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Optimal combination of energy crops under different policy scenarios; The case of Northern Greece

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HIGHLIGHTS

- A stochastic and a deterministic LP model is formulated.
- The role of CAP is vital in generated income.
- Imports and cultivated areas are subsidy neutral.
- The regime of free market results in lower income acquired from the potential crop mix.
- Non – financial motivation is a key determinant of the farmers' attitude towards energy crops.

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ABSTRACT

Energy crops production is considered as environmentally benign and socially acceptable, offering ecological benefits over fossil fuels through their contribution to the reduction of greenhouse gases and acidifying emissions. Energy crops are subjected to persistent policy support by the EU, despite their limited or even marginally negative impact on the greenhouse effect. The present study endeavors to optimize the agricultural income generated by energy crops in a remote and disadvantageous region, with the assistance of linear programming. The optimization concerns the income created from soybean, sunflower (proxy for energy crop), and corn. Different policy scenarios imposed restrictions on the value of the subsidies as a proxy for EU policy tools, the value of inputs (costs of capital and labor) and different irrigation conditions. The results indicate that the area and the imports per energy crop remain unchanged, independently of the policy scenario enacted. Furthermore, corn cultivation contributes the most to iFncome maximization, whereas the implemented CAP policy plays an incremental role in uptaking an energy crop. A key implication is that alternative forms of motivation should be provided to the farmers beyond the financial ones in order the extensive use of energy crops to be achieved.

1. Introduction

The role of bioenergy as a means of energy needs satisfaction is an issue widely surveyed by different scientific fields. Given the increasing trend for energy demand in the European Union (EU), the mitigation of greenhouse gas effect asks for further use of environmental friendly energy sources in order to diminish the dependency on fossil fuels. The reduced foreign energy dependence along with the improved rural economies and the achievement of environmental goals are a few of the advantages in the use of bioenergy recorded (Zafeiriou et al., 2014). Within this context, the EU has strongly supported first generation biofuels in the name of energy security however, a number of studies have questioned their positive impact on greenhouse gas emissions (GHG) emission reduction over the last few years. The continuous escalating global agricultural prices along with the indirect land use change and the increasing demand for biofuels resulted in global intensification effects (Deppermann et al., 2016; Grethe et al., 2013). Still, the motives for up-taking energy crops are still active and based on income, income distribution, as well as, the regional development for less disadvantageous countries (Keeney, 2009).

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The major issue arisen from the adoption of energy crops is the indirect land use change that actually has two dimensions. The first is related to food security while the second is the encumbrance in carbon emissions generated by the particular process. In particular, the increasing demand for bioenergy has led to a competition for agricultural land use with food, feed, and fiber production, which affects the GHG emissions through the direct and Indirect Land Use Changes (ILUC). Emissions attributed to land use change are mostly expected to take place outside the EU, where the additional production is likely to be realized at the lowest cost. In the case that this production is realized through the use of additional land, its conversion could lead to substantial greenhouse gas emissions being released given that high carbon stock areas such as forests are affected as a result (Directive 2009/28/EU, 2009).

The EU has confronted climate change and the greenhouse gas effect with different policy measures embodied to two Directives, supposed to be valid until 2020. The first one, the renewable energy directive (RED), has set a 10% target for renewable energy in transport, whereas the second one, the fuel quality directive (FQD), aims at a 6% reduction in the carbon footprint of transport fuels. In practice, these two policy schemes have led the EU countries to subsidize and mandate biofuels to meet the aforementioned targets, provided that they reduce emissions compared to fossil fuels. Both Directives have rules for calculating the direct carbon emissions from biofuels but without considering ILUC emissions. This creates serious problems, since according to calculations in global terms, 15% of the total greenhouse gas emission is attributed to ILUC, while the estimated indirect land-use change emissions from EU biofuel consumption in 2020 are likely to represent a very small share. This share is estimated to 0.1% annually according to the International Food Policy Research Institute dedicated to the analysis of Biofuel policies and land use related policies (IFPRI-MIRAGE-BioF), (E4Tech, 2009).

Bearing in mind the aforementioned framework and EU Directives, the cultivation of energy crops should be in accordance with the principles of food security and the production of renewable resources as a means of mitigating the greenhouse gas effect. The role of income in the adoption of energy crops seems to be vital as energy crops are not conventional crops and entail high risk. Thus, a farmer's decision becomes sensitive to risk as farms do normally behave in a risk averted manner (Zafeiriou and Karelakis, 2016; Alexander and Moran, 2013; Balezentiene et al., 2013; Gómez-Limón et al., 2003; Wallace and Moss, 2002). The objective of the present study is twofold; first, an endeavour is made to determine the most attractive structure of cultivation, including energy crops in terms of income, as well as the selection among sunflower, and rapeseed (irrigated). Second, through the application of linear programming (LP), corn is compared to energy crops in terms of financial returns under five different policy scenarios for the regional unit of Evros in Greece. This study is expected to provide answers for the up-take of an energy crop along with corn and to identify what particularly determines the adoption of an energy crop; the risk as expressed by the EU subsidies *or* the higher net income without including the subsidies?

The remainder of the paper is organized as follows; a literature review on biofuels production and energy crops is presented in Section 2, the third section presents the materials and methods employed. In Section 4 the main results of the study are discussed whereas the final section concludes.

2. Literature review

Until recently, nearly all biofuels have been mainly produced with first generation production technologies based on the cultivation of traditional agricultural commodities including cereals, vegetable oils or sugar crops. Some of the crop types, discussed before, are dedicated energy crops (Bioenergy, IEA, 2009), which are expected to be the main share of future bioenergy supplies. The bioenergy production and the repercussions of indirect land use change, caused mainly by biofuels policies, continue to be an issue of conflict in the international literature. The arguments related to the unintended consequences of production and use of biofuel including other potential economic, social, and environmental impacts, effects on food security, environmental justice, and biodiversity conservation (López-Bellido et al., 2014; Jaradat et al., 2010; De Gorter and Just, 2010).

Energy crops are strongly competed by other more standard uses of farmland, and consequently if profit and ease of provision their product to the market is not an allure for individual farmers, their selection is not an expected result (Mola-Yudego et al., 2014; Panoutsou, 2007). Though the financial reasons are not the sole ones. To be more specific other non financial reasons have been mentioned that attract or repel farmers for the adoption of an energy crop. Some of these reasons are: the ease of management, lack of the appropriate machinery, time that the land should be committed, soil quality issues, a power plant investment-to-construct and operate combined heat and power plants that use energy crops as fuel while many others can be mentioned (Glithero et al., 2013; Alexander et al., 2013). Furthermore, farmers' personal preferences play a role on the adoption of energy crops that vary not only between farmers but also with time based on past experience. A perception worth mentioning is the farmer's preference on diverse production systems based on the fact that they become able to utilize more efficiently the niche space of the production system (Havlík et al., 2011). Consequently, reducing resource losses and enhancing environmental performance may well become an achievable target, a useful strategy in the design of novel, sustainable agro-ecosystems (Weih et al., 2014; Malézieux et al., 2009), especially in the case of energy crops. Though, besides the agro-environmental dimension of energy crops, their adoption is the result of interaction among financial returns, along with other higher returns of competing activities. Thus, the increasing price of an alternative crop (i.e wheat) the preceded time period (Chatzinikolaou et al., 2015; Sherrington et al., 2008) may well motivate the selection of an energy crop. According to Villamil et al., (2008), a farmer's decision may also be affected by the dissemination of information on technical and agronomic aspects of cultivation, including also economic returns and contract agreements on energy crops. Currently, a small number of species is used for the production of first generation biofuels.

In the past few years an ample of studies can be mentioned, conducted to develop decision tools for the efficient management of agro-forestry resources (Ballarin et al., 2011). Manos et al. (2013) provide a review of the Information Architecture (IA) tools applied for the assessment of the EU policies in agriculture and environment, analyzing and classifying them according to the policy that they have been applied to and by the impacts that they have been measured. The Multiple Criteria Decision Analysis (MCDA) is a dominant tool in operational research. Applications of MCDA techniques on agricultural sector have been proposed by Romero and Rehman (2003), while among the wide range of different techniques the most suitable ones for agro – forestry resource management as alleged by Elfkih et al. (2009) are the Multiple Objective Decision Making approaches (MODM), due to the necessity for the optimization of several objectives simultaneously for the handling of such problems. Another technique employed by Ballarin et al. (2011) is the multi – period Weighted Goal Programming model for the identification of the optimal land use combinations for the achievement of the simultaneous optimization of two objectives farmer's income maximization and net biomass energy production.