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Analysing the provision of agricultural public goods: The case of irrigated olive groves in Southern Spain

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ABSTRACT

Analysis of the joint production of private and public goods (PGs) by farming activities is a fertile research field. These joint production processes are typically characterised by a high level of complexity derived from the intense relationship between the production of both kinds of outputs. An integrated approach is strongly recommended for the study of the provision of agricultural PGs and the design of public intervention in this sector. Here, we propose a theoretical framework to apply an integrated approach using the analytic network process (ANP) to analyse the production of PGs by agricultural systems to support public decision-making concerning the design and implementation of agricultural policies. We introduce a novel approach in applying ANP along both directions of the influences among elements, allowing us to identify the most influenced PGs and the farmers' most influential decisions. This methodological approach is empirically applied to a particular farming system: the irrigated olive groves (IOG) of Southern Spain. Results show that the PGs most influenced by olive growers' decisions are soil fertility, the visual quality of agricultural landscapes and farmland biodiversity. In addition, the most influential factors affecting the provision of PGs are the structural ones, namely farm size and tree density, and, to a lesser extent, management factors dealing with fertilisation, soil and irrigation management. These results are useful for supporting agricultural policy decision-making to enhance adequate management of this farming system regarding PGs production.

Introduction

The joint production of private and public goods by agriculture is a fertile research field in agricultural and environmental economics (Rossing et al., 2007; Renting et al., 2009). Works in this field usually have the main objective of supporting public decision-making, considering the provision of public goods (PGs) (and public "bads") as a key concept in the design and implementation of agricultural policies in developed countries (OECD, 2001, 2003), and particularly in the European Union (EU) (Cooper et al., 2009; EC, 2010). In fact, numerous researchers and analysts assert that only by orientating such policies to an adequate provision of PGs could public intervention be efficient from the social welfare point of view (DLAE, 2009).

On the supply side, most of the studies in which agricultural PGs production has been analysed have focused on one or a few of them, thus using *partial approaches* in their analysis (e.g., Boardman et al., 2003; Nilsson, 2009). The use of partial approaches can barely capture the abundant and complex interrelationships that characterise the joint production of private and public goods in agriculture.[1] This complex nature of the joint production processes in agriculture calls for the use of *integrated approaches* in order to analyse them (Renting et al., 2009). This is due to these approaches enabling the identification and incorporation of said complexity in the analysis of agricultural PGs production. Consequently, a growing number of studies are using integrated approaches in this field. Worthy of highlighting are those that use modelling (e.g., Rossing et al., 2007), indicator sets (e.g., Fleskens et al., 2009) or geographical information systems (e.g., Darradi et al., 2012), among others. However, further research is still needed with regards to the application of an

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[1] Likewise, it is worth noting that such joint production involves numerous interrelationships, not only between private and public goods production, but also within the production of the PGs themselves (OECD, 2001).

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integrated approach in the analysis of agricultural PGs production (Zander and Groot, 2007).

Among methodologies that incorporate an integrated approach to the analysis of agricultural multifunctionality, the analytic network process (ANP) is one of the most promising. This is because it allows interdependencies between different relevant elements of the system studied to be considered (Saaty, 2005). In any case, as with any other integrated approach, its use requires a theoretical framework including a clear definition of each PG provided by the system and an a priori set of relations explaining these production processes. Traditionally, theoretical frameworks used for integrated approaches have not fully taken into account farmers' decision-making (Rossing et al., 2007). Here, we propose a new framework based on the causality of producers' decision-making at farm level. Thus, both PGs provided by an agricultural system and their relationship with farmers' decisions have been defined, allowing us to build up a network enabling an ANP application. Furthermore, we implement ANP through a dual approach which, whilst it represents a novelty in the application of the method, allows us to take full advantage of it. Hence, the usefulness both of the theoretical framework proposed and of ANP for the analysis of such joint production is proved here through their application to a particular case: the agricultural system of irrigated olive groves (IOG) for olive oil production in Andalusia, Southern Spain.

The main objective of this work is the development of an integrated approach to analyse the production of PGs by agricultural systems to support public decision-making concerning the design and implementation of policies aimed at the governance of the farming sector. For this purpose, the paper has been developed as follows. The next section is devoted to the description of the theoretical framework used for this approach. In the third section, the agricultural system (IOG in Andalusia) which can be considered the pilot case study is described. In the fourth section the methodology is described, focusing on the way ANP is applied, data gathering and the procedure for the aggregation of experts' knowledge. The fifth section presents and discusses the main results obtained, focusing on the PGs more sensitive to olive growers' decisions, and thus, to the implementation of policy instruments. Finally, in the sixth section the main policy implications derived from the results are discussed, and the main conclusions of the work outlined.

A theoretical framework to analyse agricultural public goods

A theoretical framework has been developed to identify the PGs provided by agricultural systems consisting of an adaptation of the widely known DPSIR framework (EEA, 1999), due to its adequacy given its causal and system-orientated approach. Within this framework, a farmer produces a PG when his/her decisions entail some modification of the attributes of the environment (providing them to be non-excludable and non-rival) that affects social welfare. Here, we consider the environment in a broad sense, that is, formed by natural (climate, water, biodiversity, etc.) and socio-cultural (cultural heritage, rural viability, etc.) attributes. Consequently, farmers produce a *public good* when they modify one of these non-rival and non-excludable attributes and the social welfare increases as a result; and, in contrast, a *public bad* occurs when such modification results in a reduction of the social welfare. In terms of the DPSIR framework, the natural and socio-cultural attributes of the environment can be considered *states* (*PGs-States*). When some of these non-excludable and non-rival *states* are modified as a result of farmers' decision-making and this modification entails some variation of the social welfare, a *pressure* (*PG-Pressure*) is produced.

Here, we are interested in these *PGs-Pressures* produced as a result of farmers' decision-making. Applying such a theoretical framework, the main *PGs-Pressures* (and their relevant *PGs-States*) produced by farming activities have been identified. Such PGs are listed in Table 1, distinguishing between environmental and socio-cultural ones and highlighting the main anthropogenic factors involved in their production. It is worth mentioning that each of the 14 *PGs-Pressures* (and thus each of the 11 *PGs-States*) has different degrees of non-rivalry and non-excludability, as well as different scales of consumption. Additionally, it is also interesting to highlight that they can be strictly a public good (e.g., contributions to the national food supply), strictly a public "bad" (e.g., water pollutant emissions) or a good or "bad" depending on the farmers' decision (e.g., soil fertility).

This theoretical framework can be applied at different scales. For example, it can be used to analyse the multifunctional performance of plots, farms, agricultural systems (landscape or ecological units), or, even, regions where agricultural activities are prominent. However, in order to analyse the production of PGs, agricultural systems can be considered the most appropriate scale, as it is the most relevant one from the agricultural policy perspective (Andersen et al., 2007). This is why this spatial scope has been chosen here within which to perform the empirical analysis.

Case study description: irrigated olive groves (IOG)

Although the multifunctionality of olive grove systems has been widely studied, previous works have not given special attention to the differential characteristics of the IOG. Actually, works in this field are mainly focused on mountainous olive groves (Fleskens et al., 2009) or on making comparison among different agricultural production techniques (conventional, organic and integrated) (Parra-López et al., 2008a; Guzmán et al., 2011), but without giving such special attention to this particular olive system. Only a few works have analysed multiple functions of the IOG, but they have used other approaches, namely assessing sustainability (Gómez-Limón and Arriaza, 2011) or eco-efficiency (Gómez-Limón et al., 2012). However, there are no studies specifically analysing the provision of the PGs from IOG.

Here, we analyse the provision of PGs from IOG that produce olives for olive oil production in Andalusia (Southern Spain),[2] the world's main olive oil production region, producing roughly 35% of the world's output, approximately half of it from IOG (EC, 2012). The analysis of Andalusian IOG is highly pertinent due to its enormous expansion during the last two decades and the relevant environmental and socio-cultural impacts of this process. In fact, in the last 20 years IOG has become the most important irrigated agricultural system in the region, consuming a significant share of its water resources and occupying around half a million hectares, which represents approximately half of the current irrigated area of Andalusia (Gómez-Limón et al., 2013). This is particularly noteworthy bearing in mind that the olive has traditionally been a non-irrigated crop. This expansion has been possible primarily due to Spain's entry into the EU and the implementation of the European Common Agricultural Policy (CAP), which promoted the productivity (irrigation) of olive groves (de Graaff and Eppink, 1999; Gómez-Limón and Arriaza, 2011). Likewise, the development and improvement of drip irrigation and groundwater abstraction techniques have also

[2] Olive groves, rainfed or irrigated, can be orientated to produce olives either for olive oil or table olives. It is worth mentioning that more than 90% of Andalusian olive groves are specialised in olive oil production (CAP, 2008). Taking into account that relevant differences (in olive varieties, crop management, etc.) exist between both kinds of olive groves, probably also affecting the production of PGs, this research is only focused on IOG whose olive production is orientated to obtaining olive oil.