Global Assessment of Biomass and Bioproduct Impacts
on Socio-economics and Sustainability

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Strategies for the harmonization of environmental and socio-economic sustainability criteria (D 5.5)

WP 5 – Task 5.6

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Abbreviations

CO_2	Carbon dioxide
dLUC	Direct land-use change
EU	European Union
GHG	Greenhouse gas
iLUC	Indirect land-use change
LCA	Life cycle assessment
MJ	Megajoule (10^6 J)
RED	Renewable Energy Directive (EU Directive 2009/28/EC)
US	United States (of America)

Preface

This report was elaborated in the framework of the Global-Bio-Pact project (Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability) which is supported by the European Commission's 7th Framework Programme for Research (FP7).

The main aim of Global-Bio-Pact is the improvement and harmonisation of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. A number of sustainability certification systems are already in place, but their main focus up to now is on environmental impacts such as greenhouse gas emissions or biodiversity.

A core activity of Global-Bio-Pact is the description of socio-economic impacts in different countries to collect practical experience about socio-economic impacts of biofuels and bioproducts under different environmental, legal, social, and economic framework conditions.

In recent years, different sustainability standards have evolved or – if already existing – been adapted to the bioenergy sector. These standards have mainly responded either to the market or to the requirements of the European Renewable Energy Directive (2009/28/EC, RED). The aim of this report is to propose strategies how to harmonise environmental and socio-economic sustainability criteria and thereby explore whether and how the current list of sustainability criteria in the RED can be amended by (mandatory) socio-economic sustainability criteria and how this would impact on the environmental sustainability criteria.

1 Introduction

In many parts of the world, climate change and concerns of security of supply are the main drivers for the promotion of the use of renewable resources. One of the main pillars of most strategies to mitigate climate change and save non-renewable resources is the use of biomass for energy. Strong incentives have been put in place to increase the use of biomass for energy both in the transport as well as in the energy supply sector (heat and/or power generation), mainly in the form of mandatory targets /U.S. Congress 2007/, /EP & CEC 2009/. Many countries have successfully implemented policies to foster biofuels and bioenergy, including tax exemptions or relief, feed-in tariffs or quotas. On the contrary, much less attention has been paid to the use of biomass for bioproducts, despite considerable potentials to mitigate climate change and save non-renewable resources /Rettenmaier et al. 2010a, b/. Nevertheless, the demand for industrial crops for biochemicals and biomaterials is expected to increase in the future since biomass is the only renewable source of carbon.

However, the use of biomass, and especially the use of dedicated crops for bioenergy and bioproducts, will put pressure on global agricultural land use /Bringezu et al. 2009/. At the same time, world population growth (projected to reach 9.3 billion people by 2050 according to /UN 2011/) and changing diets due to economic development, lead to an additional demand for land for food and feed production. As a consequence, the already existing competition for land for the production of food, feed, fibre (bioproducts), fuel (bioenergy) and ecosystem services[1] might even aggravate over the next decades. Concerns have been raised both in terms of social and environmental impacts since land use competition might

- jeopardise food security /Eickhout 2007/ and give rise to social conflicts, and
- lead to an expansion of agricultural land, most likely at the cost of (semi-)natural ecosystems being converted into cropland. Several studies have pointed out the negative implications of such direct and indirect land-use changes, among others in terms of biodiversity loss and greenhouse gas emissions /Searchinger et al. 2008/, /Fargione et al. 2008/, /Gibbs et al 2008/, /Gallagher et al. 2008/, /Melillo et al. 2009/, /Ravidranath et al. 2009/.

In the light of a controversial discussion on the net benefit of biofuels and bioenergy, the European Renewable Energy Directive (2009/28/EC, RED) – which sets out a mandatory target for the share of renewable energy in the transport sector (10 % by 2020) – has established a number of mandatory sustainability criteria, which biofuels and bioliquids have to meet to be able to be counted towards the target (Articles 17(2) to 17(6)):

- <u>Climate change-related criteria</u>: The greenhouse gas emission (GHG) saving from the use of biofuels and bioliquids – including emission from direct land-use changes (dLUC) – shall be at least 35 % compared to the fossil fuel comparator (Article 17(2)). From 2017 and 2018, the GHG emission saving shall be at least 50 % and 60 %, respectively. Further details are found in Article 19 and Annex V (rules for calculating the GHG impact).

[1] Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services. /Millenium Ecosystem Assessment 2003/

- Land cover-related criteria: Biofuels and bioliquids shall not be made from raw material obtained from land that in or after January 2008 had the status of i) land with high biodiversity value such as primary forest, protected areas[2] or highly biodiverse grassland (Article 17(3)), ii) land with high carbon stock such as wetlands or continuously forested areas (Article 17 (4)) or iii) peatland (Article 17(5)).
- Cultivation-related criteria: Agricultural raw materials cultivated in the Community shall be obtained in accordance with the common rules for direct support schemes for farmers (Cross Compliance) under the common agricultural policy and in accordance with the minimum requirements for good agricultural and environmental condition (Article 17(6)).

In addition, the RED sets out a number of reporting obligations by the European Commission (please note: these are no mandatory criteria to be met by biofuels and bioliquids). The Commission shall, every two years from 2012 onwards, report (Article 17(7)):

- on national measures taken to respect the sustainability criteria set out in paragraphs 2 to 5 and for soil, water and air protection
- on the impact on social sustainability in the Community and in third countries
- on the impact on the availability of foodstuffs at affordable prices, in particular for people living in developing countries
- on the respect of land-use rights
- whether the countries that are a significant source of raw material have ratified and implemented the core Conventions of the International Labour Organisation (ILO)
- whether these countries have ratified and implemented the Cartagena Protocol on Biosafety and the Convention on International Trade in Endangered Species (CITES).

The mandatory sustainability criteria listed above – which so far only have to be met by liquid and gaseous biofuels for transport and bioliquids for heat and power generation (but not by solid and gaseous biofuels for heat and power generation or bioproducts) – only address selected environmental impacts (GHG emissions and biodiversity) and omit impacts on soil, water and air as well as GHG emissions due to indirect land-use change (iLUC). Social / socio-economic impacts are not covered at all by the list of mandatory sustainability criteria.

The aim of this report is to propose strategies how to harmonise environmental and socio-economic sustainability criteria and thereby explore whether and how the current list of sustainability criteria in the RED can be amended by (mandatory) socio-economic sustainability criteria and how this would impact on the environmental sustainability criteria. Chapter 2 summarises the lessons learnt from work package 5 (WP 5) of the Global-Bio-Pact project on the "Link between socio-economic and environmental impacts". Subsequently, chapter 3 presents approaches how to harmonise environmental and socio-economic sustainability criteria. Finally, chapter 4 contains the conclusions and recommendations.

[2] Protected areas and *non-natural* highly biodiverse grassland may be used provided that the raw material production does not interfere with nature protection purposes and that the harvesting of the raw material is necessary to preserve its grassland status, respectively. Primary forests and *natural* highly biodiverse grassland, however, may not be used at all.

2 Lessons learnt: Link between environmental and socio-economic impacts

This chapter summarises the main results from work package 5 (WP 5) of the Global-Bio-Pact project on the “Link between socio-economic and environmental impacts”. For further details, the reader is referred to the other reports on environmental issues prepared in the framework of the Global-Bio-Pact project (/Rettenmaier et al. 2011/ (D 5.1), /Diaz-Chavez & Rettenmaier 2011/ (D 5.2), /Rettenmaier et al. 2012a/ (D 5.3) and /Rettenmaier et al. 2012b/ (D 5.4)) which served as a basis for this report. Moreover, two reports produced under WP 8 were taken into account /Diaz-Chavez 2011/ (D 8.1) and /Diaz-Chavez et al. 2012/ (D 8.2). Fig. 2-1 shows how the different tasks and corresponding reports are interconnected. A core input for the different results was gained through the analysis and comparison of the Global-Bio-Pact case studies in WP 2 and WP 3. All reports can be downloaded from the Global-Bio-Pact website (www.globalbiopact.eu).

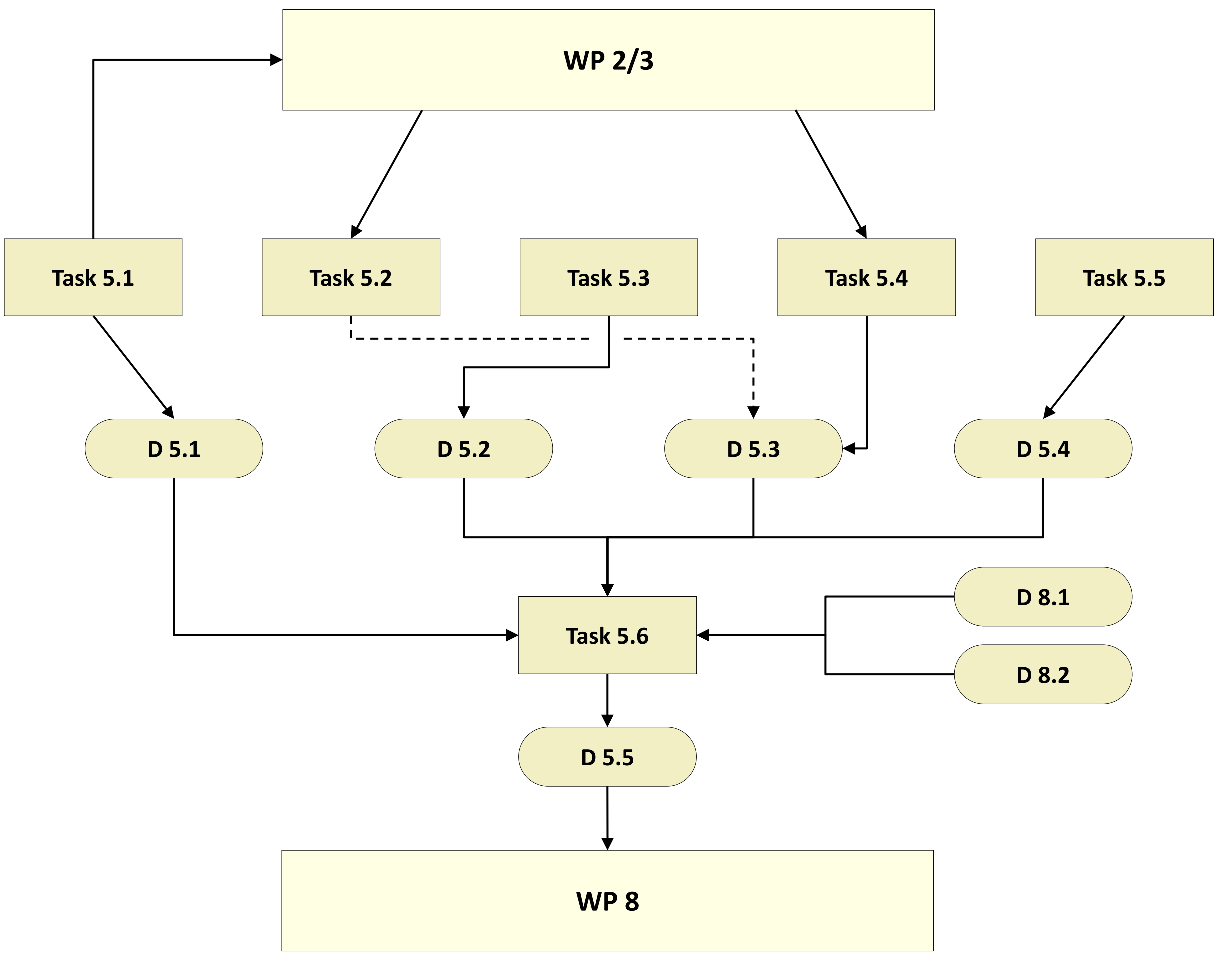

Fig. 2-1 Structure of WP 5 including inputs from WP 2 and WP 3 and outputs to WP 8

2.1 Environmental impacts, principles, criteria and indicators

The aim of the report on "General environmental impacts, principles, criteria and indicators of biomass production and conversion" /Rettenmaier et al. 2011/ was to provide i) a review of existing studies on environmental impacts and ii) a review of existing certification systems for biomass. The intention is both to support the development of socio-economic criteria – by giving guidance on what already exists in the field of environment – and to prepare the ground for the assessment of environmental impacts of the Global-Bio-Pact case studies.

Review of existing LCA and EIA studies

Biofuels/bioenergy and bioproducts are generally considered to be environmentally friendly since they save non-renewable energy resources, are biodegradable and – at least at first glance – CO_2 neutral. The latter is of course only true for the direct combustion of biofuels which releases the same amount of CO_2 into the atmosphere that earlier has been taken up by the plants. However, when looking at the entire life cycle of biofuels it becomes clear that biofuels are neither CO_2 neutral nor environmentally friendly *per se*.

Like with any other product, a number of environmental impacts are usually associated with the production and use of biomass for biofuel / bioenergy or biomaterial purposes. These include impacts on **human health** (release of toxic substances, emission of photo-oxidants and ozone-depleting gases), on the **natural environment** (release of toxic substances, emission of acidifying and eutrophying gases, land-use impacts), on natural **resources** (non-renewable energy carriers and minerals) and on **man-made environment**.

For the review of existing studies, two assessment techniques were selected: life cycle assessment (LCA) and elements of environmental impact assessment (EIA). The latter were preferred over strategic environmental assessment (SEA) /EP & CEC 2001/, since the case studies within the Global-Bio-Pact project are focussing at specific examples of biomass production and conversion (i.e. projects) rather than at (biofuel) policies, plans or programs. For more information regarding SEA of biofuels, the reader is referred to a recent OECD publication /OECD 2011/.

In literature, hundreds of LCA studies on bioenergy and bio-based products can be found, covering a wide range of products. Although LCA studies usually address a number of environmental impact categories, in recent years the scope of many LCA studies related to biofuels/bioenergy was restricted to two impact categories: the use of non-renewable energy resources and climate change. This is due to the fact that climate change and security of supply are seen as the main drivers for the promotion of the use of renewable resources.

Regarding the results, a distinct pattern becomes obvious: energy crops show environmental advantages in terms of energy and greenhouse gas savings (provided that there is no carbon stock change due to land use changes), but ambiguous results or even disadvantages regarding acidification, eutrophication, ozone depletion, summer smog, and human toxicity. With that, from a scientific point of view, an objective conclusion regarding the overall environmental performance of biofuels/bioenergy cannot be drawn.

There are still a number of scientific challenges regarding LCA methodology which have to be addressed and resolved by the scientific community. Since a few years, the biggest challenge is how to address the impact of land use on a number of environmental impact categories. The hottest topic in this field is indirect land use change (iLUC) and its impacts on carbon stocks (above- and below-ground biomass, soil organic carbon, litter and dead wood) and biodiversity.

As far as EIA is concerned, it has to be stressed that the baseline situation has to be properly studied in order to only evaluate the incremental differences of environmental impacts as well as indirect and cumulative impacts.

Due to differences regarding the ability to address environmental impacts occurring at different spatial levels, a combination of two techniques is required for the assessment of environmental impacts for the case studies: life cycle assessment (LCA) for greenhouse gas emissions and elements of environmental impact assessment (EIA) for biodiversity, water and soil.

Review of existing certification systems for biomass

A number of voluntary certification schemes currently exist for agricultural crops and forestry products which could be used for bioenergy production, among others FSC, PEFC, BSI/Bonsucro, RSPO, RTRS, Aapresid, RSB, SAN, GBEP and ISCC. Some voluntary certification schemes for agriculture have been designed for specific crops, whereas other have been developed generically and applicable to a range of crops. The above mentioned certification schemes were evaluated regarding the coverage of the following environmental aspects: soil, water, air, biodiversity as well as carbon and land use change.

The analysis showed that the range of sustainability standards reviewed has many similarities in terms of coverage of environmental aspects:

- Almost all of them include a cut-off date for land-use change
- Carbon reduction/conservation in agricultural / silvicultural operations is not well covered
- Carbon emissions related to land use change is explicitly covered in newer standards (BSI/Bonsucro, RTRS, RSB, ISCC, GBEP), but is implicit in all standards that have performance requirements related to land-use change
- Other emissions to air are not particularly well covered
- Biodiversity is addressed in all of the standards reviewed, but the detail of the requirements varies considerably

The approaches to measure the impacts vary among the different standards:

- Most of the certification schemes use qualitative performance requirements
- Most have specific measurement parameters for soil, and several for water
- Several standards have National Interpretations which may define additional measurement parameters and performance metrics
- BSI/Bonsucro is the only standard with metrics-based performance requirements
- GBEP is the only standard reviewed without performance requirements

Further details can be found in the report on “General environmental impacts, principles, criteria and indicators of biomass production and conversion” /Rettenmaier et al. 2011/.

2.2 Environmental impacts associated with the case studies

The aim of the "Report on Show Cases and linkage of environmental impacts to socio-economic impacts" was to assess the environmental impacts associated with the Global-Bio-Pact case studies /Rettenmaier et al. 2012a/.

A number of environmental impacts are usually associated with the production and use of biomass for biofuel / bioenergy or biomaterial purposes. Article 23(1) of the European Renewable Energy Directive (RED, 2009/28/EC) specifically mentions the impacts on global warming (greenhouse gas emissions), biodiversity, water resources / quality and soil quality /EP & CEC 2009/. These main areas of concern were also mentioned by the FAO-funded Bioenergy Environmental Impact Analysis (BIAS) project /Fritsche et al. 2010a/ which provides a framework assisting decision-makers and stakeholders in comparing the environmental impacts of competing bioenergy development options.

Within the Global-Bio-Pact project, it was decided to focus on these four environmental impacts (Fig. 2-2): greenhouse gas (GHG) emissions should be quantified, whereas the impacts on biodiversity, water and soil should be treated in a qualitative manner.

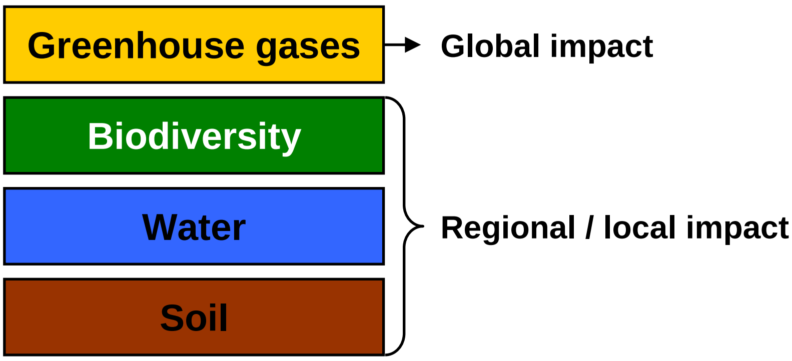

Fig. 2-2 Key modules of the BIAS framework. Adapted from /Fritsche et al. 2010a/

IFEU calculated the GHG balances based on case study-specific data provided by the project partners. The GHG calculations were performed according to the rules laid down in Annex V of the European Renewable Energy Directive (2009/28/EC, RED), since the Global-Bio-Pact project was initiated in order to explore whether and how the current list of (environmental) sustainability criteria in the RED can be amended by mandatory socio-economic sustainability criteria. Three spreadsheet tools were used: the BioGrace GHG calculation tool (for sugarcane ethanol, soybean oil biodiesel, palm oil biodiesel) /BioGrace 2011/, the ENZO2 Greenhouse gas calculator (adapted to molasses ethanol) /IFEU 2012/ and the GEF Biofuel GreenHouse Gas Calculator (for Jatropha oil biodiesel) /IFEU 2011/.

Example: Palm oil biodiesel from Indonesia

In the following, the environmental impacts associated with palm oil biodiesel production in Indonesia are exemplified. For further examples, please refer to /Rettenmaier et al. 2012a/.

Palm oil biodiesel from Indonesia shows negative implications regarding greenhouse gas (GHG) emissions, water resources and quality, biodiversity and soil. Both feedstock production and conversion contribute to the negative implications.

The most important problem is that palm oil biodiesel production in Indonesia – at least in case of the plantations and mills regarded in the case study – leads to high GHG emissions (Fig. 2-3). None of the three cases reaches the 35 % minimum threshold of the RED. This is mainly due to i) the fact that the methane emissions from the palm oil mill effluent (POME) treatment are not captured and ii) the relatively high amount of used fertilisers. Of the three investigated palm mills, only the Desa Asam Jawa case (16 %) is achieving results close to the RED default value (for mills without methane capture). This highlights the great potential for process optimisation in the palm oil industry, not only in terms of methane capture at the palm oil mill but also in terms of increased use of oil palm biomass residues.

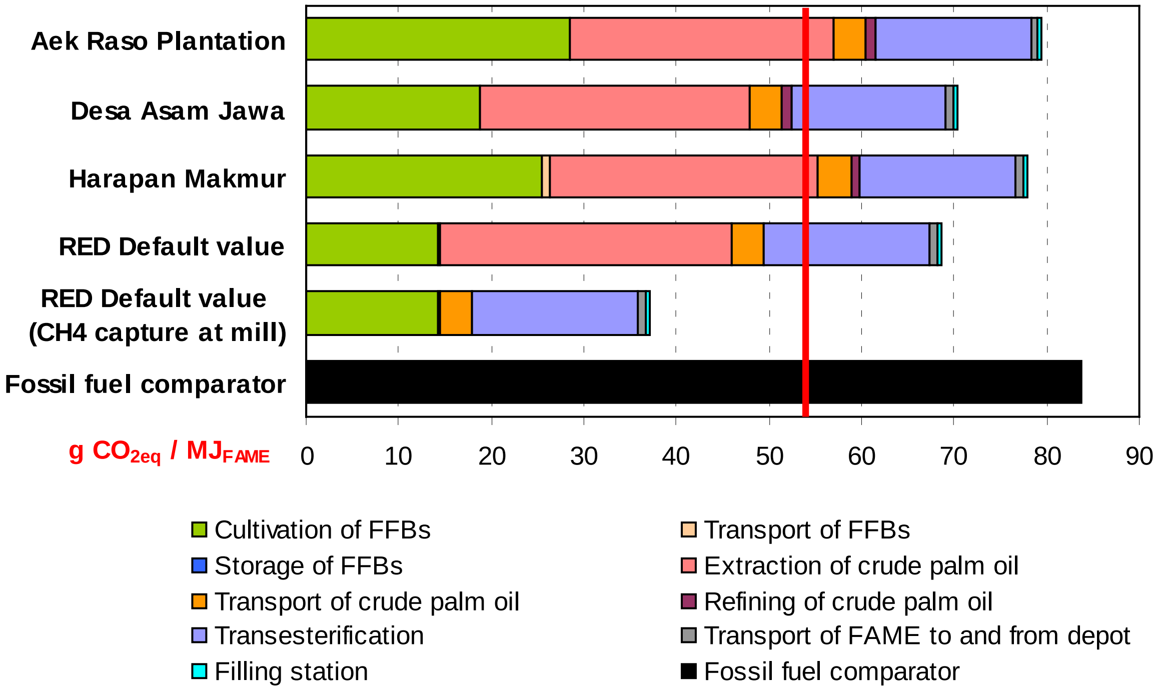

Fig. 2-3 GHG emissions from palm oil biodiesel in Indonesia compared to its fossil fuel comparator /IFEU based on Wright 2011/

In terms of biodiversity, it was found that all three cases lie within or next to areas of high biodiversity and high soil carbon stocks /Wright 2011/. The increasing demand for palm oil is a threat to these neighbouring areas, which could be converted to agricultural land, too. If rain forests are cleared and/or peat land is drained, there is a risk that high conservation value areas area permanently lost, greenhouse gas emissions are increased soil fertility is decreased. Soil compaction and application of fertilizer and chemical pesticides are further weaknesses /Wright 2011/. The application of the latter is potentially harmful for adjacent ecosystems and their water bodies and also results in increased greenhouse gas emissions. POME discharge into nearby water bodies creates another problem which can result in water contamination of the surrounding area, if not treated and handled appropriately. The palm oil mill needs to be located in the immediate vicinity of the plantation to ensure the quality of the fresh fruit bunches (FFBs) which are pressed to obtain the CPO. Therefore, the negative impacts of the palm oil mill can also affect surrounding rain forests or other areas of high conservation value.

2.3 Tools for land assessment

The aim of the report on "Tools for identifying the suitability of different land types for sustainable biomass production" /Diaz-Chavez & Rettenmaier 2011/ was to assess the existing tools for the suitability of different land types for biomass production, compare them to each other and evaluate their coverage, especially in relation to socio-economic impacts. These tools are necessary in order to define areas which do not conflict with other land uses (e.g. food and fodder production) and values (e.g. biodiversity or carbon stocks).

Land and the use of land provide a key link between human activity and the natural environment. The use of land is one of the principal drivers of global environmental change, as a consequent environmental change promoting climate change it influences the form communities use land as they have to adapt and mitigate to the effects of a changing climate /Winter & Lobley 2009/. There is also an increasing pressure on farmers and land managers to act as 'carbon stewards' as they have to adapt the land management to minimize carbon losses, and maximize carbon storage and provide substitutes for fossil fuels /Smith 2009/.

At the same time, a series of long-term trends (such as changing global dietary patterns) and shorter-term 'events' (such as recent poor harvests and droughts) have led to cons trained global food supply and stimulated pronounced changes in global agricultural commodity prices, putting further pressure on agriculture.

Traditionally, land use has been a finite resource from an environmental point of view. The appropriation of the resource has also covered some multi-functionality uses such as food, housing, fibre and fodder. This approach has been changing through time. More recently the discussion over the production of bioenergy crops for either biofuels or for energy generation has put forward a new paradigm in terms on land use and land appropriation. According to /Winter & Lobley 2009/ land and food are at the forefront of the policy agenda in most parts of the world with climate change playing an important role on land use and 'Food security'. The new emphasis on agricultural supply-chains and climate change have left the old "environmentalism" with the multifunctional agro-environments (and their focus on biodiversity and landscapes) behind /Winter & Lobley 2009/.

According to /Watson & Diaz-Chavez 2011/, different factors need to be considered to understand the implications for siting bioenergy projects: i) likelihood and desirability of converting land to bioenergy feedstocks, ii) appropriateness of contemporary relevant policies, and iii) best choice of feedstocks and production systems. In order to achieve this, a combination of tools and methods, from literature review to geographic information systems and modelling need to be conducted, including but limited to:

1. Models: spatial and non-spatial models
2. Frameworks: ecosystem services (approach), responsible cultivation, ecosystem approach
3. Planning and zoning: mapping, territorial zoning
4. Statistical analysis and databases

Most of the methods and tools used for the assessment of land for bioenergy purposes focus on land availability, the suitability for the feedstocks considering physical local conditions (e.g. water, soil, geomorphology) and after these considerations the main following one is the economic aspect.

Once the available potential of biomass is assessed, the system is optimized based on cost minimization of biomass production and utilization in energy conversion facilities. Therefore, one of the main issues is the distance of the conversion plant from the needed feedstock and the capacity of the plant itself. Given a certain biomass availability and regional distribution, at the increase of size, in fact, collecting distances increases and thus also the biomass supply costs. Many models have evaluated these issues, among them the Biomass Resources Assessment Version One (BRAVO) system in a computer based decision support system (DSS) to assist the Tennessee Valley Authority in estimating the supply cost for wood fuel as a function of the hauling distances. In this type of analysis, spatial information is needed in order to know where to collect the biomass from and where to deliver it /Angelis-Dimakis et al. 2011/.

The further links with social and economic issues at the community level are most of the time overseen and until recently considered due to the influence of policies and the need of standards to access the desirable market (e.g. Europe).

In particular the use of indicators associated with datasets and GIS provided a good source of information to assess land use for different purposes including bioenergy production (see /Watson 2008/).

Table 2-1 summarises the different methodologies and tools evaluated and their link with some social and economic issues regarding the assessment for bioenergy production. Although they are not exclusively used for these goals, they have been applied or used at some stage to assess the suitability of land.

There is not one single technique to assess suitability of land for bioenergy purpose. As it can be seen from the analysis of the different methodologies, frameworks and tools, a combination of them represents an advantage to incorporate different type of information and review the links among them.

The additional information that needs to be incorporated are the driving forces that promote this assessment such as policies, programmes and regulations.

Table 2-1 Summary and application of different methodologies, frameworks and tools

Methodology	Global/Regional	environmental	social	economic
Models				
Spatial	G/R	√		
Non-Spatial	G/R	√	√ (partial)	√
Ecosystem services	R	√	√	√ (partial)
RCA	R	√	√ (partial)	
Mapping	G/R	√	√ (partial)	
Databases	G/R	√	√	√

The modelling tools have already been developed and are subject to ongoing critique within specialized disciplines that define each of these model classes. The combined results of multidisciplinary state-of-the-art models should be informative for assessing LUC outcomes. These models should ideally subscribe to similar criteria in all regions, relying on data sources analogous to a global unified database and ground-truth verifications of projections (through data collection and monitoring) of fuel-related LUC /Davis et al. 2011/.

The assessment done by /Davis et al. 2011/ also demonstrated that feedbacks to ecosystem services are the least represented (relative to effects on production and economics) in integrated assessment models like Mini-CAM, and are more often modelled regionally without considering interactions with the global market. Connections between regional responses of ecosystem services, including greenhouse gas mitigation and carbon sequestration, and LUC must be made in order to assess global scenarios. /Davis et al. 2011/ suggested that a wide variety of existing tools must be used in aggregate to assess LUC. A combination of productivity, biogeochemistry, economics, environmental impact and social impact models must be employed to clarify the potential consequences of bioenergy in different regions of the world.

Furthermore, model inputs depend on land cover information (agriculture/ forestry/ grassland). This information is available from various products at different resolutions. Products are improving with satellite technology, but there are still differences among datasets that are partly due to classification (e.g. per cent coverage of trees that classifies land as a forest can vary from 20 % to 60 %) (see /Watson 2007/). This has to be considered when using a global comprehensive model of LUC. Standardization of land-use categories would increase the relevance of LUC models for global analysis, and should be inclusive of subdivisions with varied management practices that are employed throughout the world /Davis et al. 2011/.

The Global-Bio-Pact case studies clearly demonstrated that an integration of the different tools is necessary in order to assess the land use. Furthermore, the information also contributes and responds to policy making process in different parts of the world.

For further details, the reader is referred to the report on “Tools for identifying the suitability of different land types for sustainable biomass production” /Diaz-Chavez & Rettenmaier 2011/.

2.4 Linkage of environmental and socio-economic impacts

Another aim of the "Report on Show Cases and linkage of environmental impacts to socio-economic impacts" /Rettenmaier et al. 2012a/, besides the objective described in chapter 2.2, was to reveal hotspots of trade-offs and correlations between socio-economic and environmental impacts of biomass production in developing countries. Based upon the assessment of existing studies the interlinkages between major environmental and socio-economic impacts of biofuel and bioproduct life cycles were investigated. This is important since positive social impacts are not necessarily associated with positive environmental impacts, and vice versa.

The general linkage between environmental and socio-economic aspects is quite obvious: "the environment" actually means soil- to grow food; water- to drink, wash and irrigate crops; and air to breathe, and a host of natural food and medicinal products. It becomes clear that preserving "the environment" actually means safeguarding food production; sustaining livelihoods and preserving health. Poverty reduction, economic growth and the maintenance of life-supporting environmental resources are therefore inextricably linked /OECD 2001/. This linkage is best expressed in the "ecosystem services" approach. Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services (see also Annex 1: Ecosystem services). Changes in these services affect human well-being through impacts on security, the necessary material for a good life, health, and social and cultural relations /Millenium Ecosystem Assessment 2003/.

A SWOT analysis[3] was performed on each Global-Bio-Pact case study. This way, differences in the biomass production and conversion into the biofuels and bioproducts depending on specific environmental, social and economic conditions are revealed. The general structure of a SWOT matrix is shown below:

	Favourable	Unfavourable
Internal factors	**Strengths**	**Weaknesses**
External factors	**Opportunities**	**Threats**

Regarding the identification of linkages between socio-economic and environmental impacts the following classification was applied:

	Positive correlation	**Trade-off**
Environmental impacts	+	–
Socio-economic impacts	+	+
Environmental impacts	+	–
Socio-economic impacts	–	–
	Trade-off	**Negative correlation**

3 A SWOT analysis is a tool to assess the performance of a project, a product or a company. It originates from business management and it is a strategic planning tool to identify and assess the Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T) of the surveyed project, product or company. Internal factors are determined by the project / product itself. All others are external.

Interpretation

Through the SWOT analyses on the Global-Bio-Pact case studies, **all types of linkages** between socio-economic and environmental impacts **could be identified**: positive correlations, trade-offs as well as negative correlations. The interpretation of the identified linkages between socio-economic and environmental impacts is quite complex. First of all, this is because environmental impacts are a complex issue in themselves. They differ in terms of time scale (persistence), spatial scale (ubiquity), and (ir-)reversibility, among others.

Environmental impacts often develop insidiously over a long period of time, i.e. significant **time lags** might occur between the dose (release of a harmful substance) and the associated response (damage to organisms or ecosystems). Since ecosystems are functioning on a long time scale, environmental impacts tend to be overlooked by the short-sightedness of politics and society. Often, short-term economic profits are preferred over long-term environmental benefits. This is one of the main reasons for trade-offs between socio-economic and environmental impacts.

Moreover, the relationship between dose and response is often **non-linear** showing for example an abrupt change if a certain threshold is passed. In case this change is irreversible, the threshold is also called a tipping point. Last but not least, the **response depends on** the nature of the affected **organisms or ecosystems**, more specifically their resistance (ability to withstand) and resilience / elasticity (ability to tolerate). Thus, the same dose causes different responses in different environments.

Combining these insights and the ecosystem services approach, this means that environmental impacts lead to **changes in ecosystem services** which in turn **negatively affect the constituents of human well-being**. Despite to the complex relationship between dose and response (see above), one could postulate that there is a gradient from positive correlations to trade-offs to negative correlations, along which ecosystem services are increasingly deteriorated:

- **Positive correlations** (limited environmental impacts of a certain activity, no changes in ecosystem services, positive socio-economic impacts): The SWOT analyses of Global-Bio-Pact case studies suggest that extensive feedstock cultivation and conversion systems seem to result in positive correlations.
- **Trade-offs** (considerable negative environmental impacts, visible deterioration of ecosystem services, but still at least short-term positive socio-economic impacts): More intensive feedstock cultivation and conversion systems seem to entail trade-offs. This is the case for many Global-Bio-Pact systems. However, one has to keep in mind that there is a continuum rather than a sharp borderline between extensive and intensive cultivation.
- **Negative correlations** (severe negative environmental impacts, loss of ecosystem services, negative socio-economic impacts): Regarding the Global-Bio-Pact case studies, negative correlations between socio-economic and environmental impacts can mostly be explained by land-use conflicts and land-use changes as well as by inappropriate management practices – the latter both in terms of feedstock production (e.g. inappropriate application of agrochemicals) and conversion (e.g. inappropriate treatment of effluents).

This holds especially for ‘provisioning’ and ‘regulating’ ecosystem services which affect some but not all constituents of well-being. ‘Security’, ‘basic material for good life’ and ‘health’ are affected, whereas there is only a weak linkage between the ecosystem services mentioned above and ‘good social relations’ and ‘freedom of choice and action’.

Conclusions

The authors would like to emphasise that **the identified linkages (correlations and trade-offs) are case study-specific**. Due to the limited number of case studies (one or two per feedstock), a trend or even a general rule (in the sense of a direct causal linkage) for a certain feedstock or for a certain biofuel or bioproduct cannot be deduced.

From the analyses it can be concluded that:

- trade-offs and negative correlations between environmental and socio-economic impacts are a sign of deteriorations of ecosystem services which negatively affect the constituents of human well-being ‘security’, ‘basic material for good life’ and ‘health’. They are often related to **inappropriate management practices** during feedstock production and conversion which either **reflect the absence of respective regulations or** at least a **weak law enforcement by the country’s institutions**. Certification could help here, at least by raising awareness.
- the second cause for trade-offs and negative correlations is **land use conflicts and land-use change**. For direct land-use change (dLUC), the same applies as for inappropriate management practices (see above). However, certification doesn’t help resolving the issue of indirect land-use change (iLUC).
- the impacts associated with the production of a feedstock are fairly independent of its use, i.e. whether the feedstock is used for biofuels / bioproducts or for other purposes. Therefore, most of the conclusions drawn are applicable for the general cultivation of the respective feedstock. They do not necessarily reflect the specific impact of the biofuel production as such. Therefore **it is important to apply the same rules for all agricultural products irrespective of their use for food, feed, fibre or fuel**.
- most of the linkages between environmental and socio-economic impacts can be detected at local level whereas **some linkages can only be detected at country level** (or even higher), e.g. impacts on food security. Furthermore, some of the linkages regarding food security will need additional studies and a different methodology to be able to assess if biofuel production causes food insecurity and in how far biofuel mandates in developed countries and / or globally rising energy prices contribute to that (see recent FAO report produced within the “Bioenergy and Food Security Criteria and Indicators” (BEFSCI) project /FAO 2012b/). FAO’s BEFSCI framework /FAO 2012c/ provides some important findings and suggestions. For instance, it has identified a range of policy instruments that can be used to require or promote – either directly or indirectly – good environmental and socio-economic practices in bioenergy feedstock production, and to discourage bad practices.

For further details, the reader is referred to /Rettenmaier et al. 2012a/.

2.5 Use of marginal land and grassy biomass

The aim of the “Report on sustainability impacts of the use of marginal areas and grassy biomass” /Rettenmaier et al. 2012b/ was to challenge two frequent hypotheses, according to which land-use competition and its negative side-effects can be reduced or mitigated: i) through the use of marginal (or degraded) land and/or ii) through the use of grassy biomass. This chapter separately discusses the two hypotheses and presents our conclusions.

Use of marginal land

In order to mitigate this land-use competition and its negative side-effects, several studies have proposed to use marginal (or degraded) land for the production of biomass for energy /Fargione et al. 2008/, /Gallagher et al. 2008/, /Royal Society 2008/. ‘Marginal land’, however, is often incorrectly used as an umbrella term for all types of land ranging from fallow and abandoned land to degraded land. The crux is that land reported to be degraded is often the base of subsistence for the rural population /Berndes et al. 2003/ that it is critical to the survival of marginalised communities /Gaia foundation et al. 2008/.

Nevertheless, the idea has been taken up in the European Renewable Energy Directive (2009/28/EC, RED) which acknowledges that part of the increased demand for agricultural commodities will be met through an increase in the amount of land devoted to agriculture. More specifically, it is stated that *“the restoration of land that has been severely degraded or heavily contaminated and therefore cannot be used, in its present state, for agricultural purposes is a way of increasing the amount of land available for cultivation”* (preamble, 85). According to the RED (Annex V, part C, points 8 & 9), a bonus of 29 g CO_{2eq}/MJ is attributed to biofuels produced on such land[4].

IFEU and Imperial College come to the conclusion that **the concept of marginal land is not viable** and does not live up to the high expectations for the following reasons:

- **Unclear definition**: Marginal land is often incorrectly used as an umbrella term for all types of land ranging from fallow and abandoned land to degraded land. However, ‘marginal’ definitely is an economic term and therefore subject to the variable economic framework. Thus, it cannot be used as a stable definition. Unfortunately, other terms such as degraded land which are used synonymously are just as diverse and unclear.
  - From an environmental point of view, this creates huge problems since critical forest, peat and grassland ecosystems are often classified as "marginal" or "idle" if they are perceived as not contributing sufficiently to economic development /Gaia foundation et al. 2008/. According to /Elbersen et al. 2008/, biophysically favourable environments are classified as marginal, or secondary forest as degraded.
  - Also from a socio-economic point of view, the term ‘marginal land’ is problematic since land that is often described as "marginal" is in fact critical to the survival of the most marginalised communities. Governments often conveniently classify all sorts of lands as marginal – including those used by nomadic and pastoralist communities for grazing, small-scale farmers, indigenous peoples and women /Gaia foundation et al. 2008/.

4 According to the latest proposal by the European Commission /EC 2012/, points 8 and 9 shall be deleted. Instead of attributing a bonus to biofuels from degraded land, a malus (estimated indirect land-use change emissions) shall be attributed to biofuels from agricultural land.

- **Unclear extent and quality**: As a consequence of the unclear definition, the availability of marginal land, often identified as a major source of land for bioenergy, is highly uncertain. For the same reason, land quality is highly variable, depending on the biophysical limitations it suffers from.
  - Existing databases such as GLASOD are rather outdated.
  - Mapping the global extent of marginal/degraded land via remote sensing is challenging, since some biophysical aspects simply cannot be observed via satellite imaginary. This is even more the case for socio-economic aspects, e.g. whether the land is used by nomadic and pastoralist communities or indigenous peoples. A combined top-down and bottom-up approach (e.g. /Fritsche et al. 2010b/) would thus be needed to identify those areas, i.e. a ground-check is absolutely vital.
- **Unclear sustainability impacts**: As a consequence of the unclear definition and the unclear extent and quality, **it remains unclear if and to which degree marginal/degraded land could contribute to reduce land use competition**. Moreover, **it is difficult to generalise the sustainability impacts of the use of marginal land**.
  - In order to properly assess the environmental impacts associated with its use, it is crucial to know the exact marginal land in question. Land use-related impacts could be very positive, e.g. if the soil carbon stock was increased. However, if (semi-)natural land is used or grassland is converted into arable land, both the greenhouse gas balance (via soil carbon stocks) and biodiversity are negatively affected. In other words, a case-by-case evaluation is required since no general conclusion can be drawn.
  - However it is clear that – since marginal land is inherently less productive than fertile land – higher agricultural inputs (e.g. fertilizers) and therefore investments are required to obtain the same output as on fertile land. Thus, the environmental impacts are increased. Also, since many of these marginal lands are environmentally fragile, there is a considerable risk of irreversible degradation if inappropriately managed.
  - Moreover, due to generally unfavourable socio-economic conditions (rural poverty and lack of access to land), it is likely that non-food biomass cultivation leads to an intensification and capitalization of farming operations and thus to productivity enhancing measures. These limitations cast serious doubts whether realization of yield increases are possible in short periods of time.
- **Unclear future**: According to the RED (Annex V, part C, points 8 & 9), a bonus of 29 g CO_{2eq}/MJ is attributed to biofuels produced on degraded and heavily contaminated land. However, this bonus has not stimulated the use of such land for biomass feedstock cultivation. According to the latest proposal by the European Commission /EC 2012/, the bonus shall be replaced by a malus (estimated indirect land-use change emissions) which shall be attributed to all biofuels from agricultural land. However, this malus shall only be added to the typical values in Annex V for the purpose of the Member States' reports on net greenhouse gas emission saving from the use of biofuels. Instead of directly incentivising the use of degraded and heavily contaminated land, the use of agricultural land is somewhat discouraged.

Use of grassy biomass

The second focus of this report is on the use of grassy biomass. Grassy biomass can be obtained both from arable land (purpose-grown grassy crops), grassland (cuttings) and other (e.g. protected) areas. In the past few years, a controversial discussion on the net benefit of biofuels and bioenergy has been ongoing, showing that the use of biomass for energy is not environmentally friendly *per se*, simply because biomass is a renewable resource. Especially annual crops have repeatedly been criticised since they typically require more energy, fertiliser and pesticide input than perennial crops while achieving lower yields per unit area and lower net greenhouse gas (GHG) emission savings. Therefore, perennial crops, such as grasses, are attracting increasing interest as potential energy crops on arable land. **Several studies have argued that perennial grasses** cultivated on arable land **could reduce both land-use competition for arable land and environmental impacts** (/Tilman et al. 2006/, /Fargione et al. 2008/, /Rowe et al. 2009/, /Don et al. 2011/, /Valentine et al. 2012/).

Due to the same land-use competition – among others fuelled by biofuel policies – **grasslands are globally threatened of being converted into arable land which would result in a loss of biodiversity**. In Europe, permanent grasslands are already facing this pressure due to declining ruminant livestock numbers and forage demand. Alternative uses for biomass obtained from grasslands therefore urgently need to be developed to ensure that grassland can remain grassland. Scientists have proposed that **the use of grassy biomass for non-food purposes could actually be an option to conserve European grasslands, i.e. to avoid land-use changes** (/Rösch et al. 2009/, /Shekhar Sharma et al. 2011/). However, the fundamental question is whether economically viable options can be found which do not lead to an intensified use of high nature value grassland. **In case of land-use intensification, the use of grassy biomass for biofuels and bioproducts is a threat to biodiversity**. Taking both threats (land-use change and intensification) into account, the RED stipulates that biofuels shall not be made from raw material obtained from highly biodiverse grassland (Article 17 (3) (c)). However, an exact definition of such areas is still pending.

There are three fundamentally different types of grassy biomass which could be used for bioenergy and bioproducts: i) annual and perennial herbaceous crops cultivated on arable land, ii) grassy biomass obtained from grasslands and iii) other grassy biomass. In the following, they will be treated separately.

- **Purpose-grown grassy crops on arable land**:
  - The cultivation of perennial grasses on arable land (for the purpose of bioenergy and bioproducts) usually results in **lower *direct* environmental impacts compared to traditional crops** such as roots & tubers or oil crops. This is mainly due to higher product yields per unit area (i.e. seen from a bioenergy perspective). The advantage is less pronounced for annual grasses. Moreover, the impact on water resources and biodiversity is depending on local conditions and thus highly variable. Last but not least, a significant bandwidth/range of LCA results can be expected, both due to varying biomass yields and immature processes leading to lignocellulose-based biofuels.
  - However, when comparing different crops from a basket-of-products perspective, ***indirect* effects** have to be considered as well. In this case, the co-products obtained from traditional crops play an important role: if used as animal feed, they substitute conventional feed production and thus reduce the overall pressure on land. No such co-products are obtained from herbaceous crops. In other words, **grassy crops** are caus-

ing iLUC effects as well (potentially even worse) and **might not contribute to reduce land use competition**.

- **The socio-economic impacts of perennial grasses are not fully understood yet.** More research is needed in this field.

- **Grassy biomass from grasslands**:
  - **Unclear definition**: The term ‘grassland’ is ambiguously defined. Unfortunately, the RED has added to the confusion by introducing terms such as ‘highly biodiverse’, ‘natural’ and ‘non-natural’ grassland without providing a corresponding unambiguous definition. As a consequence, it is not fully clear, which areas are considered grassland.
  - **Land use change from permanent grassland to arable land are a no-go option**: land-use changes from permanent grassland to arable land are absolutely undesirable both from a carbon stock and biodiversity point of view.
  - **Through the use of cuttings from ‘surplus’ grasslands** (due to declining numbers of ruminant livestock) for the purpose of bioenergy and bioproducts, **synergies with a number of environmental issues could be exploited** (e.g. biodiversity conservation) – at least in Europe. Alternative uses for ‘surplus’ grasslands are urgently needed, however, in terms of environmental impacts it is absolutely crucial that these options do not lead to land-use intensification, especially in the case of high nature value grassland. The latter requirement casts serious doubts whether the potential contribution of grass cuttings is large enough to alleviate land use competition. Also, it has to be considered that in most parts of the world (i.e. outside Europe), per capita meat consumption is increasing. Thus, at global level, ‘surplus’ grasslands are **unlikely to contribute to a reduction of land use competition**.

- **Other grassy biomass**:
  - The use of grassy biomass obtained through human activities aiming at landscape conservation and/or preservation of the grassland status of protected grasslands offers many synergies with nature conservation – provided that the harvest of grassy biomass does not interfere with but rather supports the preservation of species richness and composition. Thus, it has **very positive environmental impacts**.
  - However, most of these activities are not economically viable and require substantial support by society. Despite considerable potentials in some countries, this source of grassy biomass is **unlikely to contribute to a reduction of land use competition** at global level.

Conclusion

It was shown that it is rather unlikely that the use of marginal (or degraded) land and/or the use of grassy biomass can significantly contribute to alleviate land-use competition and its negative side-effects. We think that these frequently heard hypotheses are refuted. For further details, the reader is referred to /Rettenmaier et al. 2012b/.

3 Harmonisation of environmental and socio-economic sustainability criteria

This chapter presents approaches to harmonise environmental and socio-economic sustainability criteria, taking into account results presented in the early overview type of reports produced within work packages 5 and 8 of the Global-Bio-Pact project. It highlights that the ecosystem services approach could be a suitable startegy to establish the link between environmental and socio-economic sustainability criteria, especially at local / project level. Moreover, it presents the Global-Bio-Pact set of sustainability criteria and indicators, which a accommodates both environmental and socio-economic sustainability criteria.

3.1 Sustainability indicators for bioenergy

Different standards have been produced or adapted for the bioenergy sector. These standards have mainly responded either to the market or to the requirements of the EU Renewable Energy Policy.

The Global-Bio-Pact project produced two reports that reviewed the standards. One of them focused on the environmental issues (/Rettenmaier et al. 2011/, D 5.1) and the other report focused on the socio-economic criteria (/Diaz-Chavez 2011/, D 8.1). Both reports can be found on the Global-Bio-Pact project website (www.globalbiopact.eu).

The conclusions of the report on “General environmental impacts, principles, criteria and indicators of biomass production and conversion” /Rettenmaier et al. 2011/ considered that the use of the sustainability standards examined could be a good proxy for measuring impact, particularly as they do require monitoring and mitigation activities. However, this approach would not provide consistent parameters which could be compared between operations, including those not implementing a sustainability standard.

The report also pointed out that of the standards assessed, only BSI/Bonsucro and the framework of the Global Bioenergy Partnership (GBEP, see Annex 2: GBEP Sustainability indicators) systematically provided measurement parameters. These standards are a useful starting point for developing impact indicators as they identify the important criteria and indicators for a variety of agriculture and forestry operations, and can be used as a framework for developing specific impact measurements for each of land use change, biodiversity, soil, water and air.

The report indicated some possible environmental criteria and indicators that could be developed in the Global-Bio-Pact project as per Table 3-1.

Table 3-1 Parameters to develop environmental impact indicators for within the Global-Bio-Pact project

	Parameters to develop impact indicators for
Carbon and land use change	Assessment of all parameters below before and after conversion
Biodiversity	Landscapes
	Ecosystems
	Plants & animals (including protected species)
	High Conservation Values
Soil	Physical, Chemical & biological status
	Soil carbon content
	Erosion
	Fertilizer use
	Contamination by fuels, human settlements and agro-chemicals
Water	Physical, Chemical & biological status
	Riparian zones
	Water use/efficiency
	Agro-chemical use
	Contamination by fuels, human settlements and agro-chemicals
Air	Pesticide spraying
	Burning of wastes and residues
	Burning for land use clearing
	Processing emissions

Regarding the socio-economic criteria and indicators, the report on "Assessment of existing socio-economic principles, criteria and indicators for biomass production and conversion" /Diaz-Chavez 2011/ concluded that social impacts tend to be more difficult to monitor and quantify as they require more in depth studies, normally household surveys which are time consuming and expensive. Therefore the link with the impacts from the application of the standards could be a good possibility to link with organisations that are already monitoring and certifying activities. Nevertheless, one of the main issues is that the monitoring refers more to compliance than to actual impacts

From the standards reviewed it was possible to consider that the ISEAL Impact Code and the GBEP framework offer the possibility of developing and/or using available indicators that refer to the whole supply chain of the bioenergy feedstocks and their co-products from the socio-economic point of view.

An additional issue to consider is that there will be some interactions needed to link between the environmental and socio-economic standards that will need to be considered for the analysis of the impacts. For instance, the link between the use of water for the feedstock production and the use of water by the community. A review of the results reported from the stakeholder overview of principles needed to be included can be found in the COMPETE report on Good Practice Principles /Diaz-Chavez 2009/.

The report suggested a short list of criteria to consider the development of indicators:

1. Impacts on water supply and quality affecting the community
2. Avoidance of land use change impacts that could impact food security
3. Community and women participation
4. Skills transfer
5. Improvement in services and infrastructure (energy supply, health)
6. Land rights

The following section presents the links between the environmental and socio-economic indicators.

3.2 Linkage of environmental and socio-economic indicators

Our analysis of linkages between socio-economic and environmental impacts (chapter 2.4) has shown that

- trade-offs and negative correlations between environmental and socio-economic impacts are often related to **inappropriate management practices** during feedstock production and conversion which either **reflect the absence of respective regulations** or **are a sign of weak governance** (in terms of implementation of decisions / law enforcement).
- the second cause for trade-offs and negative correlations is **land use conflicts and land-use change**. For direct land-use change (dLUC), the same applies as for inappropriate management practices (see above). However, in order to solve the problem of indirect land-use change (iLUC), global governance would be required since it affects more than one state or region.

Trade-offs and negative correlations between environmental and socio-economic impacts are also a sign of deteriorations of ecosystem services[5] which negatively affect the constituents of human well-being. This holds especially for ‘provisioning’ and ‘regulating’ ecosystem services which affect some (but not all) constituents of well-being through impacts on security, the necessary material for a good life, health, and social and cultural relations /Millennium Ecosystem Assessment 2003/ (see also Annex 1: Ecosystem services). The strong link between ‘provisioning’ ecosystem services and human well-being is also taken up in the Low Indirect Impact Biofuels (LIIB) methodology /Ecofys et al. 2012/, which constitutes a further development of the Responsible Cultivation Areas (RCA) methodology /Ecofys 2010/.

Regarding ‘good social relations’ and ‘freedom of choice and action’, the linkage to ecosystem services is weaker. Fig. 2-2 shows the linkages between ecosystem services and human well-being.

[5] Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services. /Millenium Ecosystem Assessment 2003/

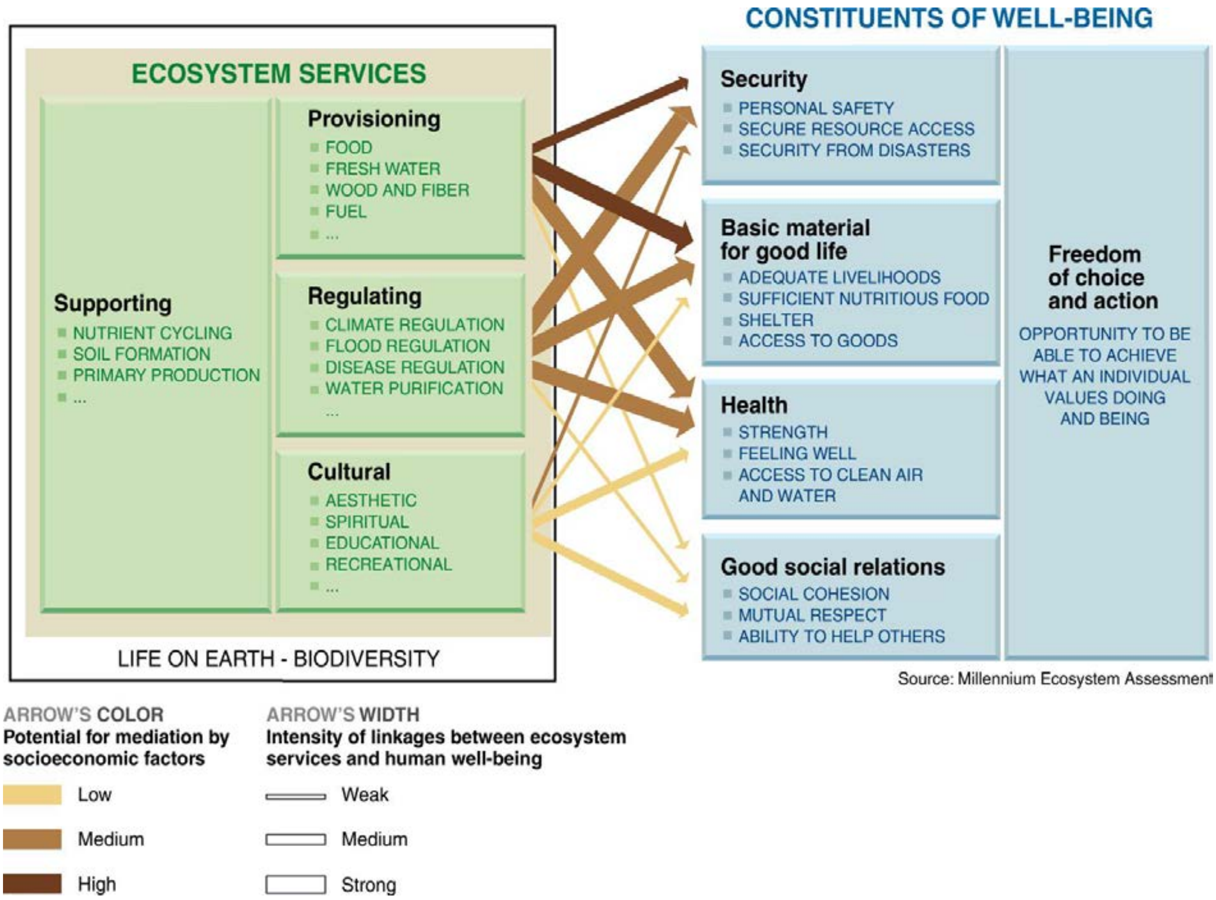

Fig. 3-1 Linkages between ecosystem services and human well-being. /Millennium Ecosystem Assessment 2005/

Ecosystem Services Review

The World Resources Institute (WRI) has also been working on methodologies to assess environmental series /Hanson et al. 2012/. The report highlights that ecosystems provide businesses with numerous benefits or "ecosystem services." Nevertheless, human activities are rapidly degrading these and other ecosystems. Ecosystem degradation is highly relevant to business because companies not only impact ecosystems and the services they provide but also depend on them. Therefore, this ecosystem degradation can pose a number of risks to corporate performance as well as create new business opportunities. /Hanson et al. 2012/ provided some examples of these types of risks and opportunities as per Box 4-1.

Box 4-1 Risk and opportunities to corporate performance /Hanson et al. 2012/

Operational

- Risks such as higher costs for freshwater due to scarcity, lower output for hydroelectric facilities due to siltation, or disruptions to coastal businesses due to flooding
- Opportunities such as increasing water-use efficiency or building an on-site wetland to circumvent the need for new water treatment infrastructure

Regulatory and legal

- Risks such as new fines, new user fees, government regulations, or lawsuits by local communities that lose ecosystem services due to corporate activities
- Opportunities such as engaging governments to develop policies and incentives to protect or restore ecosystems that provide services a company needs

Reputational

- Risks such as retail companies being targeted by nongovernmental organization campaigns for purchasing wood or paper from sensitive forests or banks facing similar protests due to investments that degrade pristine ecosystems
- Opportunities such as implementing and communicating sustainable purchasing, operational, or investment practices in order to differentiate corporate brands

Market and product

- Risks such as customers switching to suppliers that offer eco-certified products or governments implementing new sustainable procurement policies
- Opportunities such as launching new products and services that reduce customer impacts on ecosystems, participating in emerging markets for carbon sequestration and watershed protection, capturing new revenue streams from company-owned natural assets, and offering eco-labelled wood, seafood, produce, and other products

Financing

- Risks such as banks implementing more rigorous lending requirements for corporate loans
- Opportunities such as banks offering more favourable loan terms or investors taking positions in companies supplying products and services that improve resource use efficiency or restore degraded ecosystems.

Environmental management systems and environmental due diligence tools are often not fully attuned to the risks and opportunities arising from the degradation and use of ecosystem services. For instance, many tools are more suited to handle “traditional” issues of pollution and natural resource consumption. Most focus on environmental impacts, not dependence. Furthermore, they typically focus on risks, not business opportunities. As a result, companies may be caught unprepared or miss new sources of revenue associated with ecosystem change /Hanson et al. 2012/.

The World Resources Institute developed the Corporate Ecosystem Services Review (ESR) /Hanson et al. 2012/ to address these gaps. It consists of a structured methodology that helps managers proactively develop strategies to manage business risks and opportunities arising from their company’s dependence and impact on ecosystems. It is a tool for strategy development, not just for environmental assessment. Businesses can either conduct an Ecosystem Services Review as a stand-alone process or integrate it into their existing environmental management systems. In both cases, the methodology can complement and augment the environmental due diligence tools companies already use. These tools also include Social Impact Assessment and Corporate Social Responsibility.

These two tools can also work with indicators. Furthermore, according to /Hanson et al. 2012/ the Ecosystem Services Review can provide value to businesses in industries that directly interact with ecosystems such as agriculture, beverages, water services, forestry, electricity, oil, gas, mining, and tourism. It is also relevant to sectors such as general retail, healthcare, consulting, financial services, and others to the degree that their suppliers or customers interact directly with ecosystems.

WRI developed the ESR in collaboration with the Meridian Institute and the World Business Council for Sustainable Development (WBCSD). Five WBCSD member companies – Akzo Nobel, BC Hydro, Mondi, Rio Tinto, and Syngenta – road-tested the methodology, providing feedback and case examples /WRI 2012/.

Within the Global-Bio-Pact project a modified approach on the link between the social economic and environmental indicators through business and community was followed after the methodology of the WRI (see Table 3-2).

Table 3-2 Summary of methodology of corporate ecosystem services review /WRI 2012/

Step		**1. Select the scope**	**2. Identify priority ecosystem services**	**3. Analyze trends in priority services**	**4. Identify business risks and opportunities**	**5. Develop strategies**
Activity		Choose boundary within which to conduct the ESR (a specific business unit, product, market, landholdings, major customer, supplier, etc.)	Systematically evaluate degree of company's dependence and impact on more than 20 ecosystem services. Determine highest "priority" ecosystem services – those most relevant to business performance	Research and evaluate conditions and trends in the priority ecosystem services, as well as the drivers of these trends	Identify and evaluate business risks and opportunities that might arise due to the trends in priority ecosystem services	Outline and prioritize strategies for managing the risks and opportunities
Who is involved	Executive managers	√				√
	Manager(s) from selected scope	√	√		√	√
	Analysts		√	√	√	√
	Consultants (optional)		√	√	√	√
Sources of input and information	In-house business managers and analysts		√	√	√	√
	Existing and new in-house analyses		√	√	√	
	Local stakeholders		√			
	Experts from universities and research institutions			√		
	Millennium Ecosystem Assessment publications and experts			√		
	Nongovernmental organizations			√	√	√
	Industry associations			√	√	√
	Published research		√	√	√	
	Other resources and tools*		√	√	√	
End product		Boundary for ESR analysis	List of 5-7 "priority" ecosystem services	Short paper or set of data that summarizes trends for each priority ecosystem service	List and description of possible business risks and opportunities	Prioritized set of strategies
Estimated time*		1-2 weeks	2-3 weeks	4-6 weeks	1-2 weeks	2-3 weeks

*Estimates based on road tests and reflect one full-time equivalent. Time required to conduct an ESR will vary based on factors including the scope selected, availability of information, and number of staff allocated to gather information and conduct research and interviews.

The steps followed in the WRI methodology were adapted for the Global-Bio-Pact set of indicators as per Table 3-3.

Table 3-3 Methodology for ecosystem services links between environmental and socio-economic indicators (modified from /Hanson et al. 2012/)

Steps/ Data	Stakeholders	Select the Scope	Identify Priority Ecosystem Services	Analyze trends in priority services
Activity		Boundaries related to the bioenergy project along the supply chain	Evaluates the links between the company and the ecosystem services	Research and evaluate the trends of the ecosystem services between the company and the community
Who is involved	Company	√		√
	Outgrowers	√		√
	Government	√		√
	Community	√		
	Analyst[6]			√
Sources of input and information	Company's management		√	
	Company's workers		√	
	Outgrowers		√	
	NGOs		√	
	Community		√	
	Government		√	
	Published research		√	
	Other resources and tools		√	

As of 2012, an estimated 300 companies have used the Ecosystem Services Review. In addition, complementary tools and guidance now exist to help companies more fully assess business risks and opportunities emerging from ecosystem change. For example, in 2011 the World Business Council for Sustainable Development released the Guide to Corporate Ecosystem Valuation (CEV), which provides information on how to quantitatively, or in some cases monetarily, assess risks and opportunities related to ecosystem services /WBCSD 2011/. CEV can therefore be a logical next step after undertaking an ESR. The Economics of Ecosystems and Biodiversity report /TEEB 2010/ highlighted new examples of the linkages between business and ecosystem services. The ESR remains a fundamental starting point for companies to assess business risks and opportunities related to ecosystem change /Hanson et al. 2012/.

The indicators used for ecosystem services within the Global-Bio-Pact project are presented in the following section.

[6] The analyst is the person in charge to apply the Global-Bio-Pact set of indicators.

3.3 Global-Bio-Pact set of sustainability criteria & indicators

The aim of the report on the "Global-Bio-Pact set of selected socio-economic sustainability criteria and indicators" /Diaz-Chavez et al. 2012/ was to present the selected set of Global-Bio-Pact indicators to measure socio-economic impacts of projects related to bioenergy and bioproducts. The selection of most practicable and suitable criteria and indicators was based on the comparison of environmental standards (/Rettenmaier et al. 2011/, D 5.1) and social standards (/Diaz-Chavez 2011/, D 8.1) and the evaluation in Tasks 2.4 and 2.5, as well as on the direct inputs from the Case Studies in WP 2 and 3. Therefore it has two components: the background information and the list of selected indicators.

The selected indicators are impact indicators, this means that they measure the effects that the activity had in the environment or the community affecting the socio-economic aspects of it. They should be differentiated from performance indicators that are used by standards where a company needs to comply with a regulatory aspect or with the standard itself.

Some of the indicators will also be considered as performance indicators in terms of the changes that have occurred in the region and that could be attributed to the biofuel production activities. For this reason, if possible some will be from a data baseline from 2007 as per the requirements of the EU Renewable Energy Directive.

The indicators were arranged in one topic of background information and three topics of impacts as follows:

1. **Basic Information**: data that provides background information from the selected case study.
2. **Socio-economic indicators**: these include the impacts caused by bioenergy crops production and the different stages of the supply chain to produce biofuels.
3. **Environmental indicators**: in the project's context they refer to the environmental impacts that affect the socio-economic characteristics of the communities.

Table 3-4 and Table 3-5 present the main topics and indicators selected.

Table 3-4 Global-Bio-Pact set of sustainability criteria & indicators. Part I: Basic information /Diaz-Chavez et al. 2012/

Impact	Indicator
Basic information	Name and location
	Land area under cultivation
	Expansion of land area
	Average yield
	Annual production
	Certification
	Sectorial associations

Table 3-5 Global-Bio-Pact set of sustainability criteria & indicators. Part II & III: Socio-economic and environmental indicators /Diaz-Chavez et al. 2012/

Impact	Indicator
Contribution to local economy	Production cost
	Value added
	Taxes/royalties paid to the government
	Contributions made by the operation to allied industries in the local economy
	Production farmed by smallholders or suppliers
	Amount paid to smallholders and suppliers of feedstock
	Employment
	Ratio between local and migrant workers
	Percentage of permanent workers
	Provision of worker training
	Community investment
Working conditions and rights	Employee income
	Employment benefits
	Income spent in basic needs
	Hours of work
	Freedom of association
Health and safety	Work related accidents and diseases
	Personal protective equipment
	OSH training
Gender	Benefits created for women
Land rights	Land rights and conflicts
Food security	Land that is converted from staple crops
	Edible feedstock diverted from food chain to bioenergy
	Availability of food
	Time spent in subsistence agriculture
Air	Use of open burning
	Use of Best Available Technologies for reducing emissions
Soil	Implemented Practices
	Soil Erosion
	Soil analysis
Water	Water consumption (irrigation)
	Water Management Plan
	Availability of water
	Quality of water
Biodiversity	Reduction of biodiversity
	Impacts on fisheries/other aquatic fauna
	Impacts on local fauna/flora perceived by community
	Conservation Measures
Ecosystem Services	Reduction in access to ecosystem services

The main areas where environmental and socio-economic indicators are considered to be linked within the Global-Bio-Pact project **are food security, biodiversity and ecosystem services**. Although land use is also linked to all the purposes of growing crops for fuel, fodder, fibre and food.

The indicators selected for food security involved the link with the community are presented in Table 3-6.

Table 3-6 Food security indicators

Food security			
2.24	Land that is converted from staple crops	Land that has been converted from staple crops (ha)	Hectares of land that has been converted from staple crops to the feedstock production (assessor should define staple crops for the country) within the last five years
2.25	Edible feedstock diverted from food chain to bioenergy	Amount of edible raw material diverted into bioenergy production (t)	Annual amount of edible feedstock that was used in bioenergy production (5-year period)
2.26	Availability of food	Perceived change in availability of food after the beginning of bioenergy operations	Check (survey) at community level about perceived change
2.27	Time spent in subsistence agriculture	Change in time spent in subsistence agriculture in the household	Check (survey) at community level about perceived change

The indicators selected to assess impacts on biodiversity are shown in Table 3-7.

Table 3-7 Global-Bio-Pact Indicators for biodiversity

Biodiversity			
3.16	Reduction of biodiversity	Non-agricultural land or pasture that has been converted towards feedstock operation within a 5-year period (ha), type of previous vegetation of converted land	This can be check with the operation and cross checked with local or national authorities or environmental NGOs
3.17	Impacts on fisheries/other aquatic fauna	Local perceptions on impacts on fisheries/other aquatic fauna	Questions addressed to local community representatives, NGO or local authority
3.18	Impacts on local fauna/flora perceived by community	Local perceptions on impacts on local fauna and flora	Questions addressed to local community, NGO or local authority
3.19	Conservation Measures	% of surface set-aside for conservation purposes	e.g. protected habitat, buffer zones, ecological corridors, riparian vegetation, etc.

Regarding ecosystem services and the links with the social issues (especially through the impacts on the community) the indicators are show in Table 3-8.

Table 3-8 Global-Bio-Pact indicators on ecosystem services

Ecosystem services			
3.20	Access to ecosystem services	Reduction in local communities' access to hunting, fishing	Qualitative questions to local community representatives, and NGO(s)
3.21		Reduction in local communities' access to non-timber forest products	Qualitative questions to local community representatives, and NGO(s)
3.22		Reduction in local communities' access to cultural ecosystem services such as sacred and recreational sites	Qualitative questions to local community representatives, and NGO(s)

Some of the indicators are qualitative as they express the opinion of the stakeholders and the perception they have on the impacts on their environment.

For further information on the methodology to develop the indicators, see report “Global-Bio-Pact set of selected socio-economic sustainability criteria and indicators” (/Diaz-Chavez et al. 2012/, D 8.2). For the perceptions and assessment of the indicators see the forthcoming “Audit report on testing the Global-Bio-Pact set of socio-economic sustainability criteria” on the Global-Bio-Pact website (www.globalbiopact.eu).

3.4 Other approaches

BEFSCI

There have been some suggestions to link environmental and socio-economic indicators. For instance, the FAO’s “Bioenergy and Food Security Criteria and Indicators” (BEFSCI) framework. This project has developed a set of criteria, indicators, good practices and policy options on sustainable bioenergy production that foster rural development and food. The aims of the project are i) to inform the development of national frameworks aimed at preventing the risk of negative impacts and increasing the opportunities - of bioenergy developments on food security and ii) to help developing countries monitor and respond to the impacts of bioenergy developments on food security and its various dimensions and sub-dimensions.

Although the BEFSCI focuses on food security there are some important findings and suggestions from the framework. For instance, it has identified a range of policy instruments that can be used to require or promote – either directly or indirectly – good environmental and socio-economic practices in bioenergy feedstock production, and to discourage bad practices. These instruments can be grouped into four main categories /FAO 2012c/:

- Mandates with sustainability requirements
- National standards for certification
- Financial incentives
- Capacity building

Equator Principles

For large projects another initiative which also looks at these links include the Equator Principles. The Equator Principles is a credit risk management framework for determining, assessing and managing environmental and social risk in project finance transaction /EP Assoc. 2007/.

The EPs are adopted by financial institutions and are applied where total project capital costs exceed US$10 million. The EPs are primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. The EPs are based on the International Finance Corporation Performance Standards on social and environmental sustainability and on the World Bank Group Environmental, Health, and Safety Guidelines (EHS Guidelines) /EP Assoc. 2007/. The EPs are listed in the following:

- Principle 1 Review & Categorisation
- Principle 2 Social & Environmental Assessment
- Principle 3 Applicable Social & Environmental Standards
- Principle 4 Action Plan & Management System
- Principle 5 Consultation & Disclosure
- Principle 6 Grievance Mechanism
- Principle 7 Independent Review
- Principle 8 Covenants
- Principle 9 Independent Monitoring & Reporting
- Principle 10 EPFI reporting

Currently 77 adopting financial institutions (75 EPFIs and 2 Associates) in 32 countries have officially adopted the EPs, covering over 70 percent of international Project Finance debt in emerging markets.

The EPs have greatly increased the attention and focus on social/community standards and responsibility, including robust standards for indigenous peoples, labour standards, and consultation with locally affected communities within the Project Finance market /EP Assoc. 2007/. The EPs have also promoted convergence around common environmental and social standards. Multilateral development banks, including the European Bank for Reconstruction & Development , and export credit agencies through the OECD Common Approaches are increasingly drawing on the same standards as the EPs /EP Assoc. 2007/.

The EPs have also helped spur the development of other responsible environmental and social management practices in the financial sector and banking industry (for example, Carbon Principles in the US, Climate Principles worldwide) and have provided a platform for engagement with a broad range of interested stakeholders, including non-governmental organisations (NGOs), clients and industry bodies /EP Assoc. 2007/.

Along with Corporate Social Responsibility they could also make a difference in the larger investments of the bioenergy sector. Currently, none of the companies in the sector is using these approaches.

GEF Project Screening Tool

The Global Environment Facility (GEF) Targeted Research Project "Assessments and Guidelines for Sustainable Liquid Biofuel Production in Developing Countries" /Franke et al. 2012/, aimed to identify and assess sustainable systems for the production of liquid biofuels both for transport and stationary applications. Jointly lead with the Food and Agricultural Organization (FAO) and the United Nations Industrial Development Organization (UNIDO), the project will specifically provide policy recommendations to the GEF by filling in the knowledge gaps on sustainable biofuel pathways for developing countries.

Beyond the research project, the project team has worked to develop a biofuels screening tool for GEF project proposals /Müller-Lindenlauf et al. 2010/. The objective of the project screening tool was to enable the GEF and its Implementing Agencies (IA) to assess rapidly whether or not Project Identification Forms (PIF) (i.e. a brief project proposal to the GEF) meets the goals set forth by the GEF. These goals are called Global Environmental Benefits (GEB) and indicate whether or not a project will provide positive, concrete benefits to the environment. Using a traffic light system, the tool can also be used by applicants in GEF eligible countries to improve their applications and PIFs. In addition to environmental aspects, the tool also covers selected social impacts such as land tenure, labour, human health and safety as well as food security.

4 Conclusions & recommendations

The main areas where environmental and socio-economic indicators are considered to be linked within the Global-Bio-Pact project are **land use impacts on food security, ecosystem services, biodiversity, water and soil**. Within the project, indicators for these main areas have been developed and included into the set of sustainability criteria and indicators.

Different approaches can be taken to link environmental and socio-economic issues, principles, criteria and indicators. There is no one single formula and probably a mixture of these approaches and methodologies might provide the best results.

The ecosystem services approach proves to very suitable for establishing the linkage between environmental and socio-economic impacts, but is still new in the business and project arena and requires further development. The number of companies that use approaches and standards such as the Corporate Ecosystem Services Review (ESR) or the Equator Principles is still very limited, particularly in the bioenergy sector.

In terms of harmonisation of environmental and socio-economic sustainability criteria, our analysis has shown that any strategy should especially focus on the mandates with sustainability requirements such as the EU Renewable Energy Directive (2009/28/EC, RED), since these are to a large extent setting the scene.

At European level, we recommend to include socio-economic criteria and amend the RED as follows:

- **set NEW mandatory environmental sustainability criteria regarding soil, water and air protection**, i.e. criteria that have a strong link to ecosystem services (e.g. /UNEP et al. 2011/). This way, some social impacts affecting 'security', 'basic material for good life' and 'health' can be covered **indirectly**. Some of the voluntary certification systems do include such criteria, but since they are not needed to fulfil the requirements of the RED (so far, only criteria related to GHG emissions and biodiversity are mandatory[7]), there is a risk that economic operators opt for the weakest (recognised) certification system which doesn't include the suggested criteria regarding soil, water and air protection.
- **set MANDATORY social sustainability criteria** regarding working conditions and rights, land use conflicts and land tenure (see for example recent FAO guidelines /FAO 2012a/), health and safety as well as gender
- **deepen the existing reporting obligations by establishing a monitoring system** for those social sustainability criteria that could conflict with environmental ones (e.g. contribution to local economy) or that are only visible at national level (e.g. impacts on food security).
    - Since ecosystems are functioning on a long time scale, environmental impacts tend to be overlooked by the short-sightedness of politics and society. Often, short-term economic profits are preferred over long-term environmental benefits. This is one of the

[7] Obviously, the EC has discarded the inclusion of sustainability criteria regarding soil, water and air protection into the RED due to concerns related to WTO conformity. In our opinion, this should be verified once again.

main reasons for trade-offs between (socio-)economic and environmental impacts. Therefore, **we discourage to set any *mandatory* criteria regarding the contribution to local economy**.

- Some of the linkages regarding food security will need additional studies and a different methodology to be able to assess if biofuel production causes food insecurity and in how far biofuel mandates in developed countries and / or globally rising energy prices contribute to that (see recent FAO report produced within the "Bioenergy and Food Security Criteria and Indicators" (BEFSCI) project /FAO 2012b/).

Moreover, we recommend to improve and amend the RED also in terms of environmental criteria

- **widen the scope of the RED to cover solid and gaseous biofuels, too**, i.e. to extend its coverage beyond the transport sector. Not only in this case, the mandatory environmental sustainability criteria regarding biodiversity need to be extended, in particular with regard to the protection of forests with high biodiversity and to sustainability requirements for forestry (see below).
- **set ADDITIONAL mandatory environmental sustainability criteria regarding biodiversity.** There is an urgent need to include (and define) "highly biodiverse forests" under land cover-related criteria (Article 17) as well as "minimum requirements for good silvicultural and environmental condition" under cultivation-related criteria (Article 17(6)).
- **properly consider greenhouse gas emissions from carbon stock change due to indirect land-use change (iLUC)** in the rules laid down in Annex V of the RED, not only in the reporting obligation set out in Article 22(2), as recently proposed by the European Commission /EC 2012/[8].

[8] The authors consider the EC's latest proposal to amend the RED not fully convincing because i) limiting the share of biofuels from *food* crops to 5 % doesn't help solving the food insecurity problem (since the amount of land used is crucial and not the fact that some crops are edible and others aren't), ii) *non-food* crops (e.g. lignocellulosic crops) also cause indirect effects and iii) the strong push towards the use of biomass residues (through multiple counting) will probably cause undesired indirect effects ("indirect residue use competition", iRUC) and market distortions.

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Annex 1: Ecosystem services

Provisioning Services are ecosystem services that describe the material outputs from ecosystems. They include food, water and other resources.


Food: Ecosystems provide the conditions for growing food – in wild habitats and in managed agro-ecosystems.


Raw materials: Ecosystems provide a great diversity of materials for construction and fuel.


Fresh water: Ecosystems provide surface and groundwater.


Medicinal resources: Many plants are used as traditional medicines and as input for the pharmaceutical industry.

Regulating Services are the services that ecosystems provide by acting as regulators e.g. regulating the quality of air and soil or by providing flood and disease control.


Local climate and air quality regulation: Trees provide shade and remove pollutants from the atmosphere. Forests influence rainfall.


Carbon sequestration and storage: As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues.


Moderation of extreme events: Ecosystems and living organisms create buffers against natural hazards such as floods, storms, and landslides.


Waste-water treatment: Micro-organisms in soil and in wetlands decompose human and animal waste, as well as many pollutants.


Erosion prevention and maintenance of soil fertility: Soil erosion is a key factor in the process of land degradation and desertification.


Pollination: Some 87 out of the 115 leading global food crops depend upon animal pollination including important cash crops such as cocoa and coffee.


Biological control: Ecosystems are important for regulating pests and vector borne diseases.

Habitat or Supporting Services underpin almost all other services. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals.


Habitats for species: Habitats provide everything that an individual plant or animal needs to survive. Migratory species need habitats along their migrating routes.


Maintenance of genetic diversity: Genetic diversity distinguishes different breeds or races, providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock.

Cultural Services include the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits.


Recreation and mental and physical health: The role of natural landscapes and urban green space for maintaining mental and physical health is increasingly being recognized.


Tourism: Nature tourism provides considerable economic benefits and is a vital source of income for many countries.


Aesthetic appreciation and inspiration for culture, art and design: Language, knowledge and appreciation of the natural environment have been intimately related throughout human history.


Spiritual experience and sense of place: Nature is a common element of all major religions; natural landscapes also form local identity and sense of belonging.

Source: /TEEB 2010/

Annex 2: GBEP Sustainability indicators

PILLARS GBEP's work on sustainability indicators was developed under the following three pillars, noting interlinkages between them:		
Environmental	**Social**	**Economic**
THEMES GBEP considers the following themes relevant, and these guided the development of indicators under these pillars:		
Greenhouse gas emissions, Productive capacity of the land and ecosystems, Air quality, Water availability, use efficiency and quality, Biological diversity, Land-use change, including indirect effects.	Price and supply of a national food basket, Access to land, water and other natural resources, Labour conditions, Rural and social development, Access to energy, Human health and safety.	Resource availability and use efficiencies in bioenergy production, conversion, distribution and end-use, Economic development, Economic viability and competitiveness of bioenergy, Access to technology and technological capabilities, Energy security / Diversification of sources and supply, Energy security / Infrastructure and logistics for distribution and use.
INDICATORS		
1. Life-cycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and re-qualification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

Source: /GBEP 2011/