

Assessing bioenergy crop potential in Yorkshire and the Humber using land suitability and multi-objective land allocation models

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1. Introduction

The rising of the fossil fuel price and the concern for global changes are the main drivers of the increasing interest in the bioenergy path towards distributed energy generation systems, climate change mitigation and increasing opportunities for the rural development. Biomass applications include heat and electricity generation and transport fuels. They thus have an important role in the future UK overall economy (Elghali et al 2007). However, the bioenergy sector is a complex system made up by different potential feedstock, environmental impacts and technological pathways. Moreover, the development of the sector largely depends on the economic sustainability and social acceptance. Therefore an efficient and sustainable strategy for the exploitation of biomass resources for energy use should be based on an integrated analysis by a multi-disciplinary approach.

Despite the high level of interest in bioenergy, there have been few studies on the sustainability implications of broad-scale biomass exploitation in terms of land use changes and ecosystems resilience. Most of the literature comparing the environmental implications of using bioenergy against fossil fuels points out the greenhouse gas emission issues, while few studies consider the biophysical impact on the ecosystem involved in the biomass production phase (Giampietro et al 1997, Graham et al 1996). The increasing demand for bioenergy is expected to affect land use patterns and it may cause further intensification of agricultural systems. Hence the feasibility analysis of the introduction of energy crops should include an evaluation of the land suitability for the crops under specific pedo-climatic conditions, their competitiveness with traditional crops and natural environments, their impact on agricultural landscapes and the implications for biodiversity.

The aim of this work is to analyse future scenarios from the potential supply side through a landscape-based approach which takes into account the agricultural and environmental issues involved in the introduction of novel crops in existing land use patterns at the local scale. The final goal is to assess the reasonable bioenergy potential from local resources and the likely success of bioenergy chains that create the least land-use problems.

2. Background

The biomass-to-energy system has an important spatial dimension due to the dependence of the supply system on agronomic factors and environmental constraints. Compared to other energy sources, biomass has a significant land requirement and high dispersion of resources, resulting in a low energy density per unit of land. Moreover, the trade-off between energy and food production means that the land competition issue is one of the biggest challenges for the

sustainable development at the global scale (Ignaciuk 2006, Johansson and Azar 2006, Giampietro et al 1997, Berndes 2006).

For this reason Geographic Information Systems and spatial models are particularly appropriate for the analysis and decision support in agro-energy planning and design of biomass to energy supply systems. In literature numerous GIS approaches are applied for the characterization of geographic variation that may influence biomass availability (Martelli F et al 2002, Schneider et al 2001), costs (Noon and Daly 1996, Voivontas et al. 2001), supplies (Graham et al 2000) and demand as well as the optimal locating of facilities (Freppaz D et al. 2004, Ma J et al. 2005, Edwards RAH 2005, Towers et al. 1997) and biomass collection systems (Maser et al 2006, Freppaz D. et al 2004).

In this study a multi-criteria GIS-based approach for land suitability and land allocation has been applied to assess the most suitable land-conversion areas in the Yorkshire and Humber region, identifying the key parameters and related criteria for sustainable agri-energy land use.

3. Methodology

The energy crops supply scenario has been built considering both the case of annual and perennial crops. The methodology is composed of a two phase combined spatial model. The first phase aims to apply a land capability model to map the suitable area and the capability level for each energy crop by considering some pedo-climatic factors. The second phase deals with a land allocation model (figure 1) which considers some environmental constraints in order to integrate the agro-energy use in existing land use patterns. The model takes into account the need for food and feed crops and assumes that the energy crops never displace natural habitat areas or other land with high ecological value, and that only primarily agricultural land can be converted into energy crop fields. Moreover, the model allocates the different energy crops according to their agronomic requirements and management systems in such way that the less intensive systems are adopted in the areas with higher environmental constraints, such as areas with high erosion risk, high hydraulic risk, areas sensitive to pollution from fertilizers, riparian buffer areas or connection/corridor areas for ecological networks and areas with water scarcity problems. The land allocation model thus addresses nature conservation and sustainable land use needs by creating suitable land use patterns for the integration of agri-energy land uses.

Two different scenarios have been built under different assumptions for energy and environmental policy directions. The first scenarios consider the effect of strong environmental policies other than avoided greenhouse emissions, such as incentives for environmentally-oriented farming, implemented rules for natural resources conservation and regulations for global food security. The second scenario has been built under the assumption of strong bioenergy production incentives with high carbon taxes.

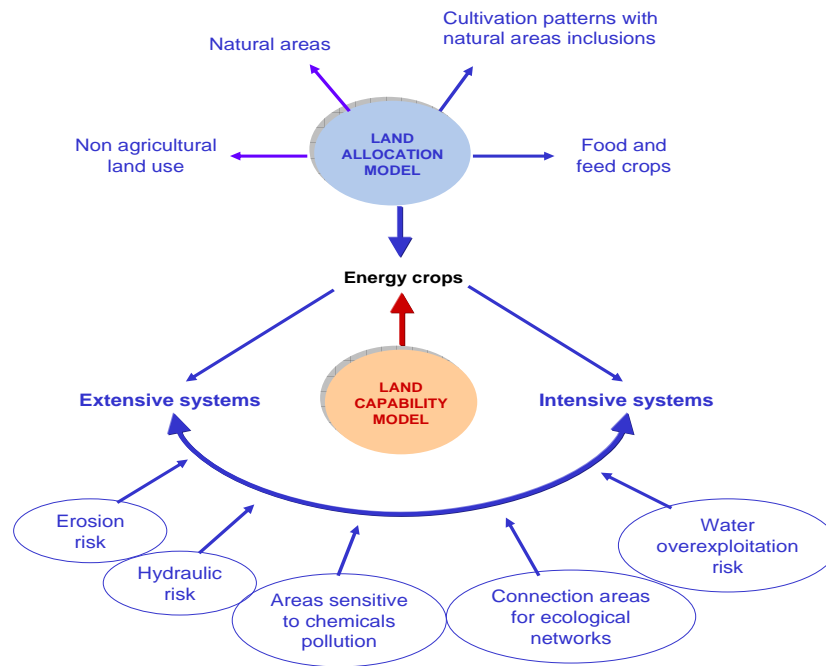


Figure 1. Multi objective land allocation model

4. Results

The results from the GIS-based methodology are represented as maps of suitable areas and locations for energy crops. The estimated potentials under different energy crop penetration scenarios represent the results of the trade-off between the different environmental and energy policy assumptions. The results are aimed at developing the best strategies for the integration of energy crops into existing rural landscapes by selecting promising pathways for sustainable biomass supply and proposing some agri-environment measures to ensure that novel crops do not cause negative impacts. The comparison between a strong energy crop penetration scenario against a lower penetration scenario with less intensive production systems shows the potential positive effects that a right choice of the crop types and cultivation systems may have on the environment in terms of land conservation and balanced management of natural resources. Considering the high biodiversity associated with the UK agricultural land (Hope and Johnson 2003), extensive cultivation systems and integrated landscape planning approach against the risk of land use intensification would provide several benefits in terms of nature conservation in UK.

5. Acknowledgements

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Biography

Patrizia Tenerelli graduated in forestry and environmental science at the University of Bari where she is currently completing her Ph.D.. Her primary interests are rural development and application of GIS for natural resources evaluation. She presently carries out research in the field of land planning for sustainable bioenergy production.

Steve Carver is a senior lecturer in the School of Geography, University of Leeds. His main interests are GIS, environmental modelling and landscape evaluation.