Life Cycle Sustainability Assessment - Conception and Experiences of a Demonstration Project

C. Mair-Bauernfeind[1], F. Hesser[1]

About the project

Dendromass4Europe (D4EU; 2017 – 2022) aims at establishing sustainable, Short Rotation Coppice (SRC)-based, regional cropping systems for woody biomass (dendromass) production on marginal agricultural land. The dendromass produced in SRC (ligneous biomass, bark and wood) is supplied to dedicated bio-based value chains that create additional income and job opportunities in rural areas. The supply chains will be tailored for optimum efficiency of supply logistics and for reducing CO_2 emissions. Innovative bio-based materials will help to replace fossil-based materials.

Introduction

Dendromass4Europe demonstrates the establishment of short-rotation wood cropping in Western Slovakia and its complete material use of dendromass for bio-based materials. Innovations are seen as drivers of economic and social progress as well as environmental degradation. Anticipating the potential impacts of innovations - already during their development - is essential for sustainable development. Aside of European-funded research, it is still not common sense to conduct sustainability assessments or apply the Safe and Sustainable by Design concept along with technology R&D. The objective of this task was to anticipate critical environmental and socio-economic hotspots and derive measures to improve the project's sustainability together with the project partners.

Investigated systems

In total the sustainability effects of five connected product systems have been investigated (see Fig.2), i.e. the dendromass production (NBBM0) cultivated in Slovakia, the lightweight boards (NBBM1) produced in Slovakia, the moulded fibre parts (NBBM2) from Poland, the wood plastic composites (NBBM3) produced in the Czech Republic and composite granulate (NBBM4) from Germany. From 1t of dendromass 2.58 t of lightweight boards, 0.40 t of moulded fibre parts, 0.71 t of composite panels and 1.27 t of composite granulate can be produced.

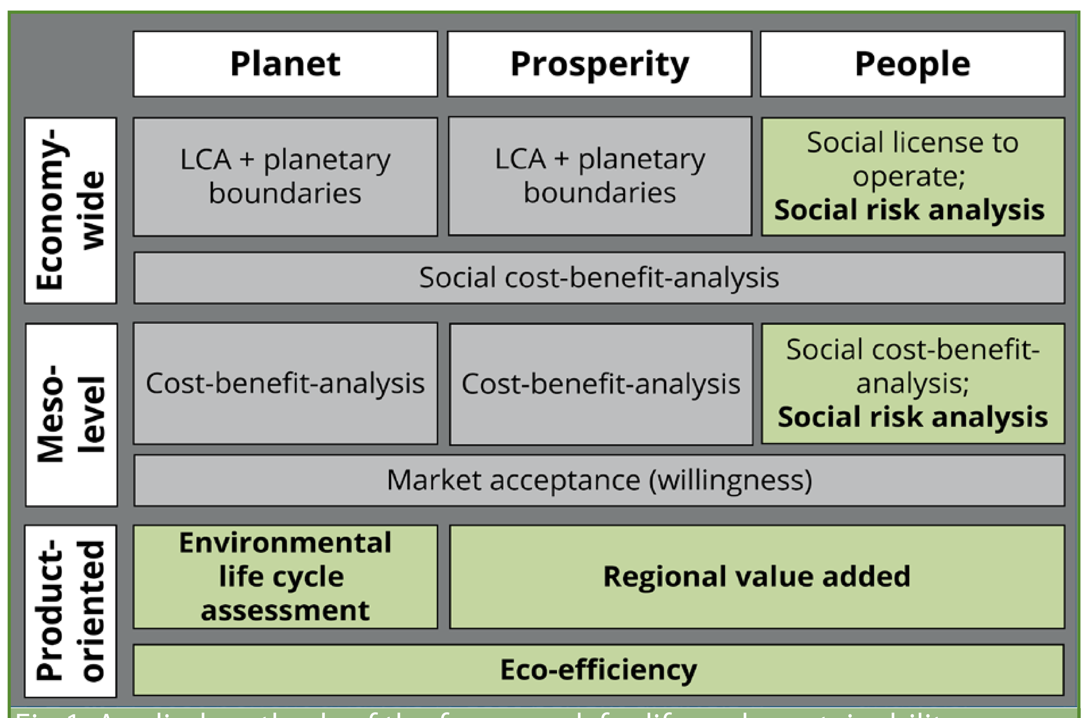

Fig.1: Applied methods of the framework for life cycle sustainability assessment, adapted from Guinée et al. (2011). Selected results of some methods (bold) are presented in this poster.

Method and Data

To get a holistic overview of the potential sustainability impacts of the D4EU activities, all three dimensions of sustainability were assessed at different levels of investigation (see Fig.1). In total, 10 different methods have been applied covering not only the assessment of potential impacts but also the acceptance of the local community towards short-rotation coppice plantations and the willingness of farmers to adopt dendromass production. This technical poster focuses on the results of the life cycle assessment (planet), the social risk analyses (people), and the socioeconomic as well es eco-efficiency analysis (prosperity).

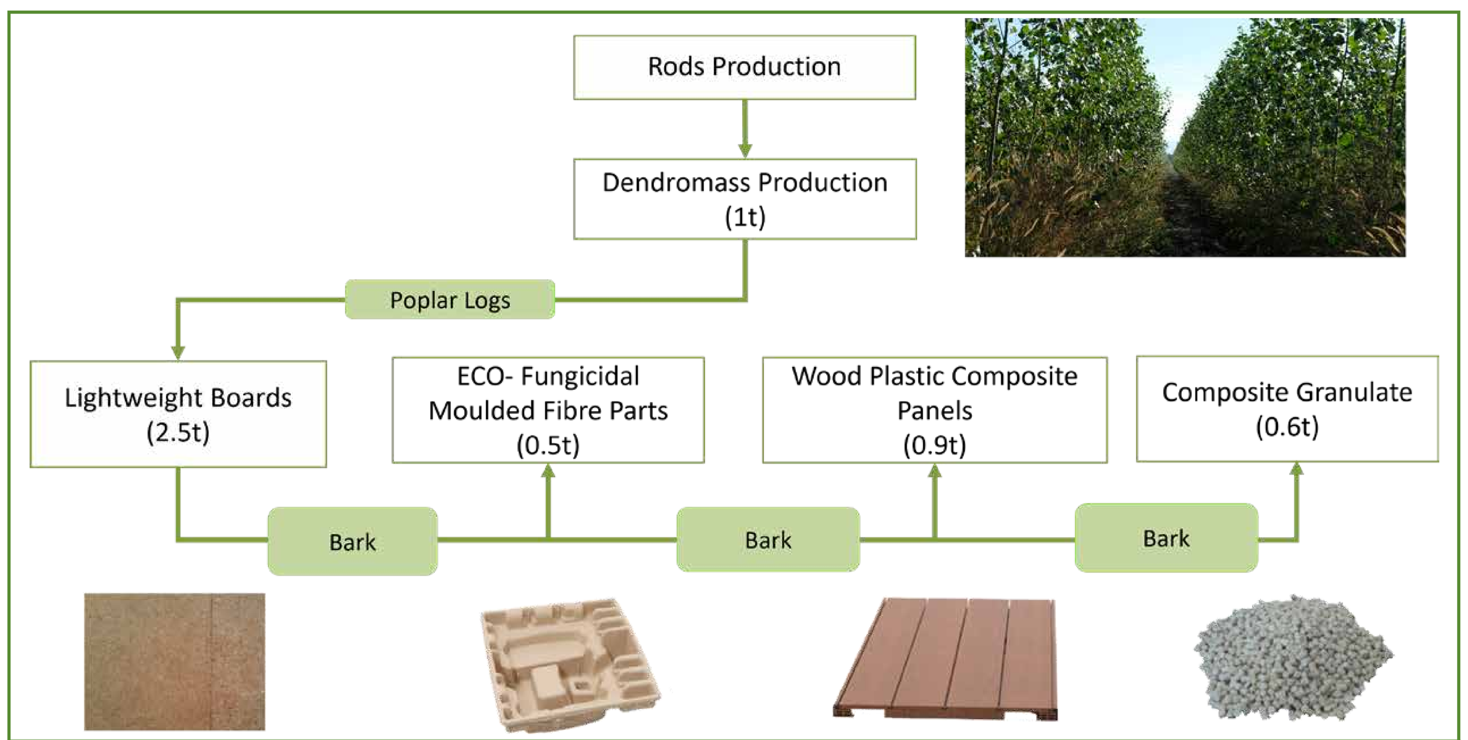

Fig.2: Investigated product system including the distribution of the dendromass among the different product systems

Results and Conclusions

Planet: The global warming potential (GWP) of the D4EU activities results in **5,419 kg CO_2 eq**. (see Tab.1). The contribution analysis (see Fig.3) shows that NBBM4 potentially causes the highest CO_2 emissions compared to the other D4EU product systems. The dendromass production has just a minor influence on the total impacts. In years 6, 11 and 16 CO_2 is emitted from the soil in the year after the harvest. Figure 3 clearly shows that, even if a lot of biomass is produced, CO_2 neutrality is still a long way ahead (see also D5.8).

People: The social dimension of sustainability is assessed with 36 indicators in 16 impact categories for three stakeholder groups (see Fig.4). The results are discussed with regard to the sustainable development goals (SDGs). The D4EU value chain mostly contribute to 'SDG 8 - decent work and economic growth' and the highest social risks identified concern the workers with regard to equal opportunities or workers' rights. More detailed results can be accessed in Fürtner et al. (in press) and D5.6.

Prosperity: The eco-efficiency calculation relates the environmental performance of a product to its product value. In this work, eco-efficiency is illustrated as the value added (VA) per impact category (see Tab.2). The results show that the best outcome in most impact categories can be achieved with Scenario 3, using all the dendromass for NBBM 1 only. More detailed results can be accessed in D5.7.

Tab.1: Potential environmental impacts of the D4EU value chain

Abbr.	Impact category	Impact
GWP	Global warming potential (kg CO_2-Eq)	6,724.57
TAP	Terrestrial Acidification potential (kg SO_2-Eq)	24.14
ODP	Ozone depletion potential (kg CFC_{11}-Eq)	0.0015
FEP	Freshwater eutrophication potential (kg P-Ep)	5.49
FDP	Fossil depletion potential (kg oil-Eq)	2,930.43
CED	Cumulated energy demand (MJ)	25,144.14

Tab.2: Ranking of eco-efficiency (value added) performances of different scenarios in the different impact cetegories (see Tab.1) from best (1) to worst (4).

BC- Base case; S1 - Economic best case; S2 - Environmental best case; S3 - NBBM1 only

Ranking	1	2	3	4
VA (€) / GWP (kg CO_2-Eq	S3	S2	S1	BC
VA (€) / TAP (kg SO_2-Eq)	S2	S1	S3	BC
VA (€) /ODP (kg CFC_{11}-Eq)	S3	S1	S2	BC
VA (€) / FEP (kg P-Ep)	S2	S3	S1	BC
VA (€) / FDP (kg oil-Eq)	S3	S1	S2	BC
VA (€) / CED (MJ)	S3	S1	S2	BC

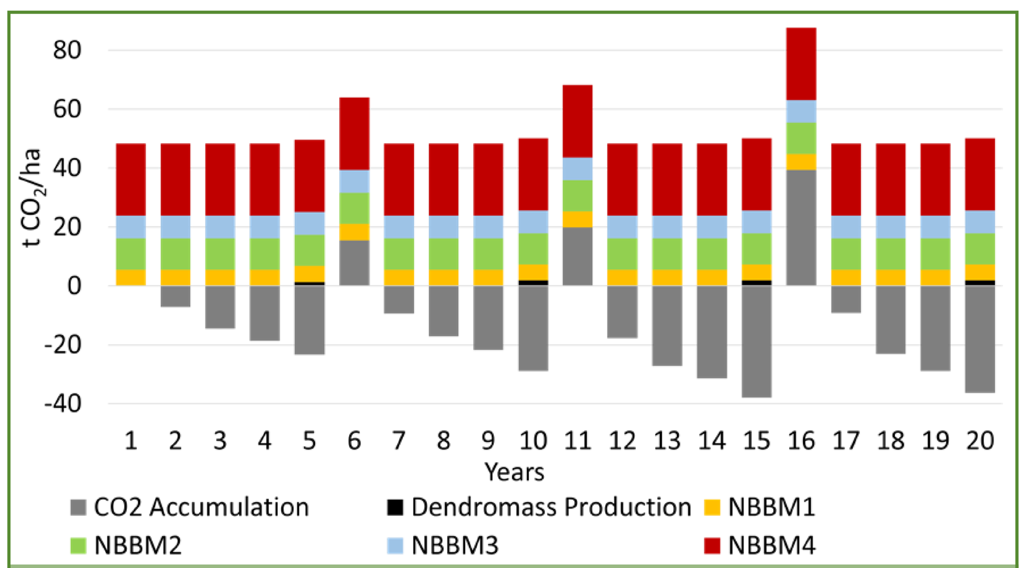

Fig.3: Total Carbon fluxes of plants and soil compared to the CO_2 emissions potentially caused by the D4EU product sxystems over 20 years

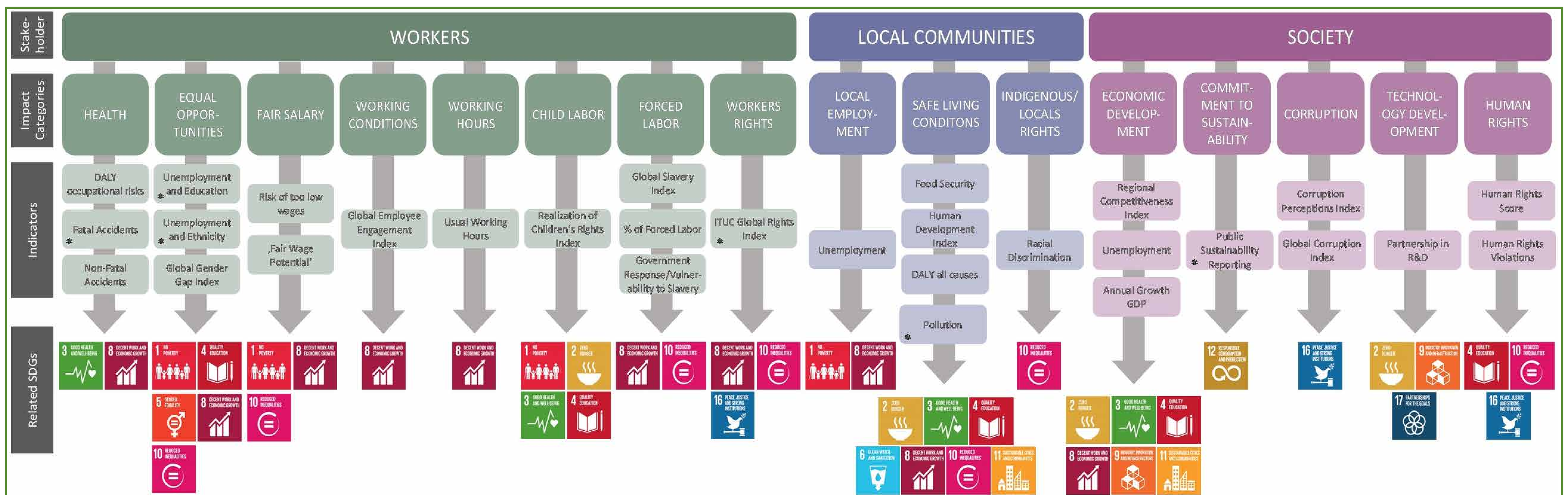

Fig.4: Social risk indicators assigned to the sustaiinable development goals (SDGs). * marks the indicators where the social risks are highest for D4EU

Life cycle sustainability assessment during R&D helps generating actionable knowledge. This is beneficial for all stakeholders (public, science, politics, industry). Together with the stakeholders you learn about the production systems which supports the acceptance to engage, the identification of trade-offs and the implementation of the precautionary principle. Options for improving the sustainability performance of the D4EU value chain include:

- develop strategies to maintain soil organic carbon accumulation in short rotation coppices also after recultivation,
- reflect local system operation optimization in light of planetary boundaries,
- promote innovative working practices to create job opportunities, especially for disadvantaged groups,
- increasing the share of locally produced materials and machinery contributes to regional value creation,
- optimizing the allocation of dendromass to the different products produced can increase ecoefficiency (increasing value added per unit impact).

References

Fürtner, D. et al. (in press): Proposing a multi-level assessment framework for social risks of bio-based value chains and its contribution to the Sustainable Development Goals. Progress in Life Cycle Assessment.
Guinée, J.B. et al. (2011): Life cycle assessment: Past, present, and future. Environ Sci Technol 45:90–96.

[1] Wood K plus - Kompetenzzentrum Holz GmbH, Altenberger Straße 69, 4040 Linz, Austria

Project Coordination:
Technische Universität Dresden
Forest Policy and Forest Resource Economics
Pienner Straße 23
D-01735 Tharandt

BBI JU Bio-based Industries Consortium
Horizon 2020 European Union Funding for Research & Innovation

D4EU has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement 745874.