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Exploring the potential of reed as a bioenergy crop in the Netherlands

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ABSTRACT

Second-generation biofuels that produce biomass for combustion or ethanol production do not yet appear to be a viable alternative to agriculture as they are low-value products. This may change, however, when energy prices increase and their production is combined with the provision of other services. The current analysis explores the potential for the production of an often overlooked biomass feedstock that can be combined with water and nature management objectives: reed. This crop has the additional advantage that it can be grown under conditions that are unfavourable to most other crops. An economics-based land-use modelling approach is applied to simulate the local competition between reed and grassland used for dairy farming under four different future scenarios in the Netherlands. Based on a location-specific assessment of potential costs and benefits of these crops under scenario-based conditions this analysis shows that the cultivation of reed for bioenergy, in combination with providing additional land-use functions, while not viable option under current economic and political conditions, may become competitive within the next twenty years if any of the following developments occur: energy prices increase substantially; water tables rise in the low-lying western parts of the country due to climate change; a policy is implemented that increases bioenergy prices; or a policy is implemented that stimulates water buffering and the preservation of peat soils.

1. Introduction: demand and supply of bioenergy

Demand for bioenergy in Europe will expand considerably in the years to come. The EU Directive on Renewable Energy of 2009 requires that 20% of all energy consumed in the EU and 10% of all transport fuel should be renewable by 2020 [1]. Although the production and use of renewable energy are rising rapidly, there is a long way to go: in 2008 the share was 10.3% [2]. The Directive does not prescribe how much of this renewable energy should be bio-based, but the 10% target for transport has to mean either electric vehicles (to the extent that the electricity comes from renewable sources) or biofuels; in 2008 renewable fuel made up only 2.5% of fuels used in road transport. Furthermore, 17% of renewable electricity is at present based on biomass; and for heating that contribution is 94% – firewood being the principal source of domestic heating other than fossil fuels or electricity (calculations based on Eurostat data).

The most important bioenergy feedstocks are [3,4]:

- Starch crops such as maize or sugarbeet, serving as a basis for making ethanol.

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- Oilseed crops such as rapeseed or sunflower, for making biodiesel.
- Residues: from agriculture (crop residues, manure), from forestry (sawdust, pellets, black liquor) and from urban areas (municipal solid waste, biogas from landfills).
- Biomass: while the first two are agricultural crops in which only the seed or the tuber is used for energy generation, here it is the entire plant. Energy is obtained either through direct combustion or as a feedstock for second-generation biofuels. Biomass crops are usually either grasses – which can produce prodigious amounts of biomass – or fast-growing trees such as willow or poplar.

Various concerns have made conventional biofuels (starch-based ethanol and oilseed-based biodiesel) seem less desirable in recent years. Firstly, the feedstocks are also sources of food, leading to higher food prices and, perhaps, lower food security in poor countries. While this concern may be somewhat overblown [5] there is undoubtedly some effect, and the reluctance to turn food resources into fuel is understandable. Secondly, expanded production of feedstocks such as sugarcane in Brazil, soybeans in Brazil and Argentina, and palm oil in Malaysia and Indonesia leads to accelerated deforestation – some of which at least is at the expense of tropical rainforest [6]. Not only will this lead to a decline in biodiversity, but also the greenhouse gas emissions resulting from such land-use change may well exceed any possible gain from replacing fossil fuels by renewable energy [7]. Thirdly, the production of these biofuels itself requires large amounts of energy: fuel for agricultural machines and transport of crops, manufacturing of nitrogen fertilizer, and processing into ethanol or diesel [8,9]. Finally, the application of fertilizer leads to emissions of nitrous oxide (N_2O), a highly potent greenhouse gas. This effect plus the aforementioned one together nullify the reduction of greenhouse gas emissions of most types of biofuels, except for Brazilian sugarcane [10].

This has led to increased interest in the other two types of feedstocks mentioned above: waste flows and biomass. The Netherlands has excellent potential for the utilization of waste flows: being a densely populated country with a high-density livestock sector, it has lots of them. The most important energy bearers in this sector are the combustion of municipal solid waste for electricity generation, and biogas from animal manure, sewage or organic household waste. All of these are used in the Netherlands, although the production of biogas is far below potential: in 2009, the country produced 7.7 PJ energy from biogas, of which only 38% came from agriculture. In this paper, however, we focus on the potential for biomass. The Netherlands does produce energy from biomass at present: a total of 19 PJ net in 2009, all of it used for combustion. The country also produces liquid biofuels (12 PJ in 2009), mostly from imported feedstocks.

This paper explores the potential for the production of biomass feedstocks, notably reed, in the Netherlands. Such potential would at first sight be small: Dutch agriculture specializes in crops and livestock products with a high value per hectare, whereas biomass is a low-value product suitable for marginal lands. However, some agricultural areas could become marginal in the future. Moreover, the production of reed could be part of a multifunctional land-use system, and such a system might become an attractive alternative to present land use under certain conditions. These conditions include climate change, energy prices, changes in markets for agricultural products, as well as policies promoting the conservation of landscapes and of the environment. They are explored here in the form of four scenarios representing different combinations of such conditions. The projections are made for the year 2030.

To a great extent, the potential for bioenergy production depends on the availability of land for energy crop production and competition with other uses, such as food production and biodiversity conservation. Global and regional assessments of bioenergy potential have been performed through non-spatial analysis [11,12]. In these assessments, the demand for food and feed was fulfilled and biofuel crops were allocated in the remaining agricultural surplus land. These assumptions were meant to ensure that both food competition and deforestation within the country were avoided.

Despite providing valuable information and insights, these studies used statistical averages for physical parameters such as crop yields and water availability. However, those can vary considerably and depend strongly on the spatial location. Therefore, a spatially explicit method was preferred as that would allow calculating the potential more accurately by taking into account the landscape heterogeneity, as well as identifying explicitly the locations with a higher potential yield.

This study aims to combine the economic rationale common to plant siting models with the attention for spatial detail more generally found in land allocation models. We, therefore, selected the economics-based Land Use Scanner [13] model to simulate the local competition between reed and grassland used for dairy farming under different future scenarios. This model allows these crops to compete for land directly according to their economic performance, which is determined by local biophysical properties (e.g. soil type and water table) and more general economic conditions (e.g. production costs and crop prices).

In the following two sections we first describe the specific characteristics of reed as part of a multifunctional land-use system and then go on to discuss costs and benefits of reed cultivation for bioenergy, both in commercial terms and from a social point of view. This analysis indicates potential favourable conditions for the cultivation of reed. In a subsequent section we present a spatial exploration that highlights where reed cultivation is likely to take place when favourable commercial and social conditions apply. This simulated spatial distribution of reed areas is helpful when their influence on the landscape is to be assessed. Such assessment would most likely consider the degree of dominance of reed in the landscape, i.e. the proportion of land dedicated to it and its distribution. A land-use model is applied to simulate this spatial distribution for each of the four scenarios. The paper concludes that reed, while not currently a viable land-use option, may become so under several scenarios, in particular as an alternative to dairying on peat soils.