Summary

Within this thesis for the first time an integrative methodology to assess the sustainability of biorefineries and bio-based products has been developed which is based on a fundamental understanding of sustainability as presented in the Brundtland report. The applied integrative concept of sustainability as developed by the Institute for Technology Assessment and Systems Analysis (ITAS) overcomes the widespread thinking in three pillars of sustainability and opens up new perspectives.

The methodology developed addresses innovative life cycle assessment evaluation methods on midpoint level as well as on the area of protection and adopts state-of-the-art assessment procedures e.g. to determine water deprivation. It goes far beyond the scope of conventional LCA studies and examines effects on human health, on the environment, on the development of knowledge and physical capital, and on regional development and acceptance.

In order to validate the developed method it was applied to an algae biorefinery currently under development and construction in the south of Spain. For this assessment for the first time extensive process data was collected of a real algae biorefinery which uses municipal waste water as a culture medium for microalgae. The use of waste water allows to reduce the demand for fresh water and avoids additional fertilisation of microalgae.

Moreover, the analysed algae biorefinery replaces conventional waste water treatment by a biological purification and produces biogas by an anaerobic pre-treatment of waste water as well as by anaerobic digestion of algae. After several purification steps the biogas can be used as automotive fuel and thus contributes to further development and increased use of biofuels.

On the one hand the sustainability assessment shows that this way of waste water treatment contributes to climate protection and to the conservation of fossil energy carrier. On the other hand approximately ten times more land is needed and twenty times more water is evaporated compared to conventional waste water treatment. The LCA calculations show, too, that the amount of harmful emissions into the air such as PM, NO2 or heavy metals and into water is inclined to be higher in the case of the algae biorefinery except for greenhouse gases and ozone depleting substances.

The research project also generates new knowledge which offers new action opportunities for future generations. In addition, the algae biorefinery increases the supply security in the south of Spain with regard to automotive fuels which proved to have a high acceptance within the general public. Yet, without any subsidies an investment for such an algae biorefinery still does not seem to be profitable but future developments can change this and will probably increase the employment rate in the south of Spain.

In summary it can be stated that the algae biorefinery has proved to be an attractive alternative to conventional waste water treatment which allows the expansion of biofuels and contributes not only to the conservation of fossil energy carriers but also to climate protection.