Introduction

Forests play a key dual role, both sequestering carbon from the atmosphere and releasing carbon to forest residues degradation after harvesting or thinning activities. For LCA, biomass from sustainably grown forests needs to be considered as carbon as the carbon released during combustion is assumed to be re-sequestered in the growing biomass. Nevertheless, carbon neutrality does not mean that the process implies climate neutrality: if used for long-lived products, if used for substitution of other materials (fuels, construction materials or if a change in the local carbon cycle occurs [plants, branches, roots, litter, soil], and the time considered for the biomass re-grows.

The objective of this study is to model the forest carbon cycle and compare the following four methodological approaches selected from an extensive literature review:

1. Individual Land Use Change (iLUC) modelling
2. A scenario approach to express the climate indicator, to evaluate the climate life cycle impact assessment (LCIA) of the process
3. Time horizon (TH) considered
4. Forest carbon pool accounted (whole carbon pool, only above ground carbon or only carbon in stem)

The outcome is expected to answer the following research question:

How to include forest carbon in Life Cycle Assessment of products?

A comparison of scenario 1, 9 and 10 shows how also different forest carbon pool influence the LCA outcome. Scenario 9 results in a higher CO2 uptake than scenario 10, despite the former accounting for carbon in the stem and the latter for the AG biomass. Among the last group of assumptions tested, the most reliable results were drawn from the first scenario.

Results and Discussion

Materials and Methods

Functional unit

1 m³ of spruce wood used for construction material.

Reference flow

The area considered for the forest C balance is 1 hectare of land, with a time frame unit of 1 year. The Net Primary Production (NP) is the reference flow, measured in tons of carbon.

Co-product allocation and system expansion

This study follows a consequential LCA (EDCA) approach to deal with co-product allocation through system expansion: the studied product system is expanded to include the processes displaced by the co-product. The identification of the displaced process is based on market mechanism and market data. Once the displaced process and its production process are identified, they are assumed substituted by the co-product. The identification of the substituted products in LCA follows market mechanism instead of sewage data.

Life Cycle Impact Assessment (LCIA)

The Global Warming Potential (GWP) is used for LCIA. Two approaches of GWP are tested: a static approach, not accounting for the timing of GHG emissions and sinks, and a dynamic approach, weighting the GHG emissions for a time dependent factor.

Modeling assumptions testing plan

For each methodological approach, a number of different options were tested and compared against each other. The options tested for each of the methodological approaches are shown in the Table. Table 2 shows the modelling assumptions testing plan. The variable blue are kept constant. The other colours underline three different groups of tests. The results are compared against each other and analyzed according to these three groups.

Forest Biome Carbon Cycle

Forest biomass is divided to above ground (AG) and below ground (BG). Each is then further divided in sub-categories. Figure 1 shows how all these categories function as both inputs and outputs of the forest carbon cycle. Figure 2 shows how the thinning procedure modifies the trend of the C stored in the forest during the rotation time, specifically in the total amount of harvested stem wood and harvested wood residues in the forest. In figure 3, the thinning process coincides with a drop of the carbon stored in stem and residues, as the thinned stems and residues are assumed harvested. It is assumed that the wood already present in the market immediately satisfies the demand of wood; the wood harvested today obviously goes in the previous 70 years (assuming a rotation time of 70 years). The red line in figure 2 outlines the time window considered in this study for which the carbon cycle is accounted.

Table 1

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References


Take-home

The results suggest that in order to include the carbon cycle in LCA, it is necessary to:

- Account for the effect of the iLUC model, especially for a short or medium value Time Horizon
- Adopt a dynamic LCIA indicator, accounting for the timing of emission and sink
- Include both above and below ground carbon stock.

The results underline in order to reach a reliable conclusion a certain degree of complexity of the model is required, leaving into account several aspects affecting both the LCI and LCA phase. Increasing the accuracy of the model improves its conformity to the reality and allows for more reliable results to be reached. Nevertheless, the answer depends on the purpose of the study including its goal and scope. Some of the choices might be neglected in specific conditions with limited consequences on the final result.

The use of wood in long-lived products does alleviate the environmental impact of falling a tree, provided that new trees are re-planted and the by-products of the system are used in the pulp and paper industry. The process may even be beneficial for the environment, contributing to negative GWP, because the GWP from uptake is larger than for emissions. The advantages are only substantial after a period of time longer than 20 years.