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Assessing impacts of Common Agricultural Policy changes on regional land use patterns with a decision support system
An application in Southern Portugal

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ABSTRACT

This paper discusses research aiming at assessing Common Agricultural Policy impacts on agriculture and forestry. For this purpose an approach is developed that includes a linear programming model to estimate the Positive Mathematical Programming production cost function coefficients of current agricultural–forestry activities. It further includes a heuristic — simulated annealing — to generate solutions for each policy scenario. This model base approach is integrated within a decision support system (DSS) for testing purposes. The DSS further encompasses a relational database that stores agricultural–forestry technical and economic data and a geographic information system that stores topological data of regional farm-type land units. The DSS Graphical User Interface provides tabular and geographical reporting capabilities. Results are discussed for an application to the Alentejo region in Southern Portugal. Results demonstrate the usefulness and relevance of the proposed approach to assess the impact of changes in prices and in agricultural policy on land use patterns and on forestry.

1. Introduction

Land use is a key human activity that drives socio-economic development in rural regions. The reforms of the European Common Agricultural Policy (CAP) have shaped European agriculture and the spatial distribution of agriculture, forestry and livestock management activities. CAP motivations included land use efficiency and socio-economic development (van Delden et al., 2008). The current CAP emphasises direct payments to farmers in order to support farmer income, food safety and quality, and environmentally sustainable production (Bach et al., 2008).

Recently, the European Council of Ministers discussed the long-term EU budget for the period 2006–2013. Some member states proposed to reduce or abolish the CAP. These proposals were unsuccessful and yet in 2012 a new budget will be discussed that may have a substantial impact on European agriculture. Changes in the agricultural policies will likely have a direct effect on land use in agricultural rural areas of the EU (Bakker et al., 2008). Moreover, changes in prices and/or in demand also impact land use patterns in these areas. Thus, tools are required that may help anticipate the impacts of changes in policies and/or prices on land use patterns.

Mathematical programming (MP) models have been frequently used in agricultural economics. In general, these MP models aim to assess economic, technical and institutional scenarios associated with changes in relative prices, in technologies and in the availability of inputs (McCarl and Spreen, 1980). In order to further assess agricultural and rural development policies, Howitt (1995) proposed the Positive Mathematical Programming (PMP) approach. PMP has been used extensively to analyse economic, social and environmental problems in the framework of the Common Agricultural Policy (Gohn and Chantreuil, 1999; Cypris, 2000; Baskaqui et al., 2001; Graindorge et al., 2001; Helming et al., 2001; Fragoso et al., 2008).

Decision support systems (DSS) are designed to assist in identifying patterns, problems, opportunities, and eventually in making decisions (e.g. Zahedi et al., 2008). Moreover, DSS provide an interesting framework to integrate database management systems with analytical and operational research models, graphic and tabular reporting capabilities to assist in natural resources management and policy analysis (e.g. Borges et al., 2003; Reynolds et al., 2005, 2008).

This paper demonstrates the use of a model base approach to anticipate the impacts of changes in CAP and/or in prices on land use in rural areas (including forest land). The model based is integrated within a DSS with a modular structure. The DSS further include an information module that stores spatial and aspatial data to characterize farm types. The model base approach encompasses three components: i) a scenario generator, used to create different policy and/or price scenarios, ii) mathematic programming models to

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represent scenarios and to generate economic information as proposed by the PMP approach and iii) a meta-heuristic — simulated annealing — for model solving e.g. for estimating land use changes in each farm type. The third DSS module is a Graphical User Interface. It enables checking and editing scenarios. It further provide functionalities for model building, model solving and for reporting results.

Results are reported for an application to the Alentejo region in Southern Portugal encompassing 31 farm types extending over 2×10^6 ha. They suggest that the proposed approach is capable of efficiently and effectively assessing the impact of changes in prices and in agricultural policy on land use patterns and on forestry.

2. Material and methods

2.1. Study area

Alentejo is a region located in Southern Portugal that extends over one third of the country's area. Agriculture and agro-forestry are the most important economic activities in its rural areas. The region has been facing serious social and economic problems, the most visible being the decrease and ageing of its population. The agricultural sector in the Alentejo is characterized by a small number of large farms. According with agricultural statistical census of 1999 (INE, 1999), the regional farm average size was above 40 ha, which is much higher than the average value in Portugal (9 ha).

A great part of the region (over than 1 million ha) is covered by a Mediterranean agro-forest in which *Quercus ilex* spp. *rotundifolia* and *Quercus suber* dominate. This is an agro-forestry system in which agricultural and forest activities complement each other. In Portugal, this agro-forestry system is named "Montado". It produces cork, firewood and fodder for livestock in grazing extensive agricultural systems with cereals and other crops. Agro-forestry is understood here as a land use system where woody perennials, agricultural crops and/or animals occupy the same land management unit, in some form of spatial arrangement or of temporal sequence and where there are both ecological and economic interactions between the system's components (Somarriba, 1992). Agro-forestry can be generally classified into silvoarable (tree-crop) and silvopastoral (tree-livestock) systems. Often, the farm management strategy within "Montado" encompasses a combination of these systems. In Southern Portugal the "Montado"'s cork and holm oak stands have varying densities and crops/fallow/pastures are managed in rotation under the oak canopy (Pinto-Correia and Mascarenhas, 1999).

The Alentejo Region in Southern Portugal is far from homogeneous. Agro-forest–ecological heterogeneity provides the framework for economic activities, particularly for agro-forestry activities. Thus agro-forestry land was classified into 31 farm types (Fig. 1) based on ecological characteristics and on current land use patterns (Borges et al., 2008a, b) to provide the spatial building blocks for testing the proposed approach. Current land uses in the Alentejo Region include cereals, horticulture, fruit culture trees, vineyards, olive trees, permanent pastures, forage, set-aside, fallow and forest. In this research, the forest land use is defined as forest area with no agriculture activity under canopy cover. Land uses within the "Montado" agro-forestry system include livestock, common wheat, durum wheat, sunflower, forage, fallow, pastures and set-aside.

2.2. Mathematical model

PMP is a method to calibrate mathematical programming models according to observed behaviours during a reference period. For that purpose it uses the information provided by the dual variables of the calibration constraints (Howitt, 1995; Paris and Howitt, 1998). In this study, a PMP supply agricultural model was developed to simulate farmer's response to changes in agricultural policies and product prices. This model was included in the model base of the proposed DSS in order to evaluate the Common Agricultural Policy impact on farm types in the region.

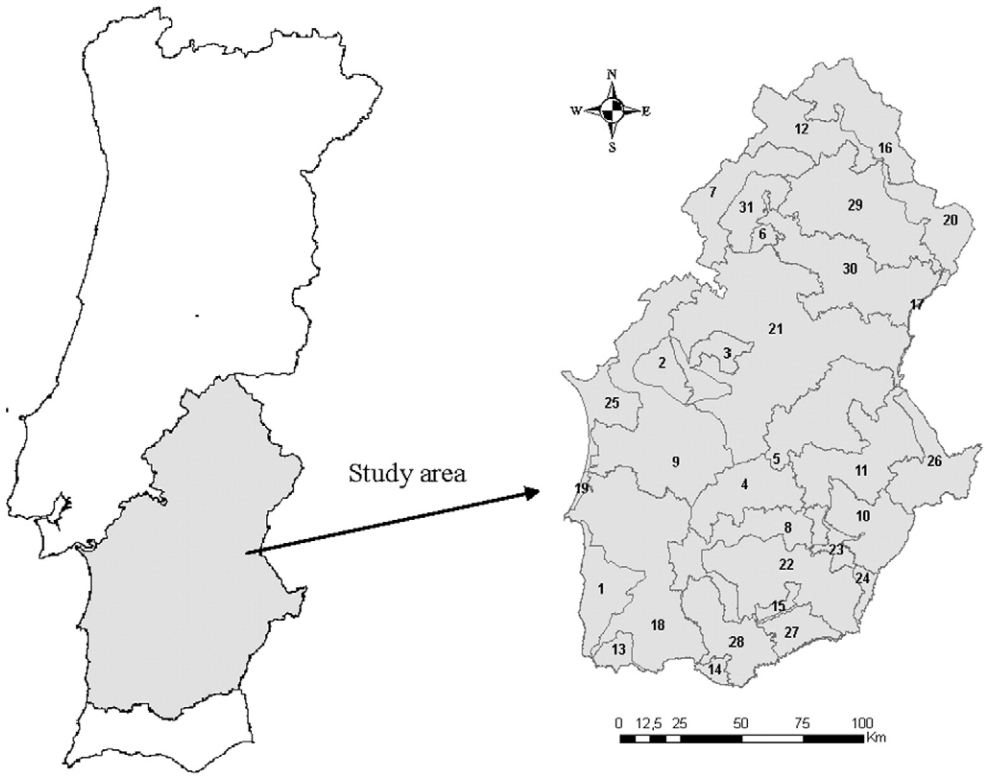

Fig. 1. Agro-forestry farm-type land units within the Alentejo region (Portugal).