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Bioenergy and Biodiversity: Potential for Sustainable Use of Degraded Lands

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Content

1 Introduction and Overview

The use of biomass for energy production is rising globally in parallel to increasing oil prices, concerns on energy security, and climate change. Many countries recognize biomass as a domestic energy resource, and some see opportunities for exports of liquid biofuels (Best 2008).

With political goals of e.g., the EU to increase the use of biofuels in the transport sector from a current rate of 2% up to 10% in 2020, and domestic biofuel quota systems being introduced in many other countries as well (GBEP 2007), there is little doubt that biomass use for liquid transport fuels, as well as for electricity and heat production, will continue to rise in the future, and that global trade with bioenergy will rise in parallel. This will pose both opportunities and risks for sustainable development for regions, countries, and the world as a whole.

In this context, the Federal Environment Agency (UBA), on behalf of the German Ministry for Environment (BMU), is funding a research project on sustainable global biomass trade, carried out by Oeko-Institut and IFEU until end of 2009.

The project covers methodical aspects concerning climate protection, biodiversity, water and land use, but also aspects related to bioenergy trade and legal concerns (e.g., WTO, bilateral agreements). The project activity is paralleled by research carried out for EEA, FAO, and UNEP. A key element in that research is to consider and elaborate on opportunities for sustainable biomass feedstock provision which have no negative or even positive environmental, biodiversity, climate, and social trade-offs.

In this briefing paper, the research approach to be used to consider **degraded lands as such an option** is described. It draws from the results of an Expert Meeting on Biomass and Biodiversity held at the Isle of Vilm in March 2008 which was organized by BfN in collaboration with UBA, and Oeko-Institut.

Section 2 gives a brief summary of the background against which the research is structured. In Section 3, the overall conceptual framework for sustainable biomass is outlined, while in Section 4, the sub-project on degraded lands is presented briefly. Section 5 gives a short outlook to the next steps, and further work.

The authors wish to express their gratitude for the substantial funding of the work from the BMU/UBA, and appreciate further support from and collaboration with other organizations, especially EEA, FAO, and UNEP, as well as several non-governmental organizations (CI, CURES, IUCN, RSB, WWF).

Darmstadt, May 2008

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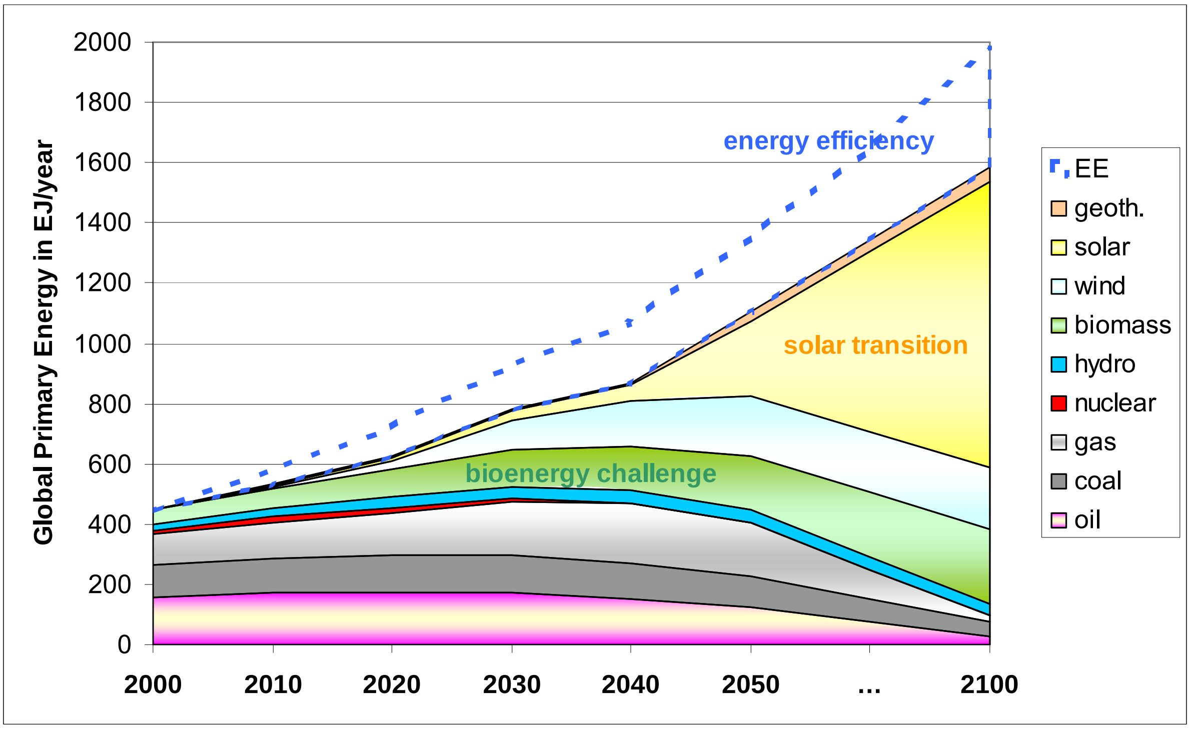
2 Background: Bioenergy and Global Energy Use

The role of biomass in future global energy provision has been analyzed quite well (see following figure), while the respective impacts in changing food, feed and fiber markets are yet under discussion.

Figure 1 A Sustainable Global Energy Vision



Source: IEA (2007), IPCC (2007), UNPD (2004) and WBGU (2003)

Bioenergy is seen by some to be a panacea for a range of energy, environment and poverty problems. However, the sustainability performance of bioenergy depends on where and how it is produced, processed, and used.

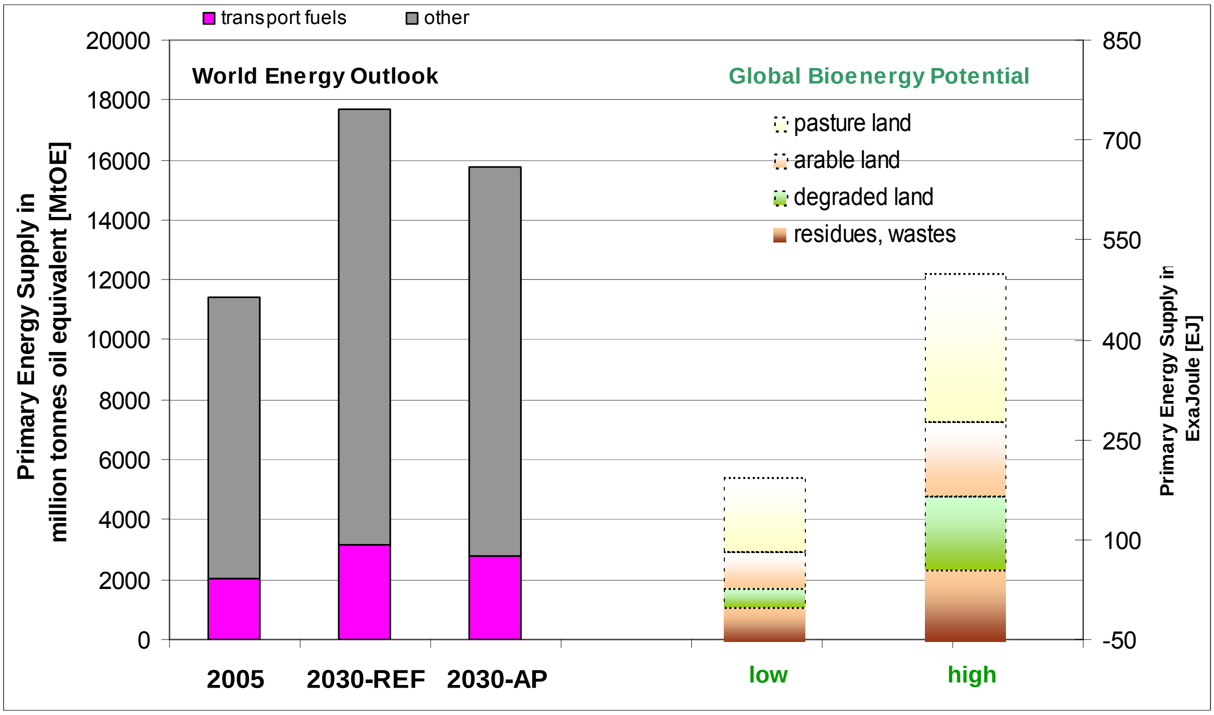
2.1 Sustainable Bioenergy Potentials

Given the substantial – though restricted – global potentials for sustainable provision of bioenergy, it **could** significantly contribute to transport fuel needs, and overall energy supply (see next figure). The sustainable potential of bioenergy depends on the developments in agriculture and forestry, as well as the overall dynamics of the food, feed and fiber markets. Its potential is further depending on the impact of global climate change, and the regionally differentiated adaptation measures to adjust to that change. One has to face a complex interaction of various driving forces, and massive feedback loops which make projections a matter of large uncertainty.

Still, current science allows to depict the **order of magnitude** to which bioenergy **could sustainably** contribute to the world's energy needs without compromising food, feed, and fiber requirements.

A **low** figure can be derived from pessimistic assumptions on agricultural productivity, moderate energy and high agricultural commodity prices, and severe climate change impacts on soils, and precipitation patterns. The **high** figure assumes optimistic values for productivity increases as well as high energy and agricultural commodity prices.

Figure 2 Global Energy Supply and Sustainable Bioenergy Potential



Source: own calculation based on IEA (2007) and Best et al. (2008)

Comparing the low end of the longer-term global sustainable bioenergy potential with current and projected transport fuel demands, and the high estimate with the total global energy supply needs as projected in IEA's World Energy Outlook underlines **the opportunities which sustainable bioenergy offers**:

It could supply **up to half** of the future transport fuel demand, or up to 35% of the overall global energy needs, taking into account conversion losses. The development of the bioenergy potential could increase income of exporting countries, and revenues for farmers and the forestry sector, favor rural job creation, and reduction of import bills for fossil fuels (UN Energy 2007).

The other side of those opportunities **is severe risk**: Since current biofuels stem from agricultural crops, arable land use competition, rising food prices and food insecurity (FAO 2008a), water resource depletion, and deforestation could arise (CBD 2008). Similarly, increased bioenergy from agricultural and forest residues, industrial wastes and even from marginal and degraded lands could impact on local communities, and negatively affect poor people as well as soils and biodiversity.

2.2 Environmental Issues of Bioenergy

Effects of bioenergy on the environment and natural resources can be either positive or negative, strongly depending on location, agricultural and forestry practices, previous land-use, and downstream conversion systems, including distribution and consumption. As current bioenergy – and especially liquid biofuels - production is closely related to agricultural crops, environmental impacts tend to be similar.

In the last decades, real prices for food and feed crops fell, and large land areas became either uneconomic for agricultural production, or were actively “set aside” through regulatory intervention in the European Union. In other areas, unsustainable cultivation practices have resulted in soil degradation and erosion, deterioration of natural habitats, and the energy intensity of agriculture and its respective carbon footprint rose significantly.

In a carbon-constrained future with both high energy and food/feed prices, paralleled by rising demands for food and feed, pressure on agriculture will be to intensify production, to reclaim land, to apply more efficient cultivation systems including conservation agriculture.

Depending on future global policies on climate change and biodiversity, agriculture could also develop business schemes for creating value out of biological carbon fixation, and for supporting biodiversity.

This is the scenario against which the environmental effects of future bioenergy production need to be considered.

Bioenergy offers significant opportunities to reduce greenhouse-gas emissions when replacing fossils fuels, provide low-sulfur biofuels which are biodegradable, and diversify plant varieties and cultivation practices, thus increasing agrobiodiversity.

Furthermore, bioenergy production could make use of perennial plants requiring less agrochemical and water inputs than traditional crops, and could help reduce soil erosion. In addition, bioenergy feedstocks could come from cultivating degraded land, and from agricultural, forestry, and other organic residues and wastes, thus relieving pressure on arable land, and respective price and land-use change impacts.

Depending on the developing path of bioenergy, the overall environmental impacts could be similar to agriculture, could add pressure, or could be positive. Furthermore, they depend on the production levels, scales, and conversion routes.

Large-scale bioenergy production bears the risk of trade-offs between e.g., GHG savings, and the protection of natural resources such as biodiversity, soil and water.

Small-scale, distributed provision of bioenergy could be less effective in terms of land productivity and GHG reduction per hectare, but might adjust better into ecosystems and landscapes, and might offer more (agro)biodiversity.

The promise of non-food ligno-cellulosic feedstocks and advanced biofuel production methods using forest, crop, and urban residues is yet a claim. The sustainability concerns as regard negative social and environmental impacts will **not** vanish even if advanced feedstock supply and conversion technology are commercialized and deployed in the market in the next decades, as these "2nd generation" biofuel will have to compete with biofuels from palm oil, and sugarcane, and their feedstock will still have to come from land, or residues.

2.2.1 Bioenergy and Nature: Land-Use Impacts on Biodiversity

Biodiversity is directly linked to properties and quality of habitats, and habitat loss is the most important threat to biodiversity[1]. Given the globally rising demand for biofuels, increasing amounts of land will be used for respective feedstock production which could both directly and indirectly result in further habitat loss if forest, grass, peat or wetlands are affected[2].

With the target to hold global biodiversity loss until 2010, there is an urgent need to protect land with high biodiversity value[3] and ecosystem services from further deterioration. In that regard, agricultural cultivation – for food, feed, fiber or fuel - needs to avoid such areas unless biomass extraction conforms to protecting or enhancing biodiversity. In other areas, cultivation practices should respect biodiversity and agrobiodiversity in using many varieties of crops, adequate rotation schemes, minimum agrochemicals, and include specific landscape elements[4].

2.2.2 Bioenergy and Land: Growing on Soils

Soil degradation, and especially soil erosion, can increase from annual bioenergy crops due to, e.g., tilling, excess irrigation, agrochemicals, and heavy farm equipment. In contrast, perennial bioenergy crops could improve soils and help to reduce erosion by creating year-round soil cover. For all cultivation systems, extraction of agricultural and forestry residues needs to reflect soil carbon and nutrient flows[5].

2.2.3 Bioenergy and Water: A Drain?

Rising agricultural water use is a serious concern, and competition for water between agriculture, urban land uses and nature could be increased by bioenergy production and processing. Agriculture is the most important user of water, accounting for more than 70% of total water withdrawals. Less than 10% of renewable water resources in developing countries were withdrawn for irrigation in the late 1990ies, but with large

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1 see Strand (2007), and Langhammer (2007); other prominent factors causing the decline of biodiversity are habitat fragmentation and isolation, land-use intensification and overexploitation, invasive species, and adverse climate change impacts - see e.g., Groom et al. (2006), and Lindenmayer//Fischer (2006).

2 see CBD (2008), and note that for small-scale production, cumulative effects need to be considered.

3 That is land qualifying as protected areas (www.unep-wcmc.org/wdpa/index.htm), areas of high conservation value (http://hcvnetwork.org/) and key biodiversity areas (Langhammer 2007).

4 e.g., ecological "stepping stones", migration and connecting corridors, buffer zones etc. (Groom et al. 2006).

5 see e.g., EEA (2007); FAO (2008b)

regional differences: 2% in sub-Saharan Africa, 1% in Latin America, but ⅓ in South Asia and more than half in the Near East/North Africa region.

Sustainable bioenergy production will have to balance water inputs with available surplus in natural flows, to apply efficient irrigation including re-use of treated wastewater, and to reduce agrochemical run-off[6].

2.2.4 Bioenergy and Climate Change: Closing Carbon Cycles

The greenhouse gas (GHG) balance of bioenergy has become an issue of intense discussion in media, science, business, and politics, driven by the increasingly acknowledged necessity to limit the use of fossil resources and to reduce GHG emissions from deforestation and other land-use change, as potential negative impacts of climate change caused by anthropogenic GHG emissions are severe[7].

One option to reduce GHG emissions – among others - is to increase the use of bioenergy. However, not all bioenergy carriers allow for greenhouse gas savings when compared to fossil fuel emissions. Especially where substantial amounts of nitrous oxide are emitted during the feedstock production, the bioenergy's advantage in terms of GHG can be reduced considerably or even become negative.

Furthermore, the life- cycle GHG balance of biofuels could become even more unfavorable if carbon-rich land is converted to cultivate energy crops and – as a direct consequence – both carbon from previous vegetation, and soil inventories are released. In these cases, it might take hundreds of years to "pay back" the carbon debt from savings in replacing fossil fuels.

This underlines that net GHG reductions need to be guaranteed for any future expansion of bioenergy, and in this, GHG emissions from land use change must receive special attention.

Nevertheless, many bioenergy systems bear a **high potential to reduce** GHG emissions:

Organic wastes and residues from agriculture, forestry, industry and households are **prime** options, as they offer very low GHG profiles, and do not induce risks for indirect land-use through displacement. Other possibilities are

- to develop low-input bioenergy cropping systems and the use of conservation agriculture practices;
- to sequester carbon in forests, grasslands and agroforestry systems using perennials, including short-rotation coppice plantations, and
- **degraded lands** for cultivation of bioenergy feedstocks without displacement risks.

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6 see for details: Royal Society (2008), and MNP (2007)

7 see for climate change impacts IPCC (2007); for food security FAO (2006); and for biodiversity CBD (2008).

3 Framework Concept: A Risk Mitigation Strategy for Sustainable Biomass

It is well known that biomass production for biofuels can have both positive and negative impacts on biodiversity (CBD 2008). The challenge is to mitigate negative effects and to promote the positive ones, especially those that arise from direct and indirect land-use change.

3.1 Protection of Natural Habitats

Protection Areas (PA) – defined through their legal status – are cornerstones of regional conservation strategies. They are dedicated to the protection of biodiversity, agrobiodiversity, and natural and associated cultural resources. These areas should represent the biodiversity of each region, and they should separate this biodiversity from processes like habitat loss, habitat fragmentation and isolation, land-use intensification and overexploitation as well as species invasions threatening its persistence, e.g., by enforcement of land-use restrictions.

As existing PA throughout the world contain only a biased sample of biodiversity, usually that of remote places and other areas unsuitable for commercial activities. Thus, they do not – as yet – come near to fulfilling global biodiversity commitments, nor the needs of species and ecosystems, given that a large number of these species, ecosystems and ecological processes are not adequately protected by the current PA network (Dudley/Phillips 2006).

To mitigate risks from bioenergy on biodiversity, areas need to be evaluated that are of importance for the protection of biodiversity, but that are currently not protected (e.g., gap analysis, PoWPA).

Both, PA and currently unprotected biodiversity-relevant areas need the same strict protection status in order to withstand additional land-use pressure occurring from biomass production.

Current legislation proposed by Germany and EU on sustainability requirements for biofuel feedstocks address this effort for PA and so-called Areas of High Natural Conservation Value (HNCV), that are characterized by a significant conservation value due to their high amount of natural recourses (biodiversity, ecosystem functions, etc.): Biomass used for biofuel production is not allowed to be grown in PA and HNCV, unless the biomass cultivation is in conformity with the protection objectives of the protected area in question. In addition, forests are not allowed to be converted to agricultural land or plantations.

3.2 Cultivation Practice for Biomass Production

Today, it is widely accepted that the implementation of conservation goals for the protection of biodiversity requires systematic planning strategies for managing landscapes, including areas allocated to both production and protection (Benedict/McMahon 2006, Groom et al. 2006). The CBD recognizes the limitations of PA as the sole tools for conservation, and promotes an Ecosystem Approach which seeks to mainstream biodiversity conservation into broader land- and seascape management (Smith/Maltby 2003, Dudley/Phillips 2006).

Also IAASTD (2008) stressed in its recent Synthesis Report that for successfully meeting development and sustainability goals, a fundamental shift in agriculture is needed that protect the natural resource base and the ecological provisioning of agricultural systems.

Cultivation practices which respect biodiversity and agrobiodiversity require broad varieties of plants, adequate rotation schemes, low-erosion land-use methods (e.g. no-till systems), and minimal agrochemical application. Furthermore, the inclusion of specific landscape elements (e.g., stepping stones, corridors, buffer zones etc.) in the cultivation area must be considered. In the EU, e.g., approaches for environmentally “compatible” biomass production systems which include biodiversity concerns have been suggested (EEA 2006+2007), but are still far from implementation.

Current legislation proposed by Germany and EU on sustainability requirement for biofuel feedstocks call for sustainable cultivation of agricultural land based on “good agricultural practice” as well as on the EU’s cross compliance scheme. To achieve the above mentioned aims, a strengthening of these tools is required, though.

3.3 Cultivation on degraded land and abandoned farmland

The cultivation of biomass on degraded land[8] or abandoned farmland (for economic, political or social reasons) can safeguard against negative **indirect** land-use change effects from bioenergy development (OEKO 2006; Searchinger 2008):

As **no displacement** of previous cultivation occurs, biomass production on these areas will **not** increase pressure on PA and unprotected biodiversity-relevant areas.

Thus, degraded land or abandoned farmland shall be prior biomass production areas, if they are neither sensitive to cultivation nor used by local people.

However, at least some of these areas might harbor high biodiversity and could belong either to PA or other biodiversity-relevant areas, and the regeneration of several areas of degraded land toward natural habitats may be more beneficial, and the status of these areas needs to be evaluated carefully.

8 Degraded land comprises former suitable (used) land that has been turned in unsuitable land by a degradation process that is not any more used for agriculture and other (land associated) human activities (Oldemann et al. 1991). Degraded land still has the potential to be restored by adequate measures.

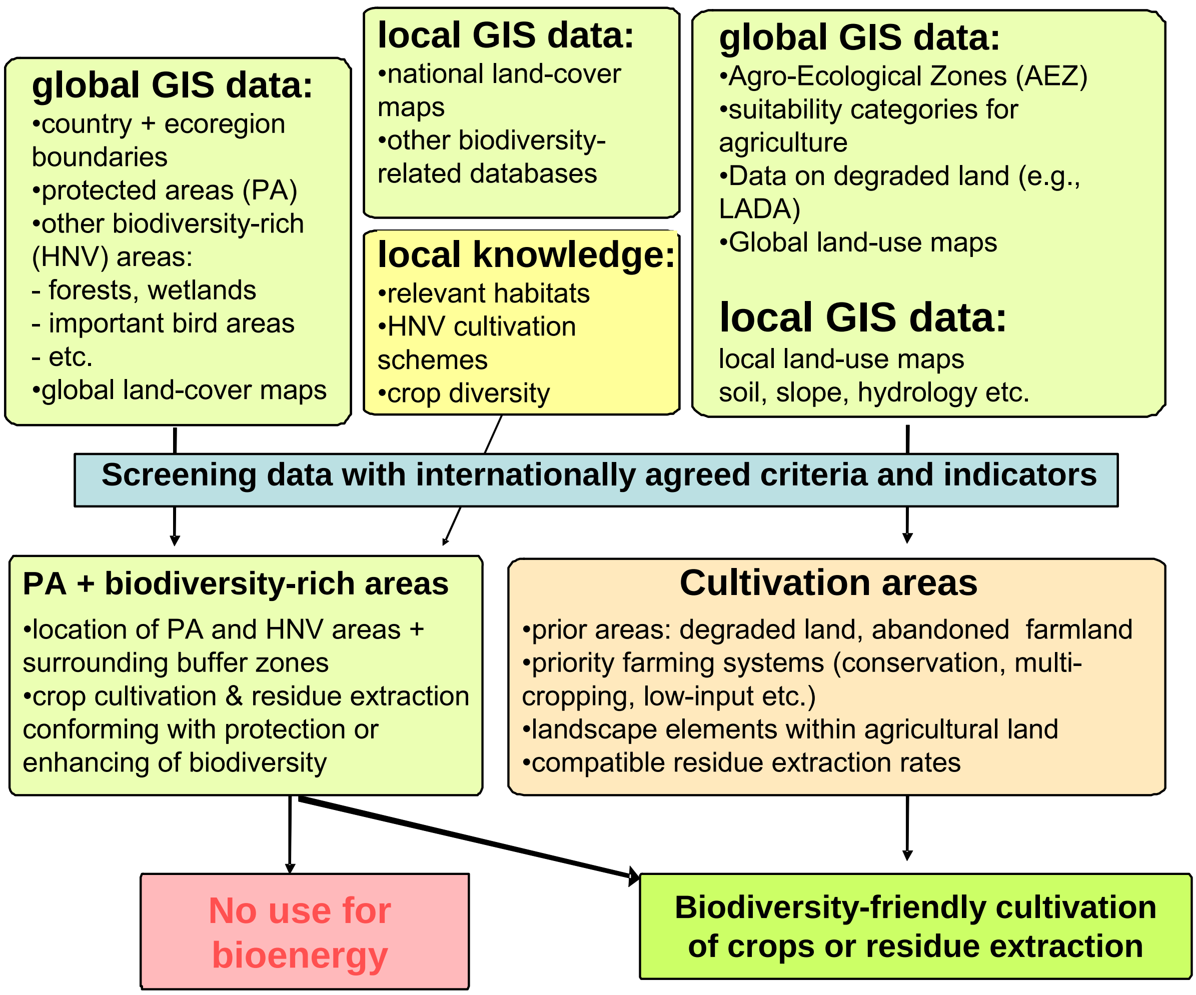
3.4 Conceptual Framework for Biodiversity-Compatible Bioenergy

The aim of the framework on sustainable biomass production (Figure 1) is to **mitigate risks**. Land is categorized in areas where no bioenergy should come from, and those were biodiversity-friendly bioenergy production or residual extraction is possible.

In a first step, relevant data need to be collected on global, national and local scales. A focus should be set on the characterization of areas relevant for the protection of biodiversity as well as on environmentally "compatible" practices for biomass production. These information need to be stored in a comprehensive GIS-database.

In a second step, PA and biodiversity-relevant areas as well as prior bioenergy cultivation systems (including landscape structure) and residual extraction with low negative or positive impacts on biodiversity need to be identified. This screening, however, must be based on (internationally accepted) criteria and indicators.

Figure 1 Framework to identify the location of PA and HNV as well as cultivation practices that are in line with the protection of biodiversity



Source: FAO (2008b)

3.5 Limitations of the Framework

There are two main limitations of the conceptual framework:

- missing of internationally accepted criteria and indicators as well as missing of several required data, and
- unknown bias in applying GIS-based screening with regard to local conditions ("hot spots", and social aspects).

Setting up criteria and indicators is – nationally as well as internationally – still in process[9]. Their sound preparation and international acceptance is the basis for the implementation of sustainability. This will be the largest challenge and prior work for the further development of the framework that should be embedded in existing international processes, especially CBD (see CBD 2008).

Several global and local data exist that can directly used in within the framework like information on the location of natural habitats[10] and data on land-cover, degradation and environmental suitability of land for agriculture. Though many data are available, many of them have a to course resolution to be informative enough for the planned framework, or they do not directly cover its scope.

A next step forward would be to apply the framework for example countries draw up what is possible with existing data and what is not, followed by the collection of additionally required data.

But even if agreed criteria and indicators and all spatial data would be available for a "screening" of land with regard to its biodiversity relevance, the second limitation needs to be considered. Local "hot spots" of biodiversity might easily be overlooked, and the **social situation** regarding land-**use** is of importance for sustainability as well.

Therefore, stakeholder involvement and "bottom-up" knowledge from the ground are required to make the conceptual framework a sound tool for sustainability.

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9 See, e.g., activities from Round Table on Responsible Soy (RTRS), UK Renewable Transport Fuel Obligation (RTFO), Netherlands biofuels sustainability standard, Roundtable on Sustainable Biofuels (RSB), proposed EU legislation and respective work of the European Parliament and of the EU Council.

10 Examples for datasets regarding natural habitats are the World Database on Protected Areas (WDPA), Ecoregions from the WWF, biodiversity-relevant areas like Alliance for Zero Extinction (AZE), Important Bird Areas (IBA), Important Plant Areas (IPA), as well as Key Biodiversity areas (KBA), FAO maps of forests, and the Global Lakes and Wetlands Database.

4 Evaluating the Sustainable Potential of Degraded Land for Bioenergy Provision

4.1 Global Potential of Degraded Land

Following on the conceptual framework, the sub-project on degraded land will first identify where and to what extend GIS-based data on land cover and land use is available from which regionalized considerations on geographical situation and scope of degraded land can be derived.

For that, resolution, refresh cycles, costs and access to the data are relevant as well as their compatibility with other data used to identify and characterize sustainable biomass.

Based on that, a **quantitative estimate** of the global potential of degraded land will be carried out. This analysis will apply the “counter-flow” principle, i.e. it will make use of both top-down and bottom-up approaches:

- Finding, evaluating and compiling GIS-based **global data bases** on soil characteristics and land cover in international organizations (especially FAO, IIASA) and European (EEA, JRC-Ispra) and US-American (e.g. NASA) and Brazilian (EMPREPA) and South-African (University of Zulu-Nataal; bmbf-BIOTA-project) research institutions. This is done through Internet und literature research and existing project contacts (e.g., to the EU COMPETE project) and meetings with relevant organizations, especially

    - JRC (Ispra), FAO (Rome) and IIASA (Laxenburg) to agree on access to and review of data repositories
    - EEA (Copenhagen) und US-DOE (Washington) to discuss joint work on the issue of “biodiversity mapping“

- The result will be a global data framework which is methodologically consistent and can be updated.
- Cooperation with selected research partners in

    - Africa (e.g., ERC and University of Zulu-Nataal, South Africa; FAO BEFS and BIAS projects in Tanzania)
    - Asia (TERI India and GTZ-/CIM projects in India and China), and
    - Latin America (e.g., INTA in Argentina, CENBIO/EMPREPA in Brazil).

    to **regionally identify** and quantify land cover, and land use. This will be compiled in brief result papers and materials to substantiate the approach with regional and local data, including information to potentially applicable plants and cultivation schemes for biomass on degraded lands.

4.2 Sustainability Issues of Degraded Land: Biodiversity, and Social Aspects

As a part of the global (top-down) and regional (bottom-up) analysis, the biodiversity-relevant areas will be identified in parallel to allow for **an overlay** of the theoretical potential with those areas to identify and "map" areas of concern.

In that regard, ongoing work in the project on HNCV criteria and indicators will be used, and discussed during international workshops with CI, IUCN, UNEP, and WWF, among others.

During the regional quantification of potentials, the social issues (positive and negative impact on local population) will be considered, and – in collaboration with CURES and RSB – discussed further.

The results will be critically reflected during workshops and expert discussions with various partners (e.g., ALTERRA, FAL, FAO, OECD, Wageningen Univ.,) and projects (e.g. EU-COMPETE).

4.3 Cultivation Systems and Costs for Using Degraded Lands for Bioenergy Production

A relevant reseach issue which is not resolved yet is the question of adequate cultivation systems for degraded land, with subsequent questions on yields, inputs and costs, as well as potential environmental impacts. As the respective data are regionally different, they will be defined for three or four typical model cases. For that, socio-economic issues are relevant also, especially land-use rights, and infrastructure requirements.

4.4 Calculation of the Global Bioenergy Potential from Degraded Land

With the results from the "bottom-up" and "top-down" potentials of degraded lands and the respective constraints from biodiversity, and social impacts. a scale-up computation of the potential global bioenergy feedstock supply and its regional distribution will be carried out. For that, the biodiversity-relevant areas will be excluded from the potentials, and social constraints will be marked as well.

These results will be compared with outcomes from other work (literature, ongoing projects), and respective conclusions for the validity of the approach and the data will be drawn, including considerations for further work.

5 Implementing the Research, and Further Steps

The sub-project on sustainable bioenergy potentials from degraded land will start in June 2008, and will run for one year.

Collaborating partners will be identified in the first month of the work, and a kickoff-meeting is scheduled to take place on July 1 at UNEP in Paris.

Subsequent workshops will be held in Fall and Winter 2008, and Spring 2009.

Through a project website, material will be made available to the public, and communication of respective events will be allowed.

In the first two months of the sub-project work, options for collaboration with similar activities especially on the EU level, in the USA, and from international organizations will be identified, and agreements of cooperation will be sought.

As criteria and indicators for biodiversity-relevant areas are of key concern for the work on spatial mapping, an **initial international workshop** on that issue will be held in cooperation with CI, CURES, IUCN, RSB, UNEP, and WWF at the **UNEP Center in Paris on June 30**, 2008, followed by the kick-off meeting on degraded lands on July 1, 2008.

Through its cooperation with the FAO BEFS and BIAS projects, Tanzania has been identified already as on of the “bottom-up” case country, and respective partners will be sought in the next weeks.

The overall partner structure is under development, and the project team would appreciate if donor agencies would consider further collaboration in that regard.

Interested parties are encouraged to contact the project management for further information:

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Abbreviations

AZE	Alliance for Zero Extinction
BfN	German Federal Agency for Nature Protection (Bundesamt für Naturschutz)
BMU	German Federal Ministry for Environment, Nature Protection, and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit)
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CI	Conservation International
CURES	Citizens United for Renewable Energy
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FSC	Forest Stewardship Council
GIS	Geographical information system (with digital spatial database)
GLC 2000	Global Land Cover 2000
HNVC	High Nature Conservation Value
IUCN	International Union for the Conservation of Nature and Natural Resources
KBA	Key Biodiversity Areas
NGO	Non-governmental organization
OEKO	Öko-Institut (Institute for applied Ecology)
PA	Protected Area
PoWPA	Programme of Work on Protected Areas
UBA	German Federal Environment Agency (Umweltbundesamt)
WCMC	UN World Conservation Monitoring Centre
WWF	World-Wide Fund for Nature