*"Non-food Crops-to-Industry schemes in EU27"*

**WP5 Sustainability**

# D5.4 Sustainability standards and criteria for non-food crops

(final version)

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# 1 Introduction

In the Crops2Industry (in short: C2I) project, Work Package 5 (WP5) aims to assess the sustainability impacts of selected RRM production systems and to identify a 'core' list of standards and criteria for the environmental and socio-economic sustainability of selected non-food crops used for biomaterials in a global and country-specific perspective[1].

Although sustainability involves economic, environmental and social issues, the work in WP5 **focuses on environmental and social** challenges, as the economics of bioenergy and biomaterials are issues of markets and governmental support, and the economic aspects are addressed in WP4.

As a key outcome of WP5, a **list of sustainability criteria** for non-food crops was developed and is presented here as Deliverable 5.4.

Non-food crops in the C2I project are the following:

- Oil crops such as rapeseed, sunflower and linseed
- fiber crops such as flax, hemp, and kenaf
- carbohydrate crops such as maize, potato, and sweet sorghum
- specialty crops such as American cornflower, peppermint, and calendula.

The work for this report was able to take into account preliminary results from the C2I WP 1 and 6, and also results from WP 5.1 through 5.3.

Furthermore, the authors were fortunate to make use of internal results from other projects on the national and international levels.

Still, the sole responsibility for the content of this publication lies with authors.

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1 Research on the sustainability of non-food crops systems is quite young, so that few studies and very few empirical data are available. In the EU, most of existing data comes from Northern and Central European countries, while the semi-arid or arid climates in Southern European countries restrict the application of results from "Northern" countries which have different soils and climates and use different farming systems.

## 2 Sustainability standards and criteria for non-food crops

The use of biomass for energy and materials, as well as for food, feed and fiber is rising globally in parallel with increases in population, income, fossil energy prices, and concerns about energy security, and climate change (OECD/FAO 2009; IEA 2011+2012).

Many countries established policies to increase utilization of domestic biomass resources, recognizing biomass as an option to reduce import dependence and improve rural development, employment, and income (GBEP 2007; FAO 2008). Some countries also envisage export opportunities, especially for liquid biofuels (IEA 2010+2011a+b; IEA Bio 2011).

Biomass production and use for electricity, heat and transport fuels as well as for (new) biomaterials will continue to increase, with global trade in biomass rising in parallel (IEA 2011+ 2012).

Parallel to rising interests in bioenergy and biomaterials, concerns about biomass sustainability became more prominent, with food security, greenhouse gas emission balances, and biodiversity impacts being discussed critically[2].

This paper provides a compilation of science-based standards and criteria to determine the sustainability of bioenergy and renewable raw materials (RRM in short) production with specific regard to non-food feedstocks.

This list was derived from a variety of activities to establish mandatory sustainability schemes especially for biofuels and bioenergy, but is **not** restricted to indicators and criteria being compatible with current trade law.

The overall sustainability “balance” of biomass cultivated for use as bioenergy or for RRM depends on the downstream processing of the feedstock into useful products, the use phase of such products, and their end-of-life management.

In that regard, non-food crops are no exception – their environmental profile largely depends on the full life-cycle of producing, converting, using and disposing (or recycling) non-food crops.

Thus, the sustainability standards and criteria developed here primarily address the cultivation stage of non-food crops.

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2 It should be noted that environmental and social impact of bioenergy were discussed critically already in the 1990s (OTA 1993). A few sources for the more recent discussion are Best (2008); CBD (2010); CCC (2011); CE. OEKO (2010); CIFOR (2010); ESA (2010); FAO (2012c); GNESD (2010); IEA Bio, IEA RETD (2009); MNP (2008); OEKO, IFEU, CI (2010); PBL (2012); UN-Energy (2007); UNEP-IRP (2009); WBGU (2009)

# 3 Environmental standards and criteria

The environmental impacts of biomass feedstock production for bioenergy or biomaterial use can be either positive or negative, depending on the cultivation system, its location and previous land-use, and the management practices with their effects on biodiversity, soil and water.

## 3.1 Land Use

Fundamental to the cultivation of all RRM is the competition for land – both directly in terms of changing previous land uses with could have been unmanaged natural land such as primary forests, peatland or savannas.

Furthermore, there could be indirect effects of converting arable land due to displacement of previous agricultural production which implies risks of indirect land use changes (ILUC)[3].

From an environmental point of view, land use is “the” critical issue for any additional cultivation of biomass – disregarding if the feedstock is used for bioenergy or for bio-based materials.

Sustainable land use is the overall standard **also for non-food crops**, expressed in specific criteria[4] which refer to biodiversity, climate change, soil, and water.

For sustainable land use, it should also be considered to take into account the overall **resource efficiency** of the feedstocks produced from the land.

For bioenergy, this has been formulated already (IFEU, CI, OEKO 2012), but not for RRM due to the different metrics, and yet early stage of sustainability discussion on integrated biomass uses (see Sections 5 and 6).

Still, it is deemed important to have the resource efficiency criterion as a subset of sustainable land use being mentioned even without further qualification or substantiation on the indicator level.

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3 It is beyond this paper to discuss ILUC – for a summary of the ongoing discussion, see e.g. Ecofys (2011); Fritsche, Sims, Monti (2010); OEKO (2011), IFPRI (2011); JRC-IE (2011a+b), and Sanchez et al. (2011).

4 Note that there are also social aspects of land use to be considered (see Sections 4.2 and 4.3).

## 3.2 Biodiversity

Due to the land use associated with biomass feedstock cultivation, the protection of biodiversity is a core concern (Alterra 2010; CBD 2010; Ecorys 2009; UNEP-WCMC 2009).

The risk of negative effects strongly depending on location, agricultural and forestry practices, previous and indirect land-use, and the conversion systems used in the downstream chain (processing, distribution and consumption).

The international literature on protecting biodiversity (OEKO, IFEU 2010; OEKO, IFEU, CI 2010) as well as the sustainability indicators recently agreed on by the Global Bioenergy Partnership (GBEP 2011) focus on the following two key issues for risk-mitigation strategies:

- Conservation of **areas of significant biodiversity** value, and
- agricultural and forestry **practices** with low negative biodiversity impacts.

In that regard, land use from the cultivation stage is the most quantitatively relevant issue for biomass life-cycles.

Habitat loss as a result of direct and indirect land-use changes is the major threat to biodiversity, with over 80% of globally threatened birds, mammals and amphibians affected wholly or in part by habitat loss (IFEU/CI/OEKO 2012). Areas of significant biodiversity value are qualified through

- the presence of threatened or endemic species, and
- rare and threatened ecosystems.

These areas are particularly concentrated in the Tropics, but exist also in e.g. Europe, and North America.

Prominent factors causing the decline of biodiversity are deforestation, conversion of wetlands, habitat fragmentation and isolation, land-use intensification and overexploitation, invasive species and adverse climate-change impacts.

In order not to further increase this trend by incrementally cultivating dedicated bioenergy crops, it is necessary to protect high-biodiverse areas, including existing protection areas. The EU RED criteria on high biodiverse land are a good first step into this direction.

It is internationally acknowledged that protecting biodiversity in protected zones alone is insufficient to halt the decline of global biodiversity, and especially agro- and forest biodiversity. Thus, the land-use itself – i.e. the **cultivation practices and harvesting of biomass** – is an important issue: Monocultures, agrochemical use and extraction practices can threaten biodiversity, and even the use of residues can have significant impacts (Curran, Howes 2011; Riffell 2011).

With regard to non-food crops., specific activities to cultivate and harvest the feedstock and to manage agricultural have to be addressed in terms of their compatibility with biodiversity in general, and agrobiodiversity in particular.

Cultivation practices which are compatible are based on the following principles: Use of domestic species and local varieties, avoiding monocultures and invasive species, preferring perennial crops and intercropping, use of methods causing low erosion and machinery use, low fertilizer and pesticide use and avoiding active irrigation.

In addition, buffer zones must be established to protect sensitive areas, and corridors and stepping stone biotopes must be preserved on cultivated land in order to improve the exchange of species between habitats and movement along migration paths.

Thus, the relevant criterion – in addition to the conservation of highly biodiverse areas as already included in the EU RED – is to maintain agrobiodiversity, and the respective ecosystem services.

## 3.3 Emissions of Greenhouse Gases (GHG)

The majority of non-food crop uses (for either bioenergy or RRM) typically result in significant GHG savings compared to fossil-fuel or mineral based products – but only if no land use changes (LUC) are included in the analysis.

Most studies indicate that RRM delivers GHG reductions at least equal to 1$^{st}$ generation biofuels, and several RRM systems can have higher GHG benefits than 2$^{nd}$ generation biofuels.

Still, GHG emissions from **both direct and indirect LUC** can dramatically change this:

**Direct** LUC from converting e.g. tropical forests or peatland has GHG implications in the order of 10 t $CO_2$eq/ha/a which could completely offset any GHG saving compared to fossil-fuel products, and direct LUC from converting grassland could still imply some 2-3 t $CO_2$eq/ha/a, thus significantly diminishing potential GHG savings.

If arable land is converted to RRM production, **ILUC effects** could occur in the order of 3-5 t $CO_2$eq/ha/a which could again reduce most of the potential GHG benefits.

Thus, the GHG balance of non-food crop cultivation and harvest – both for bioenergy and RRM uses - is a key issue of concern. The respective criterion of net GHG reduction is already established in the EU RED with regard to liquid biofuels, but need to be extended to other bioenergy uses, and to RRM. A reduction level of 50% taking into account LUC-related effects should be considered in the near-term,.

## 3.4 Environmental risks from GMO

Risks related to the application of genetically modified organisms (GMO) must be evaluated prior to their application for RRM production.

A general assessment covering all GMO is not possible, but with respect to human health and safety as well as environmental risks, policy (CBD 2010) and scientific literature indicate that a **precautionary approach** is needed, distinguishing between "white" and "green" biotechnology[5].

Furthermore, an important determinant is how the public perceives GMO-related risks: with regard to the use of GMOs in agriculture, public attitudes in Europe seem to have stabilized in being critical (CC 2010).

Thus, the criterion for non-food crops with regard to GMO should be to avoid any "green biotechnology", based on the precautionary principle.

## 3.5 Soil Erosion and Productivity

Soils are the literal fundament of cultivating bioenergy feedstocks, and biomass for food, feed and fiber. Thus, ensuring and sustaining soil quality is fundamental for future productive use of land as well as for storing carbon, and for hydrological functions such as buffering and filtering.

Cultivating non-food crops can, similar to other agricultural production, directly lead to loss of topsoil, and can indirectly increase erosion by soil compaction. There are cultivation systems and practices which avoid erosion, though, and their application should become crucial for future biomass feedstock production. Thus, a "zero erosion" criterion is considered necessary.

To assure that the cultivation systems and practices maintain or improve soil quality, also the soil organic carbon content of land being used for feedstock cultivation must be at least maintained.

## 3.6 Water Availability and Quality

While land availability is the risk mentioned most frequently, freshwater resources can be a similar limiting factor not only for bioenergy (OEKO/IFEU/CI 2010), but also for RRM in general.

A significant share of the freshwater used for irrigation at the moment is wasted and improvements in management practices could free up some capacity in use at the moment (UNEP, OEKO, IEA BioT43 2011). Developing technologies requiring less water will also help (CC 2010).

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5 "White" biotechnology is the production of chemicals and fuels by application in fermentation and enzymatic processes – here, risks seem manageable if safeguards such as multiple barriers and containments as well as adequate waste treatment are applied. "Green" biotechnology comprehends (pre-)production of chemicals in agricultural crops and its risks are far more uncertain, as GMO from "engineered" crops could be released into the environment.

# 4 Social standards and criteria

Managing land competition between RRM for material or energy use and food and animal feed production is one of the key issues of a sustainable bio-based economy.

## 4.1 Food Security

Increased demand for RRM feedstocks can reduce the availability of food and feed crops when converting previously used arable land and the displacement will imply (global) price impacts[6].

For food **importing** countries, higher food prices on the world market will have at least short-term negative impacts on food security, while for food **exporting** countries, the higher prices can be helpful to increase income and, therefore, to reduce poverty and food insecurity.

Farmers, maximizing economic returns, respond by increasing the amount of land cultivated as well as the input application level while poor consumers will rationalize their food purchases.

The consequences of this development (raising prices of food, land, inputs, and increasing numbers of malnourished people) are likely to provoke counteracting reactions. Increasing production costs (and reduced demand) will force farmers to rationalize production (limiting land and input use) while policy makers may take action to restrict crop use for biofuel production (Langeveld 2010).

Also, higher food and feed prices will shift diets to less costly patterns, especially reducing dairy and meat consumption. This in turn will "dampen" the price increase and respective food impacts.

Taken these complex issues into account, food security is a key criterion which needs further consideration on the level of respective indicators.

It must be ensured that bioenergy feedstock production – even for non-food crops- does not directly worsen food security in the country or region where the bioenergy feedstock cultivation occurs.

## 4.2 Competition for land and water

Land use has not only effects on biodiversity and GHG emissions, but also direct and indirect implications in the social realm. The social use of land is

6 Although the intense discussion on food security implications is currently focused on the impacts of biofuel policies (see e.g., FAO 2011; FAO, OECD 2011; HFFA 2011), the issue is not restricted to this domain (nor bioenergy in general) – it is a generic problem of bio-based products if arable land, and edible crops are used as feedstocks.

primarily related to the theme of access to land, water and other natural re-resources.

Land access is a consequence of land tenure. From a social sustainability perspective, this might be one of the major concerns associated with bioenergy or biomaterials development in some areas (IFEU, CI, OEKO 2012).

## 4.3 Land Tenure and Land Access

The social sustainability of RRM development is directly related to changes in land tenure and access. In many developing countries no land market has been established. The local poor population grow agro-products (food and feed mainly) even without having any kind of legal title or security of the land used.

Similarly, permanent meadows and pasture lands are essential to communities' livelihoods that depend on breeding livestock and consuming livestock sub-products.

When arable lands and lands under permanent crop, permanent meadows and pastures and forest areas are given in concession or leased to private bioenergy investors, the local poor population might lose their capabilities to ensure their life subsistence.

Land to be leased by the state or a domestic authority and/or sold through one-to-one negotiations to individual or corporate investors for biofuel development will require some kind of formal contract or titles from the government. As land tenure as well as local community livelihood conditions are influenced by land customary rights, land acquisition for RRM development must acknowledge these conditions.

Foreign land acquisition is on the rise. The High Level Panel of Experts on Food Security and Nutrition formulated policy recommendations according to land tenure in the following three areas (HLPE 2011):

1. the respective roles of large-scale plantations and of small scale farming, including economic, social, gender and environmental impacts
2. reviewing the existing tools allowing the mapping of available land
3. comparative analysis of tools to align large scale investments with country food security strategies

The report reflects that many problems due to land investment could be dealt with through more effective enforcement of existing policy and legislation on national and local levels. Governments and investors get a better balance by differentiation in terms of sector, level and actors involved (HLPE 2011).

Similarly, the Global Bioenergy Partnership's sustainability indicators compromise land use and food security as key issues, and develop respective methodologies which are applicable also for RRM (GBEP 2011).

## 4.4 Healthy livelihoods and labor conditions

Human health and labour conditions are closely related, as workers occupied in crop cultivation and harvesting procedures can be exposed to human health risks from pesticides, emissions from burning fields, and occupational risks from e.g. accidents.

Therefore, the key labor standards and principles of the ILO Declaration on Fundamental Principles and Rights of Work should be seen as a key requirement to be met. This criterion will massively reduce possible negative impacts on the overall livelihoods of people living in biomass feedstock cultivation areas.

# 5 Implementing the sustainability standards and criteria

The long term growth potential for bio-based products will depend on their capacity to substitute fossil-based products and to satisfy various end-used requirements at a competitive cost, to create product cycles that are low in terms of GHG emissions and have lower environmental impacts, i.e. generating less waste, less energy and less water (UBA 2009).

The use of RRM has a good image in politics, industry and general public. This is based mainly on the perceived environmental, climate and resource protection, sustainability, health, security of supply through commodity diversification, innovation and employment benefits. This positive image should be used for improving the policy environment for material uses, and be linked to compliance with sustainability criteria (nova 2010).

The list of sustainability standards and criteria developed here should be **extended to the level of indicators**, similar to work already carried out for biofuels, and bioenergy. This step is needed for practical application, and stakeholders and possible future certification systems need the view from the level of economic operators.

# 6 Summary and Conclusions

From the previous analysis, the conclusions of this paper can be summarized as follows:

Non-food crops cultivated on **non**-arable land or land **not** in competition with food and feed production, and **not** interfering with nature protection and using land with low carbon soils are **favorable** options, but still social safeguards against land-tenure and land access related risks need consideration.

- **In general, edible crops such as maize and potato, and crops delivering edible oils do not qualify as sustainable options due to competition with food uses.**
- **Perennial crops seem more favorable than annual cultivation schemes, but biodiversity-related issues concern siting, and management practices.**
- **In that regard, fiber and specialty crops seem most favorable, while carbohydrate and oil crops need careful evaluation**.

A key concept to improve the overall sustainability of biomass use is the "cascading" concept: material use first, then recovering the energy content of used bio-based products. This would ensure a **high resource efficiency** in the use of renewable resources, and would start with single or multiple material uses (recycling economy) followed by energy use at the end of life. The secondary and waste streams are recycled as fully as possible and/or used for energy.

It is not yet possible to derive overall resource efficiency indicators for non-food crops without implying their use as either feedstock for biomaterials, bioenergy in general, or biofuels.

Thus, it is recommended to develop a **comprehensive scheme for the sustainability of biomass** in general which integrates the different markets, and allows for cross-sectoral application. This could foster the implementation of concepts such as cascading use if coupled to an incentive system (Carus et al. 2011; CC 2010).

The list of sustainability criteria for non-food crops presented here describe a framework of criteria and indicators which could be used in future RRM support schemes.

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