Sustainability assessment for biomass supply chains

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Biomass logistics systems face considerable challenges when it comes to sustainability and its different aspects - whether economic, environmental or social. The problems around managing, designing and implementing a bioenergy scheme are complex and multifaceted. Each project involves many stakeholders and requirements that must be satisfied for the successful long-term operation of it.

Assessing the overall performance and sustainability of logistic chains and identifying key points of improvement has been at the heart of the Logist'EC project and constituted one of its major research objectives. A holistic framework has been developed to integrate chain components and assess their environmental, economic and social impact, based on two case-studies in Burgundy (France) and Miajadas (Spain). This framework enables an economic optimization of the supply chains and an overall sustainability assessment of these solutions, making it possible to achieve maximum efficiency in the logistics components. Its principles are detailed in the first section of this factsheet, while the second part presents examples of its application within the case-study value-chains.

AN INTEGRATED FRAMEWORK

The assessment framework encompasses 4 steps:

1. Determining the geographical location of fields suitable to grow energy crops;
2. Optimizing the bioenergy value-chain from production to consumption from an economic point of view;
3. Estimating the environmental impact of the bio-based value chain using two complementary methodologies;
4. Evaluating the social costs and benefits of the project using a regional input/output analysis.

Ultimately all results have been combined using Sustainability Multicriteria Multiscale Assessment (SUMMA) as an integrated approach to sustainability assessment in the comparison of various possible options for a project (Figure 1).

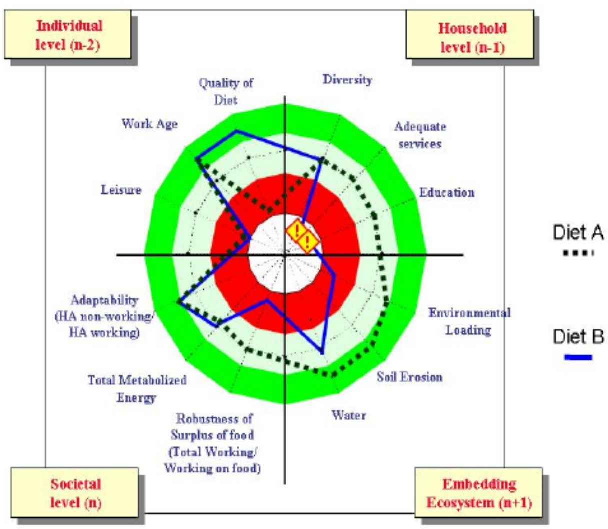

Figure 1: Example of a 'spider chart' used in SUMMA to compare 2 options in terms of different sustainability aspects (to be adapted to biomass!)

Regarding Step 1, a feedstock model with a high spatial resolution has been developed to predict the most probable location of future fields intended for energy crops, in the vicinity of a biomass conversion plant, based on landscape features, yield potentials and farmers' survey data. This produced maps of energy crop fields and yields for a given production target and maximum transportation radius from the plant, which turned out to be useful for economic optimization purposes (see Figure 2 below). The supply-chain model integrates and optimizes the logistics system by choosing among different technology options including transport routes, storage sites, pre-conditioning and processing technologies (e.g. pelletization or briquetting), harvesting (cutting date or type of technology used) and feedstock type.

In terms of environmental sustainability, biomass logistics chains were evaluated using Life-Cycle Assessment (LCA), which is widely utilized for regulatory purposes for bioenergy chains (and liquid biofuels in particular). LCA is a multi-criteria and quantitative methodology which aims at comparing products over their entire life-cycle while avoiding burden shifting between impact categories or supply chain components. The sustainability of bio-based chains is often focused on LCA results whereas social and economic impacts are far from being negligible. Most biomass logistics systems are located in rural areas where a trend of declining agricultural employment is in place. Therefore, any new economic activity in rural areas is likely to generate jobs and trigger stimuli for the local and regional economy. To estimate the total impact (direct and indirect effects) of biomass supply-chains on the economy, employment rates and the increase in demand for goods and services, the method proposed within Logist'EC has been the Input-Output methodology, which reflects the flows and interactions between the different economic sectors within a region or a country.

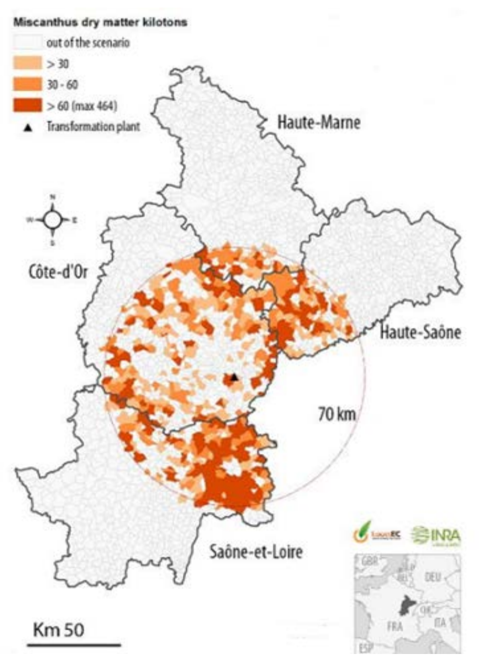

Figure 2: Map of potential new miscanthus fields around the pelletization plant of Aiserey in Burgundy (France).

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The framework for sustainability assessment developed in Logist'EC assesses biomass supply chains in all dimensions of sustainability.

A four-step approach identifies potential locations for the establishment of energy crops around a projected biorefinery, optimizes supply-chain logistics to maximize profit and assesses the environmental and social impacts of this new value-chain. It is applicable to any type of value-chains or regions.

APPLICATION TO THE TWO EXISTING VALUE-CHAINS

The assessment framework was applied to the 2 case-studies investigated in Logist'EC, involving existing bio-based value chains: a cooperative processing miscanthus biomass in Burgundy (E France) and a bioelectricity plant in Miajadas (SE Spain). In the first case, including some of the pre-conditioning options explored in Logist'EC made it possible to increase the overall profit of the cooperative by more than 30%, based on decentralized briquetting (Table 1). Other promising options included autumn harvesting of miscanthus to maximize crop yields – however creating a trade-off with GHG emissions.

Table 1 Economic figures for some of the logistics scenarios tested in Burgundy. In the last column, greenhouse gas (GHG) emissions are expressed in relation to the baseline scenario.

Scenario	Biomass Production [t yr^{-1}]	Procurement Cost [k€]	Annual Income [k€]	Profit [€/t dm]	GHG emissions [%]
Baseline	6000	942	1 072	21.7	100
Autumn harvesting	6428	977	1173	32.7	105
Upscaling of production	30000	5002	5644	21.4	112
Briquetting	6000	682	910	37.9	80

In Miajadas, the Input-Output analysis resulted in an estimate of 117 net jobs created, for an overall annual biomass supply of 50.000t, with the baseline biomass supply scenario. A share of about 80% of these jobs would be created in Spain, emphasizing the benefits of the bioelectricity plant for local to national employment.

Among the different scenarios tested in terms of supply mix, those based on residues from food crops (maize and wheat) were less labour-intensive and created fewer jobs (Figure 3).

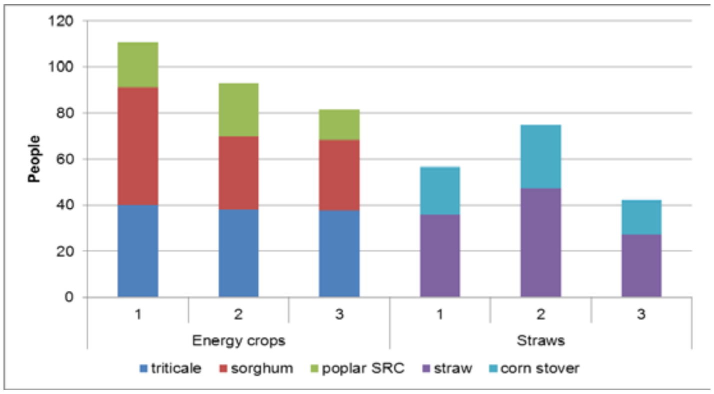

Figure 3: Net number of jobs created for different feedstock supply mixes and volumes for the Miajadas power plant.

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Supply-chain optimization pointed at logistical options to significantly increase profit in one of the case-studies.

The two bio-based value chains showed a high degree of renewability, low environmental impact compared to fossil-based equivalents, and resulted in a net creation of jobs.

The documents describing the assessment framework are available on the Logist'EC web site: www.logistecproject.eu