Chapter 21
A Web-Based Spatial DSS for Estimating Biomass-to-Energy Supply in Thessaly

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ABSTRACT
Biomass-to-energy projects have become attractive these days because of recent European policy measures that attempt to address acute environmental, agricultural and energy challenges accumulated during the last 30 years. Bio-energy issues constitute spatially dependent problems by definition due to the state-of-the-art technology and the bulky nature of biomass. Moreover, biomass profitability is linked to the structure and perspectives of the arable cropping systems since these are able to supply considerable quantities in the short and medium term required to fulfill the ambitious targets aimed at by policy makers. Therefore, appropriate tools are necessary to enable a comprehensive analysis and support decisions of policy makers, industry, researchers and farmers. Spatial Decision Support Systems that have been developed to support bio-energy decisions are used as a basis enhanced by a web-based interface, in this exercise resulting in a Web-SDSS. This tool is implemented in Thessaly, the most significant arable cropping region in Greece, in order to evaluate selected energy crop supply. The methodology and architecture of this tool are detailed in this paper, followed by an illustrative description of its operational version implemented in ex-tobacco producing areas.

INTRODUCTION
Rising trends and volatility of fossil fuel prices coupled with a reduction policy for greenhouse gases created momentum for biomass in Europe as a renewable energy source. Various directives have been decreed and an ambitious bio-energy policy has been implemented since 2004. Moreover, the Common Agricultural Policy (C.A.P.) 2003 reform that decoupled payments, eliminating crop earmarked subsidies, has decreased opportunity costs for alternative crops. Particularly in Greece where the 1992 MacSharry reform set-aside land was not applicable, it is the first time when energy
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crops seem to have become competitive against staple crops such as cotton and tobacco. Raw material cost is an important part of bio-energy products reaching more than 50% of the total cost thus a decrease in energy crops opportunity cost significantly affects the competitiveness of bio-energy. This hypothesis is confirmed in Thessaly by Lychnaras and Rozakis (2006) who have estimated regional supply of biomass for perennial plantations using analytical techniques such as mathematical programming (MP) and farm statistics (European Farm Accounting Data Network). Lacking spatial information, their results had limited value for decision makers regarding site-dependent bio-energy projects. As a matter of fact, with the exception of sunflower for biodiesel comprising a few hundred contracts, no bio-energy chain is operating in Thessaly. Therefore, it is very important for potential investors to have available information on raw materials cost.

For this purpose, a SDSS decision-making tool that contains optimisation models fed by technical, economic, and cartographic information has been built to provide stakeholders with region specific biomass-to-energy supply information. Energy to biomass raw material cost is provided in supply curve form incorporating physical land suitability for crops (survey and spatial information), farm structure (survey) and policy scenarios (new CAP specification in the model). Therefore, it is suitable for assisting in the evaluation of biomass-to-energy penetration into existing agricultural systems. Optimisation software (GAMS) is embedded in a GIS environment allowing for an interactive process in real time. A web-based interface built in open source software makes the SDSS tool available for collaborative decision-making.

A case-study explores potential supply of selected energy crops by arable farms in the Karditsa area, exploiting survey and spatial data. Numerous farms, geographically dispersed, decide maximizing gross margin, whether or not to introduce energy crops, namely sunflower, cynara and sorghum in their crop mix using crop suitability maps. Mathematical programming models of 70 representative farms are articulated and parametric optimization is used to generate supply curves for the energy crops at the regional level. The tool operates on the Internet² where the user can have full access to the data-set, enter selected parameters into the model, and enables spatial visualisation and exploration of the results, enhancing interactivity in the decision process. The architecture and the task organisation among optimisation, simulation and software are illustrated in this paper and preliminary results are discussed.

FROM CLASSIC GIS TO WEB-SDSS: OVERVIEW AND APPLICATIONS RELATED TO AGRICULTURE

Evolution and State-of-the-Art

Geographic Information Systems (GIS) have been applied to map biomass potential in forestry, industrial, agricultural or livestock residues and also have been used extensively since the eighties in numerous bio-energy studies. For example, a system model for estimating short rotation woody biomass production, harvesting and transport costs was developed and applied to a Hawaiian island, with GIS interfaced with the model to present results in cartographic form (Liu, 1992). More ambitious works have attempted to assist bio-energy policy at the national level by providing policy makers with quantitative economic and environmental information on the potential supply of energy crops in the UK (Cole et al., 1996), and the US (Graham et al., 2000).

While GIS can capture geographic variation which affects biomass cost and supply, they are effectively limited to deterministic analyses in spatial search. They can become a valuable tool when complemented by optimisation models or by Decision Support Systems (DSS), as they can exploit spatial data and also efficiently avail the model output. Limitations of decision models
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