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Comparison of methods for estimating carbon in harvested wood products

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ABSTRACT

There is a great diversity of methods for estimating carbon storage in harvested wood products (HWP) and, therefore, it is extremely important to agree internationally on the methods to be used in national greenhouse gas inventories. This study compares three methods for estimating carbon accumulation in HWP: the method suggested by Winjum et al. (Winjum method), the tier 2 method proposed by the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG LULUCF) (GPG tier 2 method) and a method consistent with GPG LULUCF tier 3 methods (GPG tier 3 method). Carbon accumulation in HWP was estimated for Portugal under three accounting approaches: stock-change, production and atmospheric-flow. The uncertainty in the estimates was also evaluated using Monte Carlo simulation.

The estimates of carbon accumulation in HWP obtained with the Winjum method differed substantially from the estimates obtained with the other methods, because this method tends to overestimate carbon accumulation with the stock-change and the production approaches and tends to underestimate carbon accumulation with the atmospheric-flow approach. The estimates of carbon accumulation provided by the GPG methods were similar, but the GPG tier 3 method reported the lowest uncertainties. For the GPG methods, the atmospheric-flow approach produced the largest estimates of carbon accumulation, followed by the production approach and the stock-change approach, by this order. A sensitivity analysis showed that using the "best" available data on production and trade of HWP produces larger estimates of carbon accumulation than using data from the Food and Agriculture Organization.

1. Introduction

Globally, harvested wood products (HWP) are estimated to be accumulating carbon at rates ranging from 26 to 139 Tg year^{-1}, depending either on the method or on the inherent assumptions used in the estimations [1–4]. This accumulation takes place both when HWP are in use and also when they are disposed off in landfills, where the decay under anaerobic conditions is slow and incomplete [5,6]. Carbon accumulation in HWP appears to be a small part of the total carbon sink provided by global terrestrial ecosystems, which amounted to 1.6–4.8 Pg year^{-1} in the 1990s [7]. Nevertheless, carbon accumulation in HWP may be significant at an individual country level [8,9]. In addition, while the terrestrial carbon sink may disappear in the future, as the saturation level is reached [10,11], HWP provide irreversible carbon mitigation benefits by reducing the use of fossil fuels and construction materials that require higher fossil fuel consumption in its manufacture [12].

There are a number of different methods for estimating carbon storage in HWP. They can be grouped into three major

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categories, according to the data they require: inflow–outflow methods, stock-data methods and direct estimation of emissions [13]. Inflow–outflow methods estimate the changes in carbon stocks as the difference between the inflow of carbon into the pool of HWP and the outflow of carbon from that pool. Two different inflow–outflow methods are available: lifetime analysis, where the outflow of carbon is estimated on the basis of assumed lifetimes for the HWP, and direct observation, where the outflow of carbon is estimated directly based on statistical data. Stock-data methods estimate the changes in carbon stocks as the difference between the stocks of carbon in HWP at two or more points in time. The stocks of carbon in HWP are obtained directly based on statistics and sampling techniques. In the methods based on direct estimation of emissions all forms of emissions from the decay and combustion of HWP are estimated directly. In this case, the changes in carbon stocks of HWP are calculated from the difference between carbon contained in harvested wood and the total carbon emissions generated over the life cycle of that wood.

There is a need to agree, at an international level, on the methods to be used in national GHG inventories due to the different outcomes from them. In this sense, some methodological frameworks have been proposed. Firstly, Winjum et al. [2] proposed a method based on a lifetime analysis (hereafter referred to as Winjum method). Another methodological framework was suggested by the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG LULUCF) [14], which provided a tiered structure of methods with varying degrees of complexity and data demand. The tier 1 method assumes that the stocks of HWP are not increasing significantly and, therefore, ignores carbon accumulation in HWP. The tier 2 method (hereafter referred to as GPG tier 2 method) is based on a lifetime analysis and is called ''first order decay method'' as HWP are assumed to decay exponentially over time. Tier 3 methods require country-specific data and thus are termed ''country-specific methods''. They comprise stock-data methods (method A), inflow–outflow methods (method B) and combined methods in which stock-data methods are employed for certain HWP pools, such as buildings and furniture, and inflow–outflow methods are used for the other HWP pools (method C). The GPG LULUCF only presents detailed calculation procedures for the tier 2 method. Both the Winjum method and the GPG tier 2 method rely on default input data and are simplified methods that most countries could use. More recently, the 2006 IPCC Guidelines [15] provided a tier structure of methods slightly different from the one suggested by the GPG LULUCF. According to the 2006 IPCC Guidelines, the tier 1 method is a first order decay method similar to the GPG tier 2 method; tier 2 methods are also first order decay methods but requiring country-specific data, and tier 3 methods are more complex, detailed country-specific methods.

The Winjum method has been applied in a number of studies, some of them with improvements to better reproduce country-specific conditions [3,9,16,17]. The tier 2 and 3 methods suggested by the GPG LULUCF have also been applied to various countries [4,17–22].

The comparison of methods for estimating carbon in HWP was only made on a few studies. For example, Flugsrud et al. [17] have estimated carbon accumulation in HWP for Norway by using both the Winjum method and a combined method, showing that there are considerable differences in their outcomes.

The objective of this study was to compare different methods for estimating carbon accumulation in HWP for Portugal, namely the Winjum method, the GPG tier 2 method and a method consistent with the GPG LULUCF tier 3 – method B (hereafter referred to as GPG tier 3 method). Carbon accumulation in HWP has been calculated before for Portugal using these methods [4,9,16,20] but a direct comparison was not yet made, which is important for the selection of the most appropriate method.

Carbon accumulation in HWP was estimated for three accounting approaches: stock-change approach, production approach and atmospheric-flow approach [23]. A fourth approach, the so-called simple decay approach, was more recently proposed [24]. This approach was not considered in the present study because it appears not to be a new approach but rather a calculation method within the production approach [25]. A distinction should be made between the terms approach and method. The term approach refers to the allocation of carbon stocks or emissions between countries, and the term method refers to the calculation framework for estimating carbon stocks or emissions within a given approach [13].

The approaches considered in this study are currently undergoing an evaluation process leading to the selection of the approach to be used in future national GHG emission inventories [26].

The uncertainty of the estimates was evaluated using Monte Carlo simulation and a sensitivity analysis was also conducted in order to assess the impact of using different statistical data on the production and trade of HWP.

2. Methodology

2.1. *Approaches*

According to the stock-change approach, carbon accumulation in HWP is equivalent to the net change in carbon stocks of HWP within national boundaries. Thus, the stock changes in HWP are accounted for in the consuming country, i.e., where they occur.

The production approach estimates carbon accumulation in HWP as the net change in carbon stocks of HWP produced from domestically grown wood. Thus, stock changes in HWP are allocated to the country in which the wood was grown. In this case, stock changes in HWP are not accounted where they occur if HWP are traded.

The atmospheric-flow approach relies on flows of carbon between the forest sector and the atmosphere rather than on stock changes. This approach allocates the emissions from the oxidation of HWP to the consuming country, i.e., where they occur. In practice, carbon accumulation in HWP in the atmospheric-flow approach is equal to that estimated by the stock-change approach, plus the net export of carbon in HWP [17].