Life cycle assessment (LCA) of bioenergy and relevance of regionalisation

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Bioenergy has gained importance in energy supply during the last decade. Along this trend, LCA studies examined their performance and compared them to fossil fuels. The conclusion regarding first generation biofuels is quite discouraging, since even in terms of climate change (carbon footprint) the might not be favorable, while they add additional impacts on ecosystems. Second-generation biofuels are expected to bring improvements of energy conversion efficiencies and waste has been identified as a good resource by LCA. However, a major portion of the environmental impacts are related to the cultivation phase and for “waste” often alternative uses exist that might also lead to increased cultivation e.g. of animal feed.

The proper LCA of bioenergy therefore required advanced developments of regionalized characterization models for impact assessment of water and land use, which are besides fertilizer and climatic conditions crucial for bioenergy production. The high spatial dependence of water use and availability opened a new research field and led to water footprint assessments. Biomass production on “marginal lands” often requires irrigation and therefore reduced the potential in terms of environmental benefits. Avoiding irrigation and expanding biomass cultivation e.g. in tropical areas, where impacts on land use and related biodiversity loss are even more harmful, is at a trade-off with impacts on aquatic ecosystems and water scarcity.

While most effects in LCA are assumed to be linear and not to change in near future, impacts of one unit land or water use typically aggravate in future due to increased stress by increased activity of biomass production for food, fiber and fuels. Resilience of ecosystems decreases. Therefore, prospective analyses need to account for increased specific impacts in future. One insight is to avoid too high intensification in favor of more distributed production in less vulnerable regions.

Regionalized assessment of bioenergy conversion is still limited and mainly addressed by individual case studies. For assessing regional sustainability of bioenergy production socio-economic aspects might be considered as these are often beneficial even if environmentally it might not be the case. The overall efficiency of the system needs to account for all co-products and their use, which again is highly depending on the socio-economic environment. These aspects can help to better allocated impacts to final products of the biomass industry and therefore help better analyzing the system. However, total sustainability assessment must include more detailed analyses of socio-economic aspects and utilize LCA result to account for environmental consequences.