Chapter 14
Assessing the Efficiency and Distribution of Agricultural Activities Using DSS: A Case Study for a Portuguese Region

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ABSTRACT
This work describes the sequential use of different Information Systems and Decision Support Systems (DSS) to measure the efficiency of a set of agricultural activities, and subsequently to propose alternative reallocations of these activities within a geographical region. The region selected as a case study was Ribatejo e Oeste (RO), an important agrarian region in mainland Portugal. The DEA (Data Envelopment Analysis) methodology was used to assess the efficiency of the most important agricultural activities in RO, using the Frontier Analyst DSS to study alternative modelling options. In a second phase, plans for redistributing the evaluated activities were studied, aiming at promoting the most efficient activities (according to DEA) but without creating at the same time drastic changes in current land uses. Several plans constituting different compromises between these two objectives were found using a multiobjective linear programming DSS. A Geographical Information System was used to constrain the areas that were adequate for each type of crop and to graphically illustrate some proposed plans.

INTRODUCTION
Decisions about land uses are an essential part of agricultural planning, with impact on the farmers’ revenue, on the quality of the products, and on the preservation of the environment. Farmers are confronted with issues such as the choice of which crops to produce and where, the definition of quality and quantities to produce, the selection
of production systems and technologies, etc. On the other hand, policy makers concerned with territorial management and agricultural activities are confronted with the need to set long term strategies influencing the use of land over long periods, from macro-economical and environmental perspectives.

To meet these challenges, besides agricultural technologies, biotechnologies and technologies for environmental preservation, the information and decision support technologies can play a major role. In particular, Decision Support Systems (DSS) (Burstein & Holsapple, 2008; Turban et al., 2007) can be extremely useful to help decision makers to know the characteristics of the soils, to choose the most appropriate crops, to select the most appropriate ways of producing these crops, and to assign these crops to the available lands.

This chapter aims to illustrate how political decision makers, planning officers concerned with agricultural activities and territorial management, and the farmers themselves, can be helped to rethink the use of land taking account of economical and environmental concerns. The chapter describes the sequential use of different Information Systems and DSS, first to gather knowledge about different agricultural activities and to assess their efficiency, and then to propose a territorial redistribution of these activities. The current distribution of crops in each agrarian region (seven in total) was first analysed and a region was selected to be used as a case study. The chosen region was Ribatejo e Oeste (RO): although this region ranks second in terms of cultivable area, it is the most varied in terms of number of crops of non-negligible importance.

The basis for this work was the data in the AGRIBASE information system, a database developed at the Agriculture Section of ISA-UTL (School of Agronomy of the Technical University of Lisbon), with participation of the first author. This database contains a detailed characterization of agricultural activities practiced in Portugal. Each activity is characterised by the agricultural product (e.g., lettuce), by the way it is produced (e.g., irrigation by electrical pumps), and by its timing (e.g., planted in April and harvested in November). Several activities differing over production methods and timings may be available for producing each agricultural product, originating different values for labour needs, water needs, machine uses, waste generated, and revenue for the farmer. Although the database contains also activities related to forest management and cattle-raising, this work focuses on agricultural activities (for producing fruits, cereals, fodder, pasture, flowers, etc.)

To assess the efficiency of the different agricultural activities we have used Data Envelopment Analysis (DEA) (Cooper et al., 2006). DEA is a technique based on linear programming models that allows assessing the relative efficiency of a set of homogeneous and comparable units (e.g., bank branches, schools, farms or, in our case, agricultural activities), which consume a set of inputs to produce a set of outputs. These units are usually called Decision Making Units (DMUs). DEA identifies which units are inefficient, indicates how much would they need to increase their outputs production (or reduce their inputs consumption) to become efficient, and identifies a set of efficient peers that can be regarded as best practices for others to emulate.

In this work, each agricultural activity from the RO region was considered to be a DMU consuming labour, machinery, irrigation water, and land cost as inputs and producing revenue as a desirable output, as well as waste (dangerous and non-dangerous) as undesirable outputs. Multiple DEA model variants were studied with Frontier Analyst (Banxia, 2003), either considering constant or variable returns to scale, varying strategies to cope with undesirable outputs, and varying the inclusion of subsidies to the farmer, in order to obtain robust conclusions.

In a second phase, we aimed to study plans for a redistribution of agricultural activities in the RO region in order to promote more efficient land