Balancing Bioenergy Production and Nature Conservation in Germany: Potential Synergies and Challenges

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The production of biomass for energy has emerged into a new, important market for agriculture in Germany. As climate protection remains the main objective for renewable energy production, the assessment and reduction of its environmental impacts are becoming increasingly important.

This assessment requires the development and application of specific indicators to enable comparisons between different production methods. As long as primary crops remain the same as those being used for food production, the exact impacts of bioenergy production do not clearly differ from other agricultural production. A case-study carried out in Lower Saxony shows that additional impacts arise only when either new production methods are applied or new crops are being taken into production.

In general, the production of biomass needs to be subject to the same standards that are being applied for food production or other commodities to ensure that biomass production does not serve as a scapegoat for all environmental problems associated with agriculture. Those standards should be defined by good farming practice or cross-compliance regulations. A consistent implementation and execution of existing standards would already result in major improvements, therefore pointing out another important priority for agricultural policy.

keywords: biomass, bioenergy, conservation, climate change, mitigation

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1. Introduction

The release of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) in 2007 has put climate change on the political agenda throughout the world. As a consequence, the two strategic policy options of mitigation and adaptation are becoming increasingly important. Mitigation describes all efforts to curtail total greenhouse gas (GHG) emissions such as CO_2 whereas adaptation includes all measures to reduce the impacts of climate change (cp. IPCC 2007 a, b). Renewable energies are generally an important contributor to reducing GHG emissions, and they also play a key role in replacing fossil fuels in the energy and transport sector. Thus, the demand in the biomass and biofuel sectors has tremendously increased - specifically in Europe and North America - over the last couple of years. This development was partially triggered by attractive financial incentives provided by the EU (aid for energy crops based on Council Regulation 1973/2004) and sometimes national governments (in Germany: Renewable Energy Sources Act, granting a 6 cent bonus per kWh generated) to develop this emerging market. Combined with other external factors such as the crop failure in Australia in 2007, these developments have helped the agricultural sector in Europe to regain strength.

Besides increasing consumer prices, the agricultural boom has also lead to a renewed debate about environmental impacts of more intensified production methods. In Germany, agriculture has always been a major contributor to excessive nitrogen loads in water and soils (RODE ET AL. 2005). Now, the objective to further reduce the environmental impact of agriculture becomes even more complex with the addition of climate protection objectives to the agenda. Currently, agriculture in Germany contributes to about 13 % of all GHG emissions (BMELV 2007: 47). With the impacts of intensive agriculture already well-described, the focus of attention from a nature conservation perspective should be directed towards three important issues:

1. In those areas with existing intensive agriculture - regardless whether crop production is for food or energy - the environmental impacts need further reduction while potential synergies with nature conservation should be fostered. The current changes in agricultural practices, caused by the increase in bioenergy production and the current debate about further reforms in the EU's Common Agricul-

tural Policy (CAP) (EUROPEAN COMMISSION 2008a), provide an opportunity for such a shift.

2. Even more important is a closer look at those environmentally sensitive areas that produced only marginal yields in the past, but are now being taken back into production due to high demand for arable land. This includes the obligatory set-aside areas in Europe which - although they were never designed as an agri-environmental measure - provided for additional habitats. These and other low yield areas usually contain a higher abundance of species due to less intensive production methods. These areas are more critical than the intensively used agricultural area when it comes to reaching environmental objectives on EU (NATURA 2000) and national levels. The limitation of environmental impacts, maybe even the exemption of these areas from agricultural production should be considered a top priority when balancing climate protection, bioenergy production and nature conservation objectives.
3. Coupled with this is the integration of all environmental impacts of individual agricultural production methods into life cycle assessments (LCA). This includes all different bioenergy production methods which at the same time should not be used as a scapegoat for all problems concerning the environmental impacts of agriculture as current changes in the agricultural sector are not only caused by an expanding bioenergy sector.

This paper discusses the potential impacts of an increased agricultural biomass production on the environment and proposes a set of indicators that enable a better, comprehensive inclusion of the aforementioned impacts on biodiversity, landscape functions and the environment in LCAs, exemplified for biomass production.

2. The Role of Biomass in Germany's Integrated Climate and Energy Policy

In principle, the use and production of biomass as a source of renewable energy has a potential for benefiting climate protection and nature conservation efforts. Overall, environmental concerns are only one component in a very complex discussion that also includes the fields of energy and food security, agricultural income or the future of rural areas in Europe (cp. WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK 2007). The two latter arguments are of lesser importance in this debate though as a vast number of other, more efficient measures to tackle these problems exist on European and national levels (such as the EAFRD funding schemes). Additionally, any agricultural policy that aims at price support for agricultural products must be considered a relapse behind the achievements of the EU's CAP 2003 reform.

Several comprehensive studies such as SRU 2007 and WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK 2007 have concluded that in terms of energy security, physical shortages of supply will not be relevant for the next few decades. Improving the economical facet of energy security will most likely not be achieved by bioenergy because of limited domestic resource potentials and the current unlikelihood of a full integration of sustainability criteria into imported biomass (HOOIJER ET AL. 2006, FARGIONE ET AL. 2008, REIJNDERS & HUIJBREGTS 2008). Under consideration of these arguments, the guiding principle and baseline assessment criteria for bioenergy policy should be its optimization under a clear priority of climate protection targets (cp. SRU 2007 # 115, WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK 2007: 218).

The German government has acknowledged a high priority to climate protection efforts. The recently adopted integrated climate protection and energy policy calls for a 40 % reduction of CO_2 emissions until 2020 compared to 1990 levels (BMWi & BMU 2007). The target will be achieved through the enhancement of energy efficiency and further investments into the renewable energies sector (cp. BMU 2007a). Increasing the renewables' share in Germany's primary energy demand from currently 5,3 % (2006) to 20 % in the year 2020 is one of the key pillars of the strategy. This target is compliant with the EU's targets for this sector (EUROPEAN COMMISSION 2008b). The overall 20 % target will be distributed to the different use groups: according to the government's plans, renewables will provide for 25-30 % of the electricity, 14 % in the heat sector, 17 % in the fuel sector and for 6 % in the biogas sector. Nevertheless, these targets are only feasible through a massive expansion of renewable energy sources. Biomass, which currently holds a 71 % share in the renewable energy supply markets, will thus continue to play a leading role in the future (FNR 2008a, KTBL 2006).

3. Renewable Energies and Bioenergy Crops: Climate Protection Potentials

While renewable energy sources offer various opportunities for climate-friendly energy production, they are not per se climate-neutral nor environmentally friendly (DOYLE ET AL. 2007: 529). Thus, it is mandatory to substitute conventional energy sources only with such that have been proved to actually contribute to the reduction of GHG emissions. The international standard for this are life cycle assessments (LCA) according to DIN EN ISO 14040 and 14044. The methodological complexity of LCAs leads to innate limitations, but these problems have been well-known for years (cp. GUINÉE 2002: 8). Despite this fact, a number of LCAs for bioenergy utilization still show a number of shortfalls (for comparison, see table 3-1 in SRU 2007: 44). While many case studies are already non-inclusive in regards to the simple direct environmental impacts on soil, water and air, they also neither include GHG emissions nor land use changes resulting from an increased demand for arable land. Current research (e.g. SEARCHINGER ET AL. 2008; CRUTZEN ET AL. 2007) seems to indicate that these processes release additional critical amounts of GHG, thus the true emissions savings potential (or contribution) remains unclear. Additionally, the monetary valuation of impacted environmental services such as biodiversity, recreational value or other landscape functions remains another complex problem which requires additional scientific research.

4. Biomass Production in Germany: Current and Potential Ecological Impacts

The area under cultivation for renewable energies in Germany has recently seen a significant increase. The figure has picked up from roughly 400 000 hectares in 1997 to a fivefold area of about 2044 million hectares in 2007 (FNR 2008a), thus accounting for 12 % of the utilized agricultural area (UAA). A further increase seems immanent, although the overall dimensions are associated with uncertainty due to the current volatility of agricultural markets. Several scenario studies forecast a potential between 2,5 and 7,3 million hectares by the year 2030 (FRITSCHE ET AL. 2004, NITSCH ET AL. 2004, THRÄN ET AL. 2005, EEA 2006), with an area of three to four million hectares by 2030 being the most realistic scenario (SRU 2008a: 5). This would equal one quarter of Germany's UAA. These areal limitations consequently result in further limits in regards to the maximum contribution of bioenergy (domestic production) to the primary energy demand which - with some technology advancement - would settle around 10 % by 2030 (SRU 2007 # 14).

To reach these ambitious goals, biomass production for energy requires an increase in agricultural productivity in the long run. But already at the current levels, these developments have heavily contributed to an intensification of agricultural cultivation in certain areas. In the East German state of Mecklenburg - West Pomerania, the agricultural ministry voiced concerns as early as 2004 that the rape seed cultivations were reaching their limit for the state (MELFF 2004). Nevertheless, since then, the agricultural area utilized for rape seed has increased by another 18 000 hectares to 250 000 hectares. This indicates that agricultural practises still intensify in certain areas despite contrary research results.

The pressure on ecosystems and biodiversity is also increased by two additional recent developments. First of all, the EU abolished all regulations for obligatory set-asides for 2008 in order to allow farmers access to more agricultural area, primarily for wheat production. Although never designed as an agri-environmental measure, the set-asides greatly benefited agrobiodiversity and endangered species, especially many bird species that used these areas as nesting and feeding habitats (DZIEWIATY ET AL. 2007: 88*)*.

Secondly, the considerable increase in grassland ploughing has severe impacts on those species that already suffer the most from changing agricultural practices (e.g. Northern Lapwing, European Curlew or Black-tailed Godwit) (cp. SUDFELDT ET AL. 2007: 12). Grassland ploughing, even in protected areas and partially illegal, has been well documented throughout Germany (e.g. NABU 2007). On the Eiderstedt peninsula, an Important Bird Area (IBA), the grassland areas have decreased by nine percent between 2000 and 2007. Simultaneously, additional drainage measures to improve agricultural cultivation conditions were applied (NEHLS 2007). Thus, several pressures were impacting the area at the same time, leading to an all-time low of Black Tern nesting pairs in 2007 (ibid.).

According to EU cross-compliance regulations, grassland ploughing becomes subject to registration and approval when reaching a more than 5 % loss on the basis of the reference area for 2003. While this threshold has been exceeded by far on a local level, the figures are being compiled on state level. Currently, three states (Mecklenburg - West Pomerania (- 4,8 %), Schleswig-Holstein (-4,6 %) and North Rhine-Westphalia (-4,2 %) are steadily approaching this threshold (SRU 2008b, table 5-1). The figures indicate that grassland losses have accelerated in 2006 and 2007.

Rising world market prices for many commodities have also lead to a problem in regards to the attractiveness of agri-environmental measures (AEM) for farmers. Premiums can no longer compete with revenues from crop production. In the state of Lower Saxony, 20 % of the arable land signed up for AEM were taken back into production in early 2007, leading to a loss of another 1500 hectares.

Additionally, the bioenergy boom does bring along socio-economic disadvantages on a national level, too. Land leases in bioenergy boom regions (e.g. Rotenburg, oder Soltau-Fallingbostel counties in Lower Saxony) have increased threefold between 2003 and 2006, thus neutralizing additional revenue generated from higher market prices for many famers (cp. BAHRS & HELD 2007).

5. Ecological Optimization of Biomass Production

The production of biomass for energy has emerged into a new, important market for agriculture. Thus, the reduction of its environmental impacts are becoming increasingly important as the main objective remains climate protection and thus an environmental benefit. Postive and negative effects may occur: changes in agricultural production patterns can lead to a diversification in crop rotation and to an improved, site-adapted cultivation. Several research projects in Germany are currently investigating in new crops for biogas production such as oil radish, Sudan grass, alfalfa, clover grass, and the use of oat or autumn-sown tricitale for whole plant silage (FNR 2008b). The chamber of agriculture in Lower Saxony also tries to increase the utilization of weeds and a combination of corn and sunflower in its SUNREG I project, including potential improvements of cultivation methods in regards to their environmental impact (crop combination, alternative harvesting dates, soil cultivation methods, fertilization, pest management, etc.) (LWK Niedersachsen 2007).

Despite these efforts, the diversity of crops being used remains limited: biogas plants currently mainly use corn, cereals or cereal-based whole plant silage for biogas production (KTBL 2007: 48). Additionally, rape is of importance for the production of plant oil and biodiesel whereas sugar beets, cereals and corn are mainly used for ethanol production (FNR 2008a). As long as primary crops remain the same as those being used for food production, the exact impacts of bioenergy production do not clearly differ from other agricultural production. The production of bioenergy crops leads to similar effects as food and livestock feed production when combining the interrelated agricultural production methods with site-specific susceptibility.

In conclusion, no general statements about environmental impacts of bioenergy crop production can be derived. Instead, in order to be able to assess the impact, it is important to analyse individual cultivation and production methods on a small scale, taking the site-specific susceptibility into account. Additional impacts that result directly from bioenergy crop production arise only when either new production methods are applied or new crops are being taken into production. An exemplary case could be corn that is introduced into crop rotation in an area that is traditionally considered a cereals production region. Additionally, the cultivation of newly-bred crops such as millet or Sudan grass could become increasingly important in the future.

6. Integrating Additional Environmental Indicators in LCAs

In order to assess the environmental impacts of such new crop rotations, a number of indicators will have to be analysed. The most important impact factors from agricultural land use are the intensity of tillage, the use of fertilizers and pesticides, water consumption and changes in crop development throughout the harvesting season (cp. table 1).

Accumulated information about every specific cultivation method allow for an in-depth analysis of the environmental impacts. The probability if and to what degree these impacts essentially occur can only be estimated in combination with site-specific information about sensitivity and vulnerability as stipulated in the methodology of ecological risk assessment (v. Haaren 2004: 97).

Table 1: Impacts and monitoring indicators for agricultural land use

Impact factor	Indicator
machinery usage	machine use frequency machinery type (weight, width)
pest management	type of pest management application time application frequency application range
fertilization	fertilizer type and combination application time apllication method nutrient balance
humus balance	humus requirements for crop / crop rotation humus reproduction from organic fertilizersr
water consumption	quantity of water consumption season of demand
soil cover	tillage methods tillage intensity tillage time point of time with highest soil cover harvest time
crop development	sowing season distance between grains / soil cover growing season height of crop crop layering harvest time

A specific cultivation method's environmental impacts are closely related to those functions and services that are provided by natural resources and landscape. (VON HAAREN 2004: 81). The interrelatedness of single impacts may influence a number of natural resources or their functions, or, vice versa, a single function may be impacted through the accumulated affects from numerous impact factors. Table 2 illustrates the interrelationship between agricultural uses and the natural environment's functions.

Table 2: Interrelationship between agriculture and natural environment

	Environmental Function						
Impact Factor	repository capacity	natural crop yield	water yield/supply	retention capacity	climatic balance	habitat allocation	recreational value
machinery use	x	x	x	x		x	
pest management			x			x	x
fertilization	x	x	x			x	x
humus balance	x	x	x	x		x	x
water consumption		x	x	x		x	
soil cover	x	x		x	x	x	x
crop development	x	x	x	x		x	x
x = impact expected/likely							

Several established methods exist to assess impacts on soil, water, air and climate if necessary data is collected and analysed, whereas valid conclusions in regards to habitat allocation can only be drawn in reference to prior land use or cultivation methods. This is due to the fact that new crops could lead to changes in species composition, but not flat-out to a decrease in biodiversity. Just as well, changes in the recreational value cannot be evaluated as positive or negative on an absolute scale, but only in comparison to its former e.g. scenery or recreational value.

7. Case Study: Indicator Application to Rye and Corn Cultivation in Lower Saxony

If this methodology is applied to the cultivation of autumn-sown rye for whole plant silage for biogas production in Lower Saxony, significant differences compared to cultivation for food or livestock feed become apparent. [1]Tilling and sowing occur at the same time, as there is no difference in the seed density applied to the acre. Because the nutrient demand for silage rye is lower (except for potassium), fertilizer applications during the vegetation period have been reduced from formerly three applications in March, April and May to two applications in March and April. [2]Further differences exist in regards to pesticide application. While silage rye received only two herbicide and fungicide applications in March, rye for food receives six applications of herbicides, fungicides, insecticides and other pesticides between March and May. Harvest time for silage rye is in May, whereas food rye harvest does not start until the end of July.

The comparison of these two cultivation methods shows that the risk of nutrient and pesticide leaching is lower for silage rye. Impacts on agricultural habitats will differ as well, but have to be assessed on a species level. Because of a lower treatment frequency, silage rye acres are less disturbed during the nesting season in April and May, which can have positive effects on birds with early nesting seasons such as grey partridge, yellow wagtail or skylark. On the other hand, the earlier harvest

[1] Initial data for the analysis was provided by SUNREG I.

[2] According to SUNREG however, pre-fertilizing is applied in February.

season results in the loss of nests and fledglings for species such as corn bunting, ortolan or quail (DZIEWIATY ET AL. 2007: 87).

Corn currently remains the most important crop for biogas and is used as a coferment in more than 90 % of biogas plants built after 2004 (Weiland 2006). Cultivation methods for biogas corn production are similar to those for livestock feed. The only difference occurs in the harvesting season as corn for biogas is harvested until November. The late-season machinery use can also result in heavier soil compaction because of likely moister soil. Overall though, the impacts remain insignificant. The impracticality to differentiate between cultivation for bioenergy or food/livestock feed applies to rape as well. Because of these little differences for corn and rape, environmental impacts from these cultivations on a site-specific scale are unlikely to vary.

On the other hand, heavy impacts can be expected in those regions were corn and rape will be added to the crop rotation. Besides impacts on soil (higher erosion risk in row cultivations, soil compaction due to numerous applications) and water (pesticide and nutrient leaching in ground and surface water due to more applications, water consumption because of high biomass productivity), these crops also introduce significant changes - in comparison to cereals - to agricultural habitats and the recreational value through a different scenery.

Whether this impact will be assessed as positive or negative depends on both crop diversity and crop percentage and distribution in a specific region. If corn production leads to the loss of bird habitats (cp. DZIEWIATY ET AL 2007: 86), the impact is negative if neighbouring areas do not provide alternate habitats. However, the negative impact can be reduced if surrounding areas feature a high crop diversity, and as the case may be corn could have a positive impact on habitat allocation and recreational value in this case.

Economic assessements of current research projects and advancements in crop breeding will show to what degree crops like sorghum or sunflower can be used to extend crop rotation. These crops are being considered applicable for biogas production and need to be assessed for the environmental impacts. As their general cultivation is somewhat similar to that of corn, analogue impacts from machinery use, fertilization, soil cover and crop development are expected.

8. Conclusions

Due to the problems associated with a clear distinction between environmental impacts resulting from bioenergy, food or livestock feed production, the general reduction of environmental impacts caused by the agricultural sector must remain a core policy objective (cp. SRU 2007 # 60 et sqq.). The case study illustrates that environmental impacts of bioenergy production in comparison to other cultivation methods need to be assessed on a cultivation and site-specific scale, resulting in complex, but necessary procedures for LCAs. Indicators to assess impacts will need further enhancement as the underlying processes are often complex and interrelated. In general, the immanent changes in the EU's agricultural policy should be used to further integrate environmental issues into agricultural practice. This should include the compensation (at competitive rates) for delivering public goods, as many farmers already do. In regards to the climate protection objectives, biomass production needs to become more efficient, including the utilization of synergies with nature conservation, thus emphasizing the true multifunctionality of agriculture in Europe. If environmental standards are further incorporated into agricultural practice, sustainable use forms of bioenergy production need be developed.

As a matter of principle, the production of biomass needs to be subject to the same standards that are being applied for food production or other commodities to ensure that biomass production does not serve as a scapegoat for all environmental problems associated with agriculture. Those standards should be defined by good farming practice or cross-compliance regulations. A consistent implementation and execution of existing standards would already result in major improvements, therefore pointing out another important priority for agricultural policy.

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