Decision Support System for sustainable forest management based on Life Cycle Assessment

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1. Introduction

The valorisation of biomass resources is recognized as a new frontier of economically sustainable and environmentally friendly processes; nevertheless, it is not possible to assume a positive comprehensive balance in term of sustainability of products based only on the fact that they are bio-based, but it is necessary to perform exhaustive studies in a life cycle perspective, considering also site-specific characteristics (e.g. the local availability of raw material and the distance from the processing plant to the delivery point) and the sustainability of the system in term of energy efficiency, total material requirement, CO_2 emissions, etc [1]. The present research focuses on the application of LCA as a main tool for sustainability technology assessment about forest management and harvesting, comparing different technological solutions referred to a specific local context, with the aim of shifting from a theoretical comparison of different technologies to a more practical assessment of technology feasibility and sustainability in a specific context, considering the potential drawbacks related to a short supply chain implementation. Considering the complexity and the multidimensional features of this kind of assessment, a Decision Support System (DSS) is considered a useful tool for the evaluation; therefore, the objective of the study is the definition of a set of sustainability indicators composing a DSS able to help local decision makers (local authorities that have to define the forest management plan and private business that need to optimize the harvesting activities) to choose the more effective solution in term of environmental, economic and social sustainability. In order to produce relevant information for decision making about the sustainability of the options under evaluation, the DSS is composed by a multidisciplinary set of indicators considering environmental, economic and social sustainability aspects applying a Life Cycle perspective; moreover, the definition of indicators is a way to introduce quantification, measurability and comparability of technology assessment studies.

2. Materials and methods

The way towards a wider diffusion of sustainable production and consumption patterns requires the development of tools able to integrate sustainability into supply chain, from raw materials to end of life. Even sustainability has becoming a term widely used in several context, an important effort is still required to make scientifically meaningful its use and to integrate several methodological approaches [2]. The challenges posed by the Calcas EU Project [3] are very important: with the growing importance of Sustainability Indicators for supporting or justifying decisions on technologies, policies, subsidies, etc. the scientific validity of such indicators is becoming a crucial factor. Sustainability concept refers to the integration of environmental, economic and social dimensions of development. Therefore, sustainability assessment of technological and operational options requires a complex and multidimensional evaluation performed in order to consider a number of different issues and to take into account local context conditions. This complex and multidimensional evaluation can be performed using a Decision Support System (DSS). The present study focuses on the development and the application of a DSS for the forest sector, encompassing forest management and harvesting processes to support local decision makers in defining guidelines for forest planning. The aim is identifying environmental principles for the design and operation of supply chains, as in some example of application of environmental impact assessment also to timber sector performed by [4], [5]. Several decision model are proposed based on environmental performance indicators, which may support decision making in the case of supply chains in the presence of environmental considerations [6].

The present methodology allows assessing the sustainability level of a technological/ operational option applied in a specific context, taking into account sustainability criteria. A comparison may be done among a number of different technologies to choose the best option in term of environmental, economic and social performance. A set of specific indicators is developed to assess the performance of a number of potential options for the implementation of forest biomass system exploitation. This may help decision makers in choosing not only the technology and the operational options that seems more efficient, in theoretical condition, but the best solution in the specific local context (see, for example, sustainability technology assessment for energy production form biomasses [7]). The steps of the methodology are:

1. setting sustainability criteria. Considering forest management and harvesting, sustainability criteria for a technological/operational options in forest management are: use of local resource considering carrying capacity of the system; short supply chain development (resource use within 70 km distance from production/supply site), greenhouse gases compensation ability, limited environmental impact, financial profitability, capability of positive economic and social effect in the local context;
2. defining system boundaries and collecting information about available technological and operational options for forest management in the specific context to populate technological/operational efficiency indicators (for example quantity of wood that could be harvested per day);
3. defining and populate indicators for the DDS. The indicators for each specific technological/ operational option are related to: resource availability; environmental impact; economic efficiency; social impact;
4. implementing LCA of the technological/ operational options. In this step, a consequential LCA methodology seems the best choice, as it allows to increase the understanding of product chain and to identify the processes and relation most important to improve [8]. Within the context of environmental assessment, some aspects are considered particularly critical, such as the impact on biodiversity and the evaluation of vulnerability of exposed ecosystem [9];
5. definition of an “optimum of application” trough the application of law limits, policy objectives, benchmark of excellence, expert judgement. This step could be enriched by the result of a stakeholders consultation, especially regarding expected economic and social benefits;
6. score attribution to each indicators, related to level of achievement of the optimum;
7. comparison among sustainability level achieved by each technological/operational option using a dashboard of indicators. An aggregated index is less meaningful: the visualisation of single performance values allows to identify priority area of intervention to increase sustainability of the analysed option.

3. Conclusions

The present work highlights the importance of the implementation of sustainability LCA as a basis of technological/operational assessment, also in supporting policy making at local scale. A promising sector of application of the model is the assessment of the sustainability of whole short supply chain, where environmental benefit has to be assessed and important economic and social beneficial to local community are expected. Further development of the research could include widen sustainability Life Cycle Analysis of the wood supply chain and the comparison between the environmental, social and economical benefits in developing a short supply chain (wood-energy) or (wood-furniture) one.

4. References

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Acknowledgement - The authors thank Lombardy Region for funding the activities (Project BOMO).