, use of imported woodfuel, and waste minimisation strategies, with a risk of creating perverse incentives. The meeting recognised that these incentives are a critical concern when choosing among the approaches. For example, if country A grows wood and exports it to country B, then under the stock-change approach the change in stock is accounted for in country B; under the production approach the change in stock is accounted for in country A; and under the atmospheric-flow approach removals due to regrowth are accounted for in country A but the emissions from oxidation of the wood products are accounted for in country B. As another example, when countries use imported woodfuels to displace fossil fuels, they would have to count the emissions from burning those biofuels under the atmospheric-flow approach, but not under the stock-change or production approaches.

Another factor that differentiates the approaches relates to the reporting needs of the UNFCCC and the Kyoto Protocol. While the Kyoto Protocol does not mention forest harvesting and wood products, it does require each Party to provide “data to establish its levels of carbon stocks in 1990 and to enable an estimate to be made of *its* changes in *stocks* in subsequent years.” The meanings of “its ...stocks” remains to be defined under the UNFCCC and some of the participants maintain that this may limit the choice of approach.

The development of more detailed methods for inclusion in the Guidelines would require further work by an expert group. This could be completed after further guidance by the SBSTA as to what approach should be adopted.

1. Introduction

In 1995, an approach for estimating the net CO_2 emissions from forest harvesting and wood products was developed by the IPCC Expert Group on Land-Use Change and Forestry. This draft approach was forwarded to the IPCC Plenary as part of the 1996 revision to the *Guidelines for National Greenhouse Gas Inventories (Guidelines)*. The IPCC Plenary, however, requested further technical work on approaches for estimating emissions from harvested wood products and sought guidance from SBSTA on policy implications. The SBSTA (December 1996) welcomed this decision and asked for an evaluation of the importance of harvested wood products as a carbon sink.

An IPCC expert meeting was held in Senegal (Dakar, 5-6 May 1998) on forest harvesting and wood products. This meeting evaluated approaches for estimating the fate of carbon from forest harvesting and wood products. The evaluation was carried out in three steps:

- *Step one* identified approaches for estimating the fate of carbon from harvesting and wood products.
- *Step two* identified criteria for evaluating approaches.
- *Step three* used these criteria to compare the approaches.

This report differentiates between forest products and wood products with the latter being a specific category of forest products. Wood products include industrial roundwood, which is used to make wood-based commodities such as sawnwood, veneer, wood-based panels, particleboard, paper and pulp, and the like; and woodfuel. Woodfuel is fuelwood, charcoal, and black liquor. Other forest products could be included in a national inventory if a country so chooses. Forests include all categories of woody biomass as defined in the *Guidelines.*

2. Background

2.1 Importance of carbon flows and stock changes from forest harvesting and wood products

The flux of CO_2 between the atmosphere and land depends on the rate at which CO_2 is emitted from and removed by vegetation and soils. Harvesting forests affect the carbon cycle because CO_2 is released during harvesting and manufacture of wood products, and by use of wood. For example, carbon is released over the short term by wood burning and use of short-lived products, and over the long term by decay and disposal of long-lived products (Figure 2-1). Carbon dioxide is sequestered when forest regrow after harvesting and when the pool of long-lived wood products increases. By managing land-use, forest resources, and wood products, countries can influence their national contribution to atmospheric CO_2 concentrations. The effect of national policies and measures on CO_2 emissions can be estimated using national inventories of emissions or changes in carbon stock.

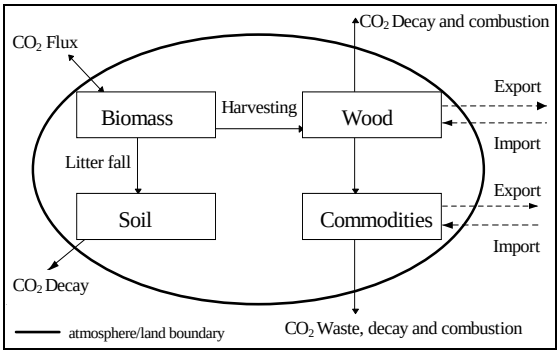


Figure 2-1: Diagram of CO_2 exchange between the biosphere and atmosphere, showing flows between carbon pools

Worldwide emissions of CO_2 from forest harvesting and wood products are potentially significant. In 1990, the estimate of gross emissions totals about 980 Tg C/yr (Winjum et al., 1998). The estimate is based on FAO data and is most likely an underestimate due to under-reporting of woodfuel consumption. More than 50% of this 980 Tg C/yr is emitted from the direct use of wood and charcoal for energy, about 20% from the decomposition of slash (170 Tg C/yr), and about 30% from the use of short-lived wood products, from long-lived products in use, and from waste generated during wood processing (295 Tg C/yr) (Figure 2-2). However, the estimate does not make allowances for uptake through forest growth. This is likely to exceed emissions from harvesting and use of wood products in most countries.

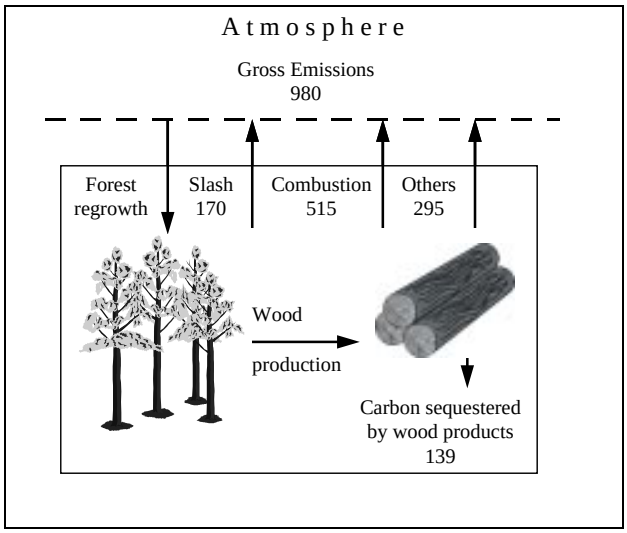


Figure 2-2: Global carbon fluxes between the terrestrial biosphere and atmosphere in Tg C/yr for forest harvesting and wood products (Winjum et al., 1998)

Globally, the carbon sequestered by wood products may also be important. In 1990, the increase in the long-lived wood-products pool was about 139 Tg C/yr (Figure 2-2). This is equal to about 2% of the global CO_2 emissions from fossil fuel use and cement production. This global estimate accounts for roughly 14% of gross emissions from harvesting (Winjum et al., 1998) and is equal to about 10% of the total net emissions from land-use change in the tropics (Schimel et al., 1995). In the 1990s, gross emissions from forest harvesting and wood products represented a significant amount - 16% - of total CO_2 emissions from fossil fuels and cement production (Marland et al., 1994).

The amount of carbon sequestered in the long-lived product pool as a percentage of total emissions from forest harvesting and wood products varies from country to country. In developed countries, the increase in the wood-products pool was equivalent to about 28% of total gross emissions from forest harvesting and wood products for 1990; in developing countries, the increase was equal to only about 5% of total gross emissions (Winjum et al., 1998).

National representatives reported similar results: 6% for Finland (Pingoud et al., 1996), 15% for Norway (Martinsen et al., 1998), 29% for the USA, 12% for Canada, 4% for Brazil, India, and Indonesia (Winjum et al., 1998), 34% for Sweden and 198% for The Netherlands (Nabuurs and Sikkema, 1998). The Netherlands had a particularly high percentage of carbon sequestered into the product pool compared to its total gross emissions because most products are imported and little harvesting occurs in national forests.

Over the past decade, the wood-products pool increased globally by about 20% on average. Historical trends suggest that from 1983 to 1990, forest products and industrial roundwood production increased by 266 million m^3, or by 18% (FAO forest products data, 1990). Over the same period, the production of sawnwood increased by 63 million m^3, or by 14%. Similarly, production of wood-based panels increased by 21 million m^3, or by 20%. This carbon stock is likely to continue to increase, particularly in countries where wood is widely used for construction.

2.2 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

The *Guidelines* include a chapter for tracking the movement of biotic carbon in the terrestrial biosphere. Within this chapter, emissions and removals of CO_2 are treated as a closed system in four categories of activities in the land-use change and forestry sector (LUCF). Emissions and removals resulting from forest harvesting and wood products are captured in one of these categories, *Changes in Forest and Woody Biomass Stocks.*

The *Guidelines* treat wood products as if there is no change in their stocks, so that emissions from harvested wood are treated as though they are released to the atmosphere in the year of harvest (Figure 2-3). This means that emissions from harvested wood are attributed to the year of production and in the country of harvest; no account is taken of delayed emissions from wood products with a lifetime greater than a year. The default assumption in the *Guidelines* is reasonable if the product pool remains constant, whereas in reality, it is increasing globally over time (Winjum et al. 1998); that is atmospheric CO_2 is being sequestered into the product pool. The *Guidelines* (Reference Manual, pp 5.17) acknowledge this process, but a default approach is not provided. However, the *Guidelines* do state that "If data permit, one could account for increases in the pool of forest products" (Reference Manual, Ch. 5, Box 5).

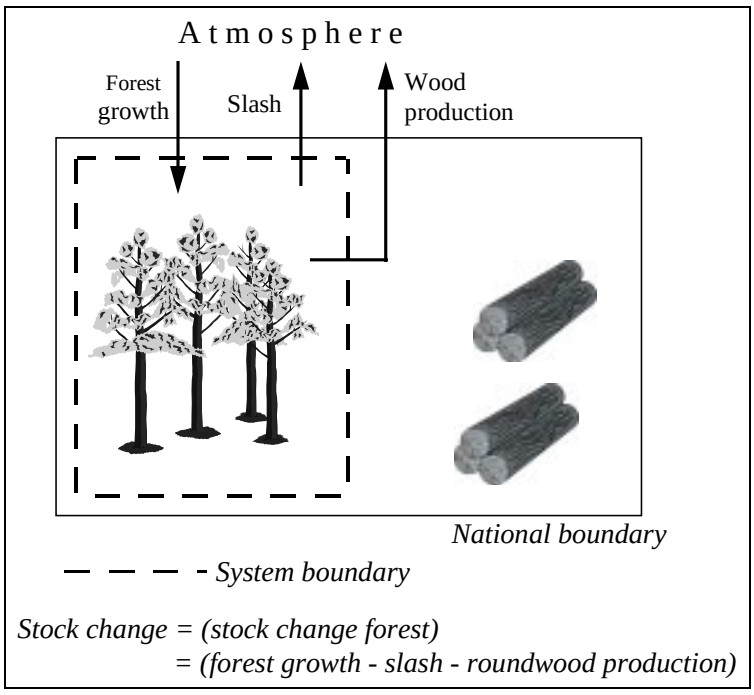


Figure 2-3: Main components and equation for the present IPCC default approach

Currently, about 34 Annex-1 Parties have reported their national GHG inventories to the UNFCCC. Most follow the reporting format of the *Guidelines* for LUCF. Recent inventory data from Annex-1 Parties show that most of the net CO_2 emissions - about 90% - from LUCF are from *Changes in Forest and Woody Biomass Stocks*. However, not all countries treat emissions from harvesting and wood products in the same way: Norway, the United States, and the United Kingdom, for example, *do* account for wood products, but many countries *do not*.

3. Approaches for estimating the fate of carbon from forest harvesting and wood products

This report identifies three approaches for estimating the fate of carbon from forest harvesting and wood products: (1) the *stock-change*, (2) the *production*, and (3) the *atmospheric-flow*. From the scientific and technical perspective, the differences among the approaches are not large globally; they will generate the same net carbon exchange with the atmosphere. At the national level, however, they differ for two main reasons.

First, the *atmospheric-flow* approach calculates net carbon emissions to the atmosphere, while the *stock-change* and *production* approaches calculate the net change in carbon stocks in the forest and product pool.

Second, the system boundaries, that is the national inventory boundary, of the three approaches are different. The *atmospheric-flow* approach has a system boundary between the country and the atmosphere, so that the sum of all carbon fluxes to and from the atmosphere is counted. The *stock-change* approach has a system boundary around a country, so that the stock changes, including imports and exports of wood commodities in that country, are counted. The *production* approach has a system boundary around the wood that was grown in a particular country, even if it is exported and consumed elsewhere.

Because of these technical factors, net emissions of carbon or changes in carbon stocks are allocated differently among producing and consuming countries. (The producing country is where the wood is grown, whereas the consuming country is where the wood is used, either as roundwood for manufacture of commodities/products or directly as wood commodities/products.) These allocation differences may influence, for example, incentives for sustainable forest management, biodiversity, and the use of wood products and biofuels. The next section summarises the key features of the three approaches. For a discussion of the implications of the approaches on the management of forest resources, see Annex 1 and Table A1.

3.1 Stock-change approach

The *stock-change* approach estimates the net change in carbon stocks in the forest and in the wood-products pool within national boundaries (Figure 3-1). Stock changes in forests are accounted for in the producing country, whereas stock changes in wood products are accounted for in the consuming country (Winjum et al., 1998), i.e. stock changes are accounted for in the country where they occur. Any carbon stocks that cross a system boundary (Figure 3-1) are transferred from one country's inventory to another. The treatment of emissions differs from that of fossil fuels. For carbon in biotic products with an annual lifecycle, the average change in stock is zero.

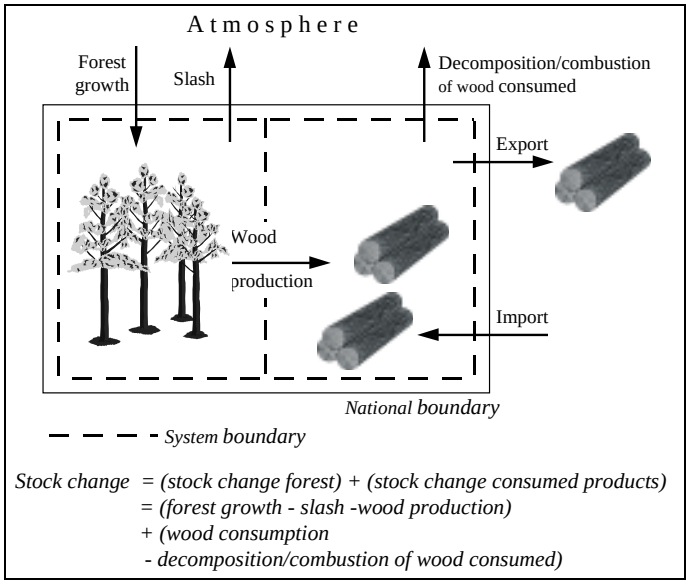
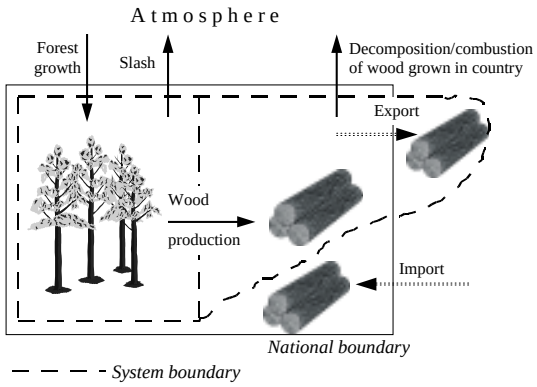


Figure 3-1: Main components and equation for the stock-change approach

3.2 Production approach

The *production* approach also estimates changes in carbon stock in the forest and in the wood-products pool (Figure 3-2). Stock changes derived from forests are accounted for in the producing country. The carbon contained in exported wood products remains accounted for in the carbon stock of the producing country. That is any carbon stocks that cross a system boundary (Figure 3-2) are not transferred from one country's inventory to another; the exported carbon remains in the inventory of the exporting country. The treatment of emissions differs from that of fossil fuels. For carbon in biotic products with an annual lifecycle, the average change in stock is zero.

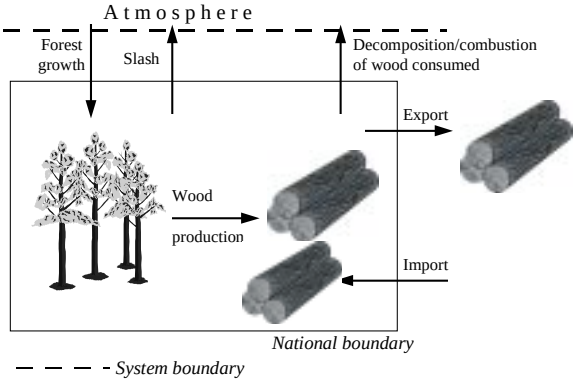


Stock change = (stock change forest) + (stock change domestic-grown products)
= (forest growth - slash -wood production) + (wood production - decomposition/combustion of wood grown in country)

Figure 3-2: Main components and equation for the production approach

3.3 Atmospheric-flow approach

The *atmospheric-flow* approach estimates the flows of CO_2 between the biosphere and the atmosphere. It accounts for *actual* emissions and removals within national boundaries *where* and *when* they occur (Figure 3-3). Gross emissions from harvesting roundwood and from wood products are accounted for in the consuming country, whereas uptake from forest growth is accounted for in the producing country (Winjum et al., 1998). Any emissions associated with carbon stocks that cross a system boundary (Figure 3-3) are transferred from one country's inventory to another. The treatment of emissions is the same as that of fossil fuels. If the wood is domestically produced and consumed, there is no change in the allocation of emissions.



Atmospheric flow = forest growth - slash - decomposition/combustion of wood consumed

Figure 3-3: Main components and equation for the atmospheric-flow approach

4. Evaluating approaches for estimating the fate of carbon by forest harvesting and wood products

This section identifies criteria for evaluating the three approaches and describes how these criteria were applied.

Criteria for the evaluation Criteria for evaluating approaches depend on the purpose of the inventory. The main purpose of the IPCC default approach is to help countries prepare national inventories under the UNFCCC. In this context, key criteria are: *completeness, consistency, comparability, verifiability, transparency* and *accuracy.* Others were identified at the meeting (Table 0-1) and were later revised to

minimise duplication. The choice of any approach is likely to involve trade-offs among criteria. The key categories of criteria considered, unranked, are:

- *feasibility of approach*
- *accuracy of approach*
- *relevance to the reporting needs of the UNFCCC and Kyoto Protocol*
- *relevance to national policies*

Evaluating approaches For each approach, participants developed the conceptual framework at different levels of complexity (i.e. tiered methods). The next section lays out the issues according to the categories of key criteria. Further details are found in the Working Group Reports (Annex 2).

4.1 Feasibility of approaches

A fundamental principle of the *Guidelines* is that default approaches should be applicable by all countries. As such, they must be as simple as practicable. Criteria that affect the feasibility of approaches include: complexity of approaches, availability of data, costs of data collection, availability of national expertise and capability, and applicability at various spatial scales. A further consideration is whether changes in the wood-products pool are sufficiently large to justify the use of a more complex approach.

4.1.1 Complexity of approaches

How easily can the approaches be applied?

All three approaches offer a range of tiered methods at various levels of complexity. Each approach, except for the *atmospheric-flow* approach, begins with a simplified IPCC default method that is based on the current IPCC default. In general, complexity increases across tiers. For the default approaches, emissions from the wood products pool are assumed to be emitted in the year of harvest. For the *atmospheric-flow* approach, import and export data are also needed for the default. At the simplest level, all three approaches can readily be applied.

4.1.2 Availability of data

How reliable are the available data?

Data availability is critical for all approaches. The tiered methods of all three approaches require more data than the present IPCC default, but their data requirements are similar. Default information is available from the FAO. The data needs of the three approaches are the following; production, imports, and exports of roundwood and commodities. At the higher tiers, data are also needed to estimate the amount of wood remaining in service from past use. The FAO (1995a,b) Yearbook of Forest Products provides data from 1961 onwards with which the amount of wood remaining in service can be calculated. Therefore, all of the default approaches can be applied and none can be rejected on the basis of data availability.

The higher tiers of each approach can be very data-intensive, however, and only a few countries would be able to apply them. For the highest tier of the *stock-change* approach, one constraint is data on stocks of end-use products (e.g., wood in houses, etc.). Few countries directly measure these stocks, thus limiting the potential use of this method. For the *production* approach, a major constraint is that stock data are required for all countries to which products are exported.

There is also the question of the availability of national data. Imports and exports of industrial roundwood and commodities are well-tracked commercial products, but data on harvesting rate and cross-boundary movements of woodfuel are probably unreliable. The relevant data should generally be available in many countries, especially as countries provide these data to the FAO. This may not be true for data on woodfuels as these products are often informally gathered. Therefore, the availability and quality of these

statistics could be limited in all countries. Such data are not needed, however, for the highest tiers of the *stock-change* and *production* approaches.

4.1.3 Costs and ease of data collection

What are the costs and ease of data collection?

For all three approaches, national data should be readily available for use with the default and tier one methods. As such, the cost of data collection would be relatively low. Data quality may vary widely across countries, however. Any approach that uses production and trade statistics would be relatively cheap and simple to implement; these data are often collected in many countries, but as noted above, woodfuel data may be underestimated. Where no data currently exist, application of the higher tiers may be too expensive.

4.1.4 Availability of national expertise

Is national expertise available to apply the approaches?

All countries have the national expertise to apply the default methods for all approaches, and many should be able to use the lower tiers. The higher tiers of all approaches could be problematic.

Table 0-1. Criteria for evaluating approaches

Feasibility of approaches	Accuracy of approaches	Relevance to the reporting needs of the UNFCCC and the Kyoto Protocol	Relevance to national policies
Complexity of approaches Availability of data Cost and ease of data collection Availability of national expertise Applicability at various spatial scales	Assumptions in the approach Quality of underlying data Applicability at various spatial and temporal scales Consistency at various spatial and temporal scales, and across tiers Precision of definitions Completeness of accounting Uncertainty of emissions estimates Scientific acceptability Repeatability of estimates Potential for continued inventory improvement	Types of approaches Verification and transparency Applicability at various spatial scales Consistency with other sectors of the *Guidelines* Understandability Potential for adaptability Ability to gauge the effects of national measures Ability to use for projections	Usefulness for national planning Ability to track the effects of measures Applicability at various spatial scales Consistency with sustainable forest management

4.2 Accuracy of approaches

Many factors affect the accuracy of approaches, including: assumptions used in the approaches; quality of underlying data; applicability and consistency at different spatial and temporal scales; precision of definitions; completeness of accounting; scientific acceptability; repeatability; consistency within different tiers; and potential for continued improvement of the inventory. All of these factors can affect the uncertainty of emissions or stock-change estimates. Some of the main criteria are discussed below.

4.2.1 Assumptions in the approaches

Are the proposed approaches accurate enough? How can accuracy be improved?

The accuracy of an approach is generally believed to improve with increasing complexity of the methods used. This is not always true. The bias of an estimate depends on the quality of the data and is highly sensitive to the number of assumptions in an approach. Often, the greater the number of assumptions, the larger the uncertainty of the emission estimate. All three approaches are likely to involve many assumptions at the most complex level.

Each of the approaches involves assumptions about: decomposition and discard rates of products, factors for converting units of volume to biomass (e.g., biomass expansion factors), and factors for estimating slash produced during harvest. Tests have shown that conversion of volumes of wood to units of biomass is highly sensitive to the biomass expansion factors (Winjum et al., 1998). The experts suggested that decomposition rates of wood and paper or discard rates of wood in use are highly uncertain too. They vary from one country to another, and are related to economic activity and technologies used for waste disposal and recycling.

If any of the three approaches were developed for the *Guidelines*, further work may be needed to refine the assumptions. Given that many of them are based on research in developed countries, these assumptions would need to be examined critically to assess their applicability under conditions in developing countries. New factors might need to be developed to better reflect conditions in these countries.

4.2.2 Quality of underlying data

What is the quality of underlying data?

The quality of wood-product data in the FAO database is variable. The FAO collects these data from countries through questionnaires. Typically, countries collect the commodity data using standard collection procedures specified under trade agreements. The FAO also compares the national data with the UN statistics as a consistency check. The error bar around these data is about $\pm$ 10-15% for OECD countries and as high as $\pm$ 50% for non-OECD countries (Bruce Michie, European Forest Institute, pers. comm., 1998). Data on roundwood production are less reliable than trade statistics as there are no independent checks to verify them.

4.2.3 Uncertainty of emissions estimates

What is the uncertainty in estimates of the fate of carbon from forest harvesting and wood products compared with uncertainty of emissions and removals from the land-use change and forestry sector?

The uncertainty of emissions from and removals by land-use change and forestry is often said to be large. In some cases, the uncertainty in estimates from the sector as a whole would be much greater than the uncertainty in emissions from wood products. Emissions from wood products would be lost as 'noise' among these emissions estimates. This suggestion is difficult to assess given that Parties do not consistently report uncertainties in their National Communications. For some countries, however, the uncertainty of emissions from wood products could be relatively low because formal harvesting of wood

is an economic activity, and data for such activities are often well tracked. This does not apply to informal harvesting. Some Parties report reasonably high confidence levels of < 15 to 25% for the category of *Changes in Forest and Other Woody Biomass Stocks*. These countries are Belgium, the United Kingdom, New Zealand and Slovakia. For such countries, the uncertainty of emissions estimates from wood products might be similar to or lower than the uncertainty of estimates from LUCF. For the data-poor countries, the uncertainty of emissions estimates from wood products may be considerably greater.

4.2.4 Other criteria

What other criteria affect the accuracy of the approaches?
Because the wood-products pool is increasing globally, the IPCC default approach is likely to overestimate gross emissions. However, not all countries are increasing their carbon stocks significantly; for these countries, any default method would be perfectly adequate.

If the availability and reliability of data are not issues, the accuracy within an approach improves across the tiers with increasing consistency and completeness of accounting. For all approaches, double counting with emissions from the waste sector was identified as a potential issue. Including CO_2 from landfills has implications for double counting of carbon (as CH_4) in national GHG inventories. This also raises the question as to whether an approach should be developed to include both wood products in use and wood products in landfills. As national studies (e.g., Pingoud et al., 1996) have shown, the latter is a potentially important sink. The carbon sequestered in landfills might be three to four times higher than for wood products in use, though the uncertainty of these estimates varies by type of disposal and climate. Some estimates of decomposition rates for sanitary landfills have been made (Micales and Skog, 1997), but how and where waste is dumped, and the associated decomposition rates are particularly uncertain for the developing countries.

The accuracy of the approaches is also scale-dependent. At the higher tiers, greater accuracy is achieved at increasingly finer scales for the *stock-change* and *atmospheric-flow* approaches. But the *production* approach may be more accurate at the national than the project level.

4.3 Relevance to the reporting needs of the UNFCCC and the Kyoto Protocol

Several criteria were identified for evaluating the approaches according to their relevance to the reporting needs of the UNFCCC and the Kyoto Protocol. The key ones were: verification and transparency of approaches; applicability at various spatial scales; consistency with other sections of the *Guidelines*; ability to gauge the effects of national measures, and ability to use approaches as a basis for projections.

4.3.1 Types of approaches

Do the approaches meet the reporting needs of the Protocol and the UNFCCC?
Many participants felt that the *Guidelines* should strive towards providing quality inventories for the UNFCCC. The Kyoto Protocol does not explicitly require Annex-I Parties to include harvested wood products. There is an option, however, for the Conference of the Parties, serving as the first Meeting of the Parties, to consider '*which additional human-induced activities related to changes in greenhouse gas emission by sources and removals by sinks in the agricultural soils and land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts.'* Under the UNFCCC, it may be necessary to consider whether harvested wood products should be included among '*additional human-induced activities'*.

The Protocol also requires a Party to provide '*data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in stocks in subsequent years'*. The meanings of 'its' and 'stocks' still remain to be defined under the Convention. Nevertheless, some of the participants maintain that the *stock-change* and *production* approaches both estimate change in stocks, and that the *atmospheric-flow* approach estimates emissions. Those participants maintain that this may limit the choice of approach . Other participants maintain that both stock and flow data can be the basis for estimating both stock changes and net emissions or net sink.

4.3.2 Verification and transparency

Do the approaches allow for the reporting of transparent and verifiable information?
The Protocol requires that '*emission from sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner'*. Estimates derived from all three approaches should be verifiable and transparent. However, The more complex the method, however, the greater the level of effort required to ensure transparent reporting.

4.3.3 Applicability at various spatial scales

Can the approaches be applied at the national and project scales?
Under the Kyoto Protocol, there are provisions to transfer emissions from one Party to another. As a result, entities other than governments may be able to participate in national mitigation strategies. This may require that emissions estimates be aggregated from the project to the national scales. Hence, approaches should give comparable results at all spatial scales. Whereas all three approaches could be applied at different scales, they may give very different results at the project and national levels.

4.3.4 Consistency

Are the approaches consistent with other sectors of the Guidelines?
A key criterion for evaluating approaches is the consistency of an approach with other sectors of the *Guidelines*. This criterion brings out the differences among the approaches. The *atmospheric-flow* approach is consistent with the energy sector; emissions are accounted for in the country *where* and *when* they occur. The *production* approach deals with emissions in the same way as the current IPCC approach for stored carbon in traded plastics and for LUCF; emissions are accounted for in the producing country. The *stock-change* approach is consistent with the treatment of LUCF and other biological materials in the *Guidelines*, but differs from the treatment of fossil fuels.

4.3.5 Other criteria

Can the approaches be used to gauge the effects of national measures and as a basis for projections?
The highest tiers of all three approaches satisfy both these criteria. The default method would, however, be inadequate for these purposes. The *atmospheric-flow* approach gives detail on the processes that influence carbon flows from forest harvesting and wood products, thus providing the information needed for a policy tool. It can also be used for projections, allowing the effects of national measures to be estimated. The *stock-change* approach (stock-based) cannot be used for projections since it does not track changes in processes. The *production* approach can only be used for projections of domestic, not imported, wood products.

4.4 Relevance to national policies

Participants identified several criteria relevant to national policies. The criteria included: usefulness as a national planning tool; ability to track the effects of measures; consistency with sustainable forest management; including the effect on the use of wood fuels.

4.4.1 Promotion of sustainable forest management

What are the implications of the approaches on the management of forest resources, including wood products?

Much of the discussion on the three alternative approaches centred on the allocation of national GHG emissions and removals (see Annex 1 and Table A1). One principle in the *Guidelines* is that emissions and removals of GHG appear in the inventory of the country where they actually occur. This philosophy is embodied in several chapters of the *Guidelines*, including Energy and Industrial Processes. Exceptions to this principle are emissions from bunkers, and traded short-lived carbon products, such as food and textiles. It is often argued, however that emissions from fossil and non-fossil fuels should *not* be treated in the same manner. The combustion of fossil fuels is seen as a one-way flow of CO_2 emissions to the atmosphere. Such emissions are *irreversible* over timeframes of decades. By contrast, CO_2 emissions from wood products are *reversible* over similar timeframes, i.e., atmospheric CO_2 can be returned to the land through the regrowth of forest vegetation. Emissions from harvested wood products are thus part of a closed cycle. The *Guidelines* recognise the difference between fossil and non-fossil fuels, and treat the land-use change and forestry module of the *Guidelines* as a closed cycle. The *stock-change* and *production* approaches would be consistent with the LUCF Chapter of the *Guidelines*, but the *atmospheric-flow* approach would not. Adoption of the flow approach would imply a change from the present principle of accounting in the LUCF Chapter of the *Guidelines*.

The accounting principles of the various approaches have implications for forest management. The IPCC default approach is consistent with the goals of sustainable forest management, but is of limited utility. To some extent, all the approaches are consistent with this goal.

There are other implications for sustainable forest management. For example, the *production* approach may not provide an incentive to a consuming country to better manage the use of imported wood since emissions are accounted for in the producing country. In contrast, the *atmospheric-flow* approach does not necessarily provide an incentive to import fuelwood. The implications of the various approaches are provided in Annex 1, although none of these were discussed in detail at the meeting.

4.4.2 Other criteria

Can the approaches be used as a national planning tool and to track the effects of measures?

For all approaches, the default method does not provide adequate information for national planning nor for tracking the effects of measures. Only the higher tiered methods will satisfy these criteria. One drawback of the *production* approach is that the exporting country remains responsible for stock changes in exported products. Because information on the ultimate fate of the exported products may be hard to obtain, the exporting country would have to assume the same lifetimes and fates of products used domestically. These assumptions could introduce errors into national emission estimates. Furthermore, any measures to reduce emissions from waste would not be detectable in an importing country. As a consequence, the importing country may have little incentive to improve the management of waste.

5. Conclusions

This meeting examined the way in which CO_2 emissions from forest harvesting and wood products are currently dealt with in the *Guidelines*. The IPCC default approach assumes that there is no change in the size of the products pool, and all emissions are accounted for in the producing country during the year of harvest. Participants concluded that the current IPCC approach could be improved.

The rationale for proposing revisions to the IPCC approach was scientific. It is based on a review of the relative importance of changes in the wood-products pool. At the global level, changes in the product

pool are potentially significant, estimated to be about 2% of the global emissions of CO_2 from fossil fuels. This amount is projected to increase in the future. This global estimate may be underestimated as it does not include the carbon that is sequestered in waste disposal sites, where it may remain stable for up to several hundred years. National case studies show that the changes in carbon stock of wood products vary widely from country to country. As these changes are important for some countries, the meeting agreed that the *Guidelines* should provide approaches to account for the fate of wood products.

To improve the IPCC approach, three alternatives were proposed. They were the *stock-change, production* and the *atmospheric-flow* approaches. The *stock-change* and *production* approaches may not require a change in allocation of emissions or stock changes compared to the current IPCC default approach for harvesting and wood products. The *atmospheric-flow* approach would require a change.

For each approach, participants developed a framework of tiered methods of increasing complexity. Each tiered approach was developed along different principles, and further work would be needed to incorporate one of these approaches into the *Guidelines.* Each country would be responsible for deciding if it should go beyond the default approach to estimate emissions from forest harvesting and wood products. This decision would partly depend on whether its carbon stock in wood products was increasing fast enough to warrant the extra effort of applying a complex method and whether the data were available. Data requirements should not, however, be a major consideration as default data are available for all approaches.

Globally, all three approaches give similar results. 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.

6. Next steps

Before further development of one of the three approaches for the *Guidelines*, guidance by the Parties to the Convention to the IPCC is needed. Depending on the approach chosen, one small meeting with about 10-15 experts may be needed to develop tiered methods. In developing any approach, it would be necessary to carefully define the reporting framework and to establish whether estimates of net emissions or stocks were required under the Convention. This work would involve developing a set of default factors (e.g., for converting volumes to mass of carbon, disposition to uses over time, rates of discard from use over time, and rates of decay after discard, etc.) and calculation worksheets for the *Guidelines.* A decision would also be needed on how to deal with wood in waste disposal sites as this is a potentially important carbon sink. On timing, it may be logical to incorporate future revisions to the IPCC approach during the next update of the Land-use Change and Forestry Chapter.

GLOSSARY

Approach is a conceptual framework for estimating emissions and removals of greenhouse gases in inventories. Within each approach, there may be more than one method (see *Method*).

Method is the calculation framework within an *approach* for estimating emissions and removals of changes in stocks of greenhouse gases in inventories (see *Approach*).

IPCC default approach provides changes in carbon stock in forests. This is the present IPCC approach and assumes that there is no net change in the stock of wood products.

Stock-change approach provides changes in carbon stock in forests and wood products and counts them in the country where the changes in stock occur. The module takes into account when and where stock-changes in carbon in wood products actually occur.

Production approach provides changes in carbon stock in forests and wood products and counts them in the country where the wood is produced (grown). The module takes into account when but not where stock-changes in carbon in wood products actually occur.

Atmospheric-flow approach provides carbon fluxes to and from the atmosphere for a given country. The module takes into account when and where CO_2 fluxes between the atmosphere and forests and wood products actually occur.

Producing country is the country in which the wood is grown.

Consuming country is the country in which the wood product (either roundwood or commodities) is used.

Actual emissions are estimated by approaches with a time function, and take into account delayed emission and removal processes.

Potential emissions are estimated by methods that ignore delayed emission and release processes.

Slash is the wood, organic debris and other material remaining on site after harvest. It is composed of leaves, twigs, branches, tops and stumps.

FAO United Nations Food and Agriculture Organisation.

IPCC Intergovernmental Panel on Climate Change.

SBSTA Subsidiary Body on Scientific and Technological Advice.

UNFCCC United Nations Framework Convention on Climate Change.

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