Quantifying sustainability of genetically modified crops

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Introduction

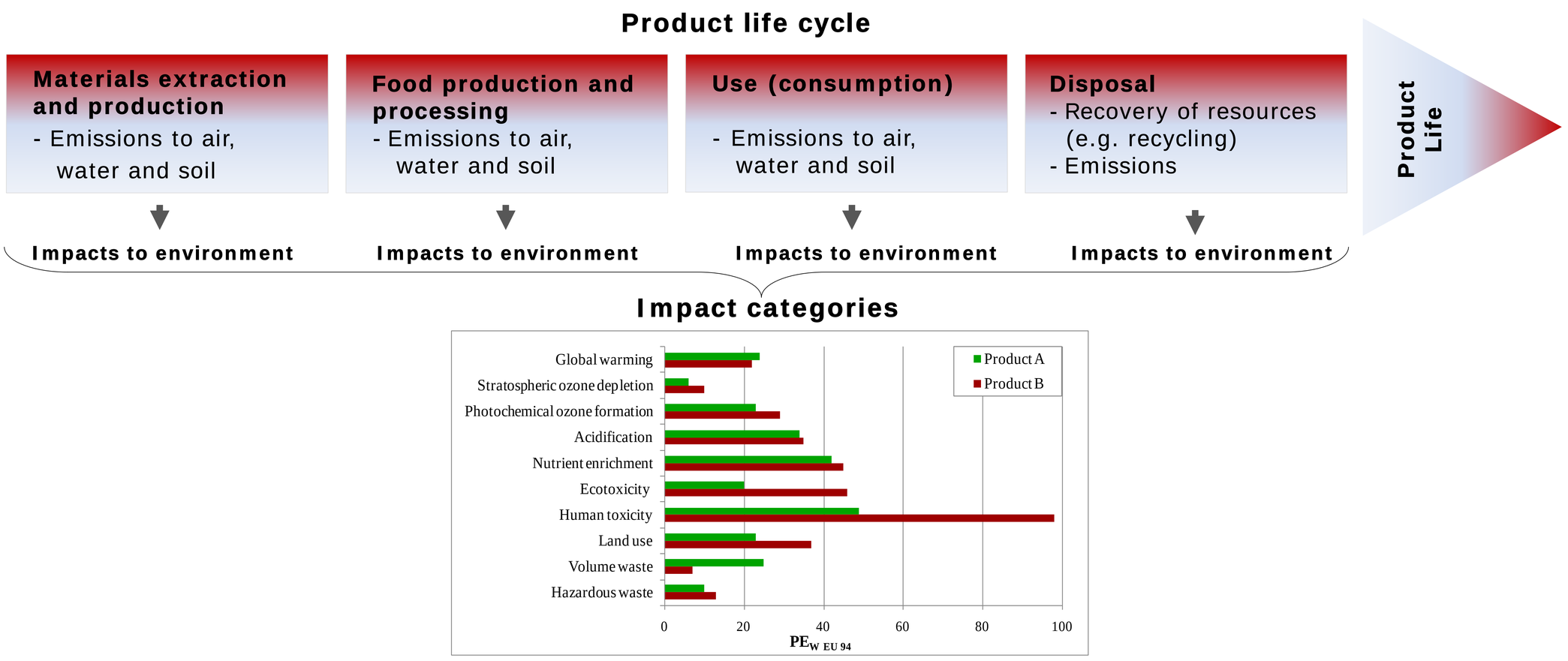
As a consequence of human activities, atmospheric CO_2 levels are rising. This will affect the food industry, because the composition and quality of crops available on the market will change. Many crops produce more biomass under elevated CO_2 levels, mainly starch, thus diluting for example proteins in the crops and as a consequence lowering the nutritional value of the edible parts of the crops.

To overcome these problems, the project 'Development of genetically modified cereals adapted to the increased CO_2 levels of the future", a multidisciplinary project carried out at several Danish universities and research institutions, aims at genetically tailoring of barley to increase the crop's protein and possibly zinc content.
Present subproject aims at quantifying the potential environmental trade-offs associated with the farming of (cis-) genetically modified crops (GMCs), under future elevated CO_2 levels relatively to farming of traditional crops under the same set of climatic conditions.

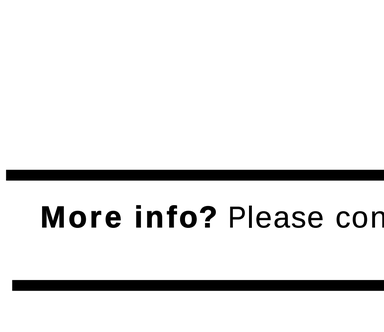
Methodology

Life cycle assessment (LCA) is a comprehensive methodology capable of quantifying the potential environmental impacts of the exchanges between a product system and the environment, from the product's cradle to its grave. The impact evaluated covers a broad range of impact categories including global warming, resource use, land use, toxicological impacts, etc..

An LCA of GMCs can for example be carried out by comparing the environmental impacts of GMC-based food products to those produced from traditional crops under current and future climate circumstances. The study will not focus solely on the food industry, but on all stages of the life cycle of a food product, such as the agricultural stage, downstream application of biomass leftovers for energy generation, etc., will be included.
The results of will be compared with the outcome of an Environmental Risk Assessment (ERA) of the GMCs in order to determine how both methods can complement each other.



Expected outcomes



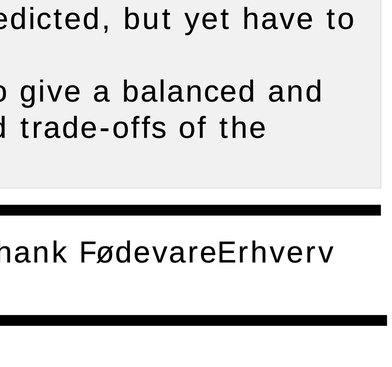
• Higher biomass production
Increasing yields of the GMC crop will lower the land area needed to provide the same amount of crops without compromising food quality.
As a side effect, more residual biomass is available as a source for renewable energy or materials.

• Avoided land use
The nutritional value of the GMC is kept at the same level or even increased to higher levels, compared to traditional crops. Additional land use for providing the same nutritional functional unit is thus avoided.

• Higher fertilizer consumption
As a consequence of the higher mineral and protein uptake by the GMC, more fertilizers will have to be applied. Production of some fertilizers is energy-intensive (nitrogen fertilizer), others are scarce (phosphorus fertilizer, picture). Impacts are further increased by run-off of fertilizer to the environment.

• Lower pesticide use and emissions
GMCs can be tailored for pest resistance, thus lowering the pesticide requirement. Because of the toxic nature of pesticides, decreasing their use will result in lowering of the toxic effects in the life cycle of GMCs.

• LCA and Risk Assessment complement
LCA considers the whole life cycle and impact potentials, but the methodology is not intendend to deal with specific risks (gene pollution, ecosystem balance, etc.) potentially having large consequences. Risk Assessment focuses on (perceived) risks in great detail. In symbiosis, both methods can generate a balanced picture of the impacts of GMC introduction.



Conclusion

The environmental impacts of food products based on genetically modified crops will be compared to those based on traditional crops taking a life cycle approach in which all processes in the life cycle of the product are taken into account.
Consequences of the introduction of GMCs are predicted, but yet have to be quantified in order to assess their relevance.
Together with risk assessment, LCA is expected to give a balanced and comprehensive overview of the consequences and trade-offs of the introduction of GMCs.

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