Methodology for Carbon Footprint in Forestry Findings and Ways of Improvement

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Abstract. Classic methodologies for carbon footprint are made for conventional companies or territories. None is well adapted for entire sectors or parts of sectors, which usually contain numerous and very different companies, such in the forestry. In this work, we proposed a methodology to count GHG emissions for forestry in a region, from harvest preparation to the entrance of industries. We divided forestry in three steps: harvesting, forwarding and transport, for which we listed each GHG emitting process. Then, we applied this methodology in the Auvergne region (FR) and estimated GHG emissions to bring one cubic meter of wood to the industry to an average of 4.7 kgCe; with each step (harvesting, forwarding and transport) causing around a third of it. We also estimated related emissions for different types of wood (timber, industrial wood and fuelwood) and finally, we proposed 32 recommendations to reduce GHG emissions in forestry.

Keywords: forestry, GHG, emissions, carbon, footprint, wood, forest.

1 Introduction

For many years, the Greenhouse effect has become one of the favorite talking points. Human used the Earth for ages, and now he starts to think about consequences. Many authorities already set objectives to reduce Greenhouse gases (GHG) emissions and every sector has to take actions for that. The work we present here, for the Auvergne (FR) DRAAF (Regional Management for Alimentation, Agriculture and Forest), consisted in adapting a Carbon Footprint method to a whole sector — the forestry — and to suggest different ways of reduction for its GHG emissions. We will first describe the context of the study, then the methodology we used to collect data and finally the results in Auvergne and the list of propositions we made.

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2 The Subject

2.1 The Context

The goal of this study was to propose a methodology to realize carbon footprints for forestry on a region scale. Thus, along financial and social considerations, the market would use the environmental factor to compare projects. To develop our approach, we took inspiration from the ADEME (French Environment and Energy Management Agency) methodology: the Bilan Carbone®. Unfortunately, the Bilan Carbone® is only adapted for conventional companies or territories, not for larger entities like the forestry in a region. We needed thereby to propose a methodology adapted to a whole sector, containing numerous and different companies. After having delimitated geographical and structural frames, we had to gather raw data and change it into carbon equivalent. Like in most of carbon footprint methodologies, we decided to estimate GHG emissions over one year of activity; in our application case it was 2008.

2.2 Bibliography

A lot of studies focus on carbon sequestration in the wood — e.g. the Carbofor project [1] in France — but much fewer deal with GHG emissions in forestry. However, several significant works have been carried out in some of the main forested countries (Sweden, Finland, Canada and the USA). For instance, Dimitris Athanassiadis worked on GHG emissions due to mechanized harvest in Sweden [2] and GHG emissions resulting from the manufacture of a forwarder [3]. There have been other studies on the subject; some were general [4] or more specific to one species or area [5-7]; but none really took in account all GHG emissions we wanted to study here (e.g. those of woodcutters using motor saw). Our work took up with listing each emitting activity, from harvest preparation to the entrance of industries (paper mills, sawmills, etc.). We proposed a generic method and applied it to the Auvergne region.

3 Methodology

3.1 Different Sectors

Some data on the forest were available at region organizations but, because of the parceling of the forest between owners, it was almost impossible to gather statistics over the whole forest using owners' data. Then, we decided to base our methodology on forestry companies, which are much fewer than forest owners and better referenced in institutions [8]. For commodity with statistics, instead of dealing with companies working in a region, we decided to deal with companies based in that region.

To ease data gathering and processing, we divided forestry in three sectors: (1) wood harvesting (mechanized or manual), (2) wood forwarding and (3) wood transport. Then, in each sector we listed every emitting activity:

Table 1. Emitting activities for each forestry sector

Mechanized harvesting/forwarding	Manual harvesting
Car use	Car use
Motor saws consumption	Motor saws consumption
Motor saws amortization[1]	Motor saws amortization
Others (computers, services, etc.)	Others (computers, services, etc.)
Machines consumption	
Machines amortization	**Transport**
Transport truck use	Truck consumption
Transport truck amortization	Truck amortization

Three different machines are used in forestry: the harvester (for harvesting), the forwarder (for forwarding) and the skidder (for forwarding). GHG emissions for these machines are the same type so we treated them the same way. We also included fuel consumption for cranes to (un)load logs on working sites. Concerning the transport part, a rough estimation stated besides emissions (e.g. for non-driver employees) as 25-30 times less important than trucks emissions, thus we neglected it. In this model, emissions from logging facilities are neglected as well, because they are frequently included in ETF[2] personal buildings, and so cannot be included in forestry emissions.

3.2 Data Gathering

The wood transport is different from other types of transport because there is usually no return load[3]: trucks are adapted to shapes and dimensions of wood pieces. Thus, general statistics on transport were useless and, to gather data, we used a note from FCBA (Forest, Cellulose, Construction-wood, Furniture) [9] and a recent national report [10] to get information on wood transport (type of trucks, GVWR[4], fuel consumption, use, etc.). For harvesting and forwarding, we based our statistics on two sources. Firstly, we used a survey on mechanization in Auvergne forestry [11], which gives us the annual mean time of utilization per type of machine. These values include

[1] The amortization of a product represents emissions due to its manufacture divided by the number of years it will last.
[2] ETF (Entrepeneurs de Travaux Forestiers) are, literally, “forestry contractors”. They are self-employed workers who carry out forestry works (harvesting, forwarding, etc.) and usually work alone or in a small group of associates.
[3] In our case, we used a 60 % loaded rate, as logistics optimize routes.
[4] GVWR stands for Gross Vehicle Weight Rating.

all machines activities. Secondly, we collected data from different forestry professionals, forestry machines manufacturers and ETF's, including their machines ranges of work and productivities.

3.3 Emissions Factors

Once we had gathered data on all the emitting activities (productivity, loads, etc.), we needed to "turn them" into emissions. Moreover, as we decided to obtain simple and comparable results, it was necessary to express results with only one unit.

Consequently, as it is the most commonly accepted unit — notably in the Bilan Carbone® — we decided to use the kgCe, which stands for kilogram "Carbon equivalent". Using that, all GHG emissions would be expressed the same way.

In order to change raw data, such as fuel consumption, into kgCe emissions, we used values called emissions factors, which turn raw data into the GHG emissions they lead to. Most of the emissions factors we used were taken from the Emissions Factors Guide [12]; the others were adapted from IPCC (Intergovernmental Panel on Climate Change) issues. Here are the emissions factors (EF) we used the most:

Table 2. Most used emissions factors during the study

EF diesel oil	0.804 kgCe/l	EF various services	0.03 kgCe/€
EF premium gasoline	0.774 kgCe/l	EF machine manufacture	1.5 kgCe/kg
EF oil	0.82 kgCe/l	EF computer manufacture	350 kgCe/unit
EF car (with amort.)	58 gCe/km	EF institution employee	1.14 tCe/year

4 Findings

We decided to express emissions for each type of wood (industrial wood, timber, fuelwood) and the average wood in Auvergne (which was called "general"). Values varied with the proportion of mechanized harvest; the proportion of forwarding done with forwarders; the transport distance and the wood density. The harvesting/ forwarding information was adapted from the survey on mechanization in Auvergne forestry [8]. Table 3 presents the results.

We can notice that the distribution of emissions between sectors is clearly defined. Harvesting, forwarding and transport count for almost a third each, and the rest of it goes to cooperatives and institutions for which we used a single emission factor: the emissions per employee and per year. The harvesting proportion is a little less important than the two others because a large part of it is manual in the Auvergne region. It should be noted that we voluntarily excluded the emissions from roads construction because of its allocation particularities, but a rough estimation showed that they could represent substantial values for this type of activity.

Table 3. Estimation of emissions for each part of forestry, depending on the use of the wood and expressed in kgCe per cubic meter of wood

Sector	Wood	Type	Per m³ (kgCe)	%
Harvesting	General	Mean	1.178	24.9
	Industrial	57 % mechanized	1.204	22.6
	Timber	64 % mechanized	1.277	28.6
	Fuelwood	10 % mechanized	0.6797	20.6
Forwarding	General	Mean	1.675	35.4
	Industrial	81 % with forwarder	1.550	29.1
	Timber	20 % with forwarder	1.787	40.1
	Fuelwood	80 % with forwarder [5]	1.555	47.1
Transport	General	75 km	1.760	38.4
	Industrial	127.5 km	2.510	47.1
	Timber	70 km	1.333	29.9
	Fuelwood	30 km	1.003	30.4
Other (institutions, cooperatives)	General	/	0.0627	1.3
	Industrial	/	0.0627	1.2
	Timber	/	0.0627	1.4
	Fuelwood	/	0.0627	1.9
Total	General	/	**4.676**	100
	Industrial	/	**5.327**	100
	Timber	/	**4.460**	100
	Fuelwood	/	**3.300**	100

5 Ways of Improvement

Since GHG emissions are a recent issue, there haven't been a lot of actions already taken in this area. However, in the forestry sector, the ecological optimization is also economical (more than 75 % of emissions are due to fuel consumption by cars/trucks/machines); so some actions have been done to reduce emissions, but indirectly.

Several studies were conducted to determine if one action or another was ecologically relevant [13-16]. The Canadian organization FPInnovation worked on numerous possibilities to improve wood transport [17-22] and the AFOCEL (Forest Cellulose Association), in France, created several notes suggesting improvements in forestry. Based on these works and personal observations, we listed 32 propositions to reduce GHG emissions in forestry and we classified them according to their reduction potential and applicability.

[5] The rest is done with tractors. To estimate tractors emissions and productivity, we used skidders data which, considering the influence on results, can be assimilated to tractors ones.

Table 4. List of suggestions to reduce GHG emissions in forestry, and the relevance of their realization (+++ stands for the most relevant suggestions)

Suggestion	Relevance
Cable-forwarding in plain	++
Use of biofuels	+++
Piggy-back or fluvial transport	++
Transport of drier wood	++
Auto-inflating for tires	++
Better aerodynamic for trucks	+
Eco-drive for truck drivers	++
Use of larger forwarders for large operations	++
Centralizing for logistics	+++
Cooperative for trucking companies	+++
Give priority to depot on the bottom of sloping working sites	++
Use of hybrid or electric machines	++
Use of hybrid or electric trucks	++
Use of larger trucks	+++
Use of GPS to optimize machines moves	++
Adapting logging trucks to other freight	+++
Limit the crane transport on logging trucks	++
Change of machines to reduce consumption	++
Drive the machines on the road to reduce their transport	+++
Limit road transport by lengthening forwarding distances	+++
Create straighter forest roads	++
Give priority to specialized logging trucks	++
Limit the use of air-conditioner	+
Lower the size of trucks engines	+
Reduce trucks tare weight	+
Fuel-saving tires	++
Encourage industries to use wood closer to their site	+++
Encourage industries to hire ETF closer to forest sites	+
Grouping for manual ETF	+
Use the alternative methods for forwarding	+
Give priority to manual harvest	++
Use harwarders (harvester/forwarder)	+++

We can notice that the most important suggestions usually concern the transport or forestry as a whole. Finally, when we add all suggestions “realizable” on a close future, we can hope to cut emissions by 15 %. On a longer scale (several years), we can estimate reductions to be up to 25-30 % if professionals follow these suggestions.

6 Conclusion

Studies on carbon balances are more and more important in all types of activity. Unfortunately, some sectors cannot really carry out a carbon footprint because there isn't any adapted methodology yet. That is the case in forestry. In this article, we presented a simple methodology to obtain GHG emissions data for the process of a cubic meter of wood, depending on several parameters (transport distances, mechanized proportion, etc.).

Our methodology, by dividing steps and emitting activities in forestry, saves us from meeting the usual problems when the sector is fragmented. Our approach, by presenting results per cubic meter of wood, makes the comparisons easier. This study also led to 32 suggestions to reduce GHG emissions in forestry. Applied to the Auvergne region, this work estimated emissions due to forestry to an average of 4.7 kgCe per cubic meter, with each step (harvesting, forwarding and transport) causing around a third of it. We also could evaluate possible reductions in a close future to 15 %, and up to 30 % in several years if professionals follow our propositions.

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