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Transportation Research Procedia 22 (2017) 95–104

Transportation Research Procedia

www.elsevier.com/locate/procedia

19th EURO Working Group on Transportation Meeting, EWGT2016, 5-7 September 2016, Istanbul, Turkey

Determining an Optimal Area to Locate a Biorefinery under Economic and Environmental Criteria

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Abstract

Facilities location is a strategic decision which has to be carefully considered because it could involve the failure or success of a business. For that reason, anything that helps decision makers to facilitate their location decision processes is of their utmost interest. The aim of this paper is, therefore, providing a methodology that could be useful for the decision makers by giving them not only an optimal point but also a whole region where they can focus on their attention. Knowing that biofuels are settling as a new alternative energy source which has been spreading around the world to reduce greenhouse gas emissions and oil dependence, this methodology is tested in the real case of locating a biorefinery in Navarre, Spain. Moreover, A Mixed Integer Linear Programming (MILP) model has been developed to generate optimal region vertices as well as some other supply chain characteristics, including, among others, which crops are going to be harvested, when they are going to be collected, and their storage levels. Additionally, two criteria were implemented in MILP model to create two optimal regions: one considering an economic criterion and other one minimizing environmental impact. As a result, two regions were drawn in the Navarrese territory that point out where a biorefinery should be located and how the supply chain should be designed.

Peer-review under responsibility of the Scientific Committee of EWGT2016.

Keywords: Facility Location Problem; Biorefinery, Mixed Integer Linear Programming, Biofuels

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2214-241X
Peer-review under responsibility of the Scientific Committee of EWGT2016.
10.1016/j.trpro.2017.03.014

1. Introduction

The location of a specific facility may be the difference between bankruptcy and success of its associated business. Decisions about location are said to be strategic because they require a large amount of resources which will have a long projection over time. Thus, locating a facility is a crucial decision companies usually have to face, at least, once in their life. For that reason, a lot of attention has been paid to develop several tools (Decision Support Tools, DST) that help decision makers to support their decisions in general, and their facility location decisions in particular. Such is the case that a whole branch of Operations Research deals with this kind of problems, which is known as Facility Location Problem (FLP).

Factors affecting locations decisions are unlimited, however, researchers have tried to identify the most important ones in order to measure and implement them in their DST. For instance, Chan (2001) considered two great factors classes: tangible factors (easy to quantify), which include transport costs, staff costs, energy costs, land availability, taxes…; and intangible factors (difficult to quantify), such as government stability, competitors, costumers/workers preferences, pollution and others. Then, some qualitative and/or quantitative analyses have been performed to obtain an optimal location given the aforementioned factor (Daskin, 2013). However, many problems can arise (administrative or legal issues, underestimated cost, unconsidered negative factors, etc.) when obtaining just a point to locate a facility once you have considered all the factors. For that reason, it is useful not only providing an optimal point to set up a firm but also a whole area to be considered by decision makers, or even several areas following. By doing so, the DST became a complete tool that helps the decision makers to locate the facility, providing information of two types: positive (the set of points being candidates for the location) or negative (set of points which should not locate the facility).

As a way to illustrate the previous methodology, this paper aims to determine optimal regions to place a biorefinery. A biorefinery can be defined as a complex facility that uses biomass as feedstock for the sustainable production of a range of different products (mainly biofuels, but also chemical commodities and electricity) which requires the integration of a huge variety of technologies (Cherubini et al, 2009). The biofuels have been reaching more and more interest because they search a worthwhile substitution for fossil fuels in transportation sector. Firstly, the fact that biofuels are usable in current vehicle setup make simpler their adoption and growth (Al-Mulali, 2015). Secondly, the use of biofuels allows a reduction of the dependence of many Western countries from oil production and extraction (Kallas and Gil, 2015). Finally, biofuels are considered a way to reduce level of CO2 emissions and increase energy security (Börjesson et al, 2014). For these reasons, among others, policy makers are promoting the use of biofuels in transportation (Cansino et al, 2012) which leads, therefore, to the consideration of building facilities capable to generate such biofuels (biorefineries) over the world. In this case, we will consider the Spanish Northern region of Navarre as a place where locate a potential biorefinery (see Fig. 1).

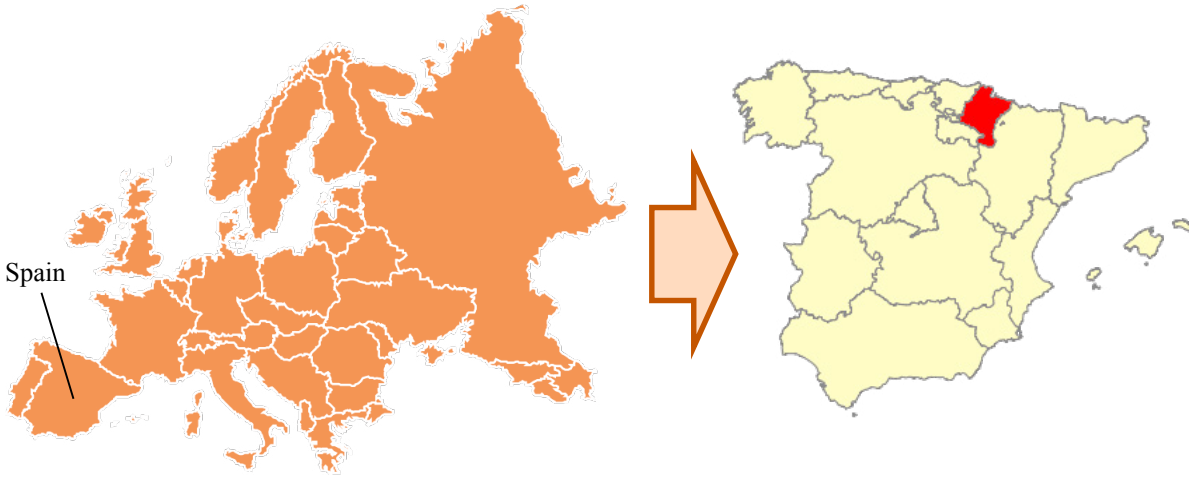

Fig. 1. Location of Navarre in Europe and Spain.