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A participative approach to develop sustainability indicators for dehesa agroforestry farms

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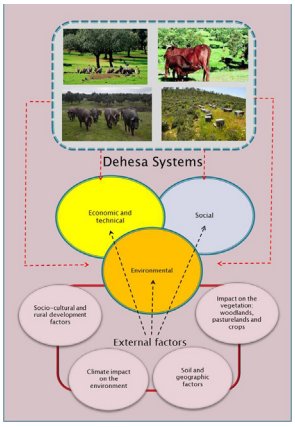
HIGHLIGHTS

- Dehesas' sustainability is endangered by low profitability and dependence on subsidies.
- Current management can jeopardize the maintenance and persistence of dehesa farms.
- Specific tools are needed so that farm managers can assess sustainability in an easy and reliable way.
- Delphi method has been used to design a set of sustainability indicators adapted to dehesas.
- Indicators were selected based on consensus and representativeness regarding sustainability pillars.

GRAPHICAL ABSTRACT



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ABSTRACT

This paper provides a list of specific indicators that will allow the managers of dehesa farms to assess their sustainability in an easy and reliable way. To this end a Delphi analysis has been carried out with a group of experts in agroforestry systems and sustainability. A total of 30 experts from public institutions, farming, research bodies, environmental and rural development associations, agricultural organizations and companies took part in the study which intended to design a set of sustainability indicators adapted to dehesa agroforestry systems.
The experts scored 83 original indicators related to the basic pillars of sustainability (environmental, social and economic) through a two-round procedure. Finally, 24 indicators were selected based on their importance and the consensus achieved.
From an environmental point of view, and in line with its significance for dehesa ecosystems, it has been observed that "Stocking rate" is the indicator with greater relevance. Within the economic pillar, "Farm profitability" is the most important indicator, while regarding the technical indicators "Percentage of animal diet based on grazing" is the one that got the highest score. Finally, the "Degree of job satisfaction" and the "Generational renewal" were the most relevant labor indicators.
It is considered that the Delphi approach used in this research settles some of the flaws of other sustainability models, such as the adaptation to the system to be studied and the involvement of stakeholders in the design.

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1. Introduction

When we talk about the agricultural sector in Spain, we are referring to a complex reality of enormous significance. Complex because of its wide variety of landscapes and uses and of great significance because it involves more than 23 million hectares of agricultural land (INE, 2017), as well as for its importance in employment and economy in Spain.

Despite the fact that agriculture in Spain has lost much of the economic importance it had only a few decades ago, it still employs around 4% of workers, an amount somewhat lower than the European Union average, but higher than that of countries like France or Germany. Similarly, the weight of the agricultural sector in the Spanish economy has also been losing importance, going from levels close to 20% of GDP in 1960 to around 2.5% today, a trend consistent with what has happened in other developed economies. However, it must be kept in mind that agriculture is still an important source for smallholder income in rural areas, where it covers large spatial extents and harbours high biodiversity.

Within the farming systems in the Iberian Peninsula, the dehesa agroforestry systems are of great relevance. These agrosilvopastoral systems have their origin in the use of the traditional Mediterranean forests of the area, where tree density was reduced to enhance their use by livestock. Dehesas are characterized by the presence of a tree layer with densities of 30–50 trees per hectare in which oaks and cork oaks prevail, together with a herbaceous/shrub layer in which agricultural crops (cereals and some legumes), pastures and shrubs can be found and where cattle, sheep and Iberian pigs graze freely (San Miguel, 1994).

In fact, one of the most outstanding characteristics of these systems is the positive interaction that takes place –if management is correct- between livestock, trees, pastures and crops (Montero et al., 1998). Due to their high environmental and socioeconomic values dehesas are a clear example of multifunctional farms, a characteristic that influences their sustainability (Gaspar et al., 2016).

Market changes, together with the reforms of the European agricultural subsidies have led to a decrease in the profitability of these farms. As a consequence, there have been changes in the use of land, which have driven to productive intensification in some farms and to the abandonment of others (Ripoll-Bosch et al., 2012) in what is called land polarization (Stürck et al., 2015). Due to the fragile balance between the different productive elements of dehesas (livestock/trees/grass/crops), the increase of the stocking rate can be followed by lack of regeneration, overgrazing and soil degradation due to compaction and erosion. At the other end, the abandonment of livestock production (e.g. due to the decoupling of European subsidies and lack of generational renewal) can lead to shrubby invasion, which ultimately means the disappearance of the agroforestry system as we know it.

There are also other anthropogenic and environmental factors challenging the survival and sustainability of these valuable ecosystems. Thus, younger farmers taking over these low-profitable systems will need to transform current production models into cost-efficient operations that will work together with the nature, and not against it. To this end they will have to lower input costs, find alternative sources of income, recycle resources, stimulate natural regeneration, improve soil and increase farm productivity so that their land can become economically and environmentally sustainable.

It is also widely considered that the one of the most important problems currently affecting dehesas is the absence of natural regeneration exacerbated both by the intensification/abandonment of woodlands and by external shocks such as the Sudden Oak Death Disease Syndrome, known as “La Seca”. The propagation of “La Seca” is linked to a variety of biotic, abiotic and anthropogenic factors, among them hydrological stress, increased summer and winter temperatures and poor management practices (inadequate pruning, lack of tree regeneration). This directly affects the system's ability to cope with climate variability and drought survival.

Thus, sustainable management plays an increasingly important role in these farms, and therefore, the measurement of sustainability becomes an aspect of great relevance. However, it is not a task that can be easily addressed, since sustainability is a multidimensional concept and requires an approximation based on different indicators that need to be measured or calculated independently for each holding. In addition, and although it is generally accepted that sustainability covers three basic pillars (environmental, social and economic) there is not a unique and generally accepted methodology, but different approaches based on the systems addressed or the information available. Fig. 1 sets out the main factors affecting the sustainability in dehesa agroforestry systems.

In this context, this article develops the initial stages of the design of a toolkit to assess the sustainability in dehesa farms. The peculiarities of dehesas and the delicate balance in which these systems move generates the need for managers to have adapted tools, which can be easily used and help them in the planning and maintenance. The definition of a set of personalized sustainability indicators paves the way for further developments, which will help to reduce the vulnerabilities of these farms in the current environment of global competitiveness.

At an agricultural policy level we consider that the work offers an overview of the fundamental indicators of sustainability for dehesa agroforestry systems. In this sense, the present study is a first attempt to obtain global sustainability indicators for these systems. Due to its global nature and its methodological approach aimed at obtaining aggregate results, it does not replace or pretend to qualify the hundreds of partial studies that have been carried out. Measuring the sustainability of such a heterogeneous productive economic activity such as agriculture requires both field studies and global analyses. In this sense, the work has sought to identify a group of environmental, economic and social indicators from which the evolution of agricultural systems, their measurement and quantification can be assessed.

To this end it has been decided to use the Delphi methodology, which is based on consulting a panel of experts who have to reach a consensus on the problem studied. The Delphi technique has clear advantages in uncertain environments where the lack of clear and objective information, or the presence of excessively diverse and hard to access base information, hinders the application of other methodologies (Landeta and Barrutia, 2011).

Due to its versatility, the Delphi methodology has been widely used in diverse fields, such as forest management (Edwards et al., 2011), climate change and food production (Kirezieva et al., 2015), the identification of trends in meat consumption (Chamorro et al., 2012) or the innovation performance of agricultural co-operatives (Luo et al., 2017). Examples of application can also be found in agroforestry systems, such as (Horrillo et al., 2016) on the adoption of organic production in dehesas or that of (Rositano and Ferraro, 2014) on the assessment of ecosystem services.

2. Materials and methodology

2.1. Research area

The study covers the Southwestern regions of Spain and Portugal where dehesa and montado (the Portuguese word for dehesa) systems are mainly located. They occupy a total area of 5.8 million hectares in Spain and 0.5 million hectares in Portugal (Gaspar et al., 2008; Joffre et al., 1999). Dehesas/montados are one of the largest agroforestry systems in Europe (Eichhorn et al., 2006).

The predominant tree species are oaks, mainly holm oak (*Quercus ilex* subsp. *ballota*) that is found in 80% of the dehesas, and cork oak (*Q. suber*). Dehesa soils are acid, shallow sandy loams of low fertility with and a marked lack of phosphorous and low levels of organic matter which make them marginal for cereals (San Miguel, 1994). The climate is continental Mediterranean, with annual average temperatures