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Multi-attribute evaluation and selection of sites for agricultural product warehouses based on an Analytic Hierarchy Process ☆

J.L. García [a], A. Alvarado [a], J. Blanco [b,*], E. Jiménez [c], A.A. Maldonado [a], G. Cortés [d]

[a] Department of Industrial Engineering and Manufacturing, Instituto de Ingeniería y Tecnología, Universidad Autónoma de Ciudad Juárez, Ciudad Juárez, Mexico
[b] Department of Mechanical Engineering, University of la Rioja, Logroño, Spain
[c] Department of Electrical Engineering, University of la Rioja, Logroño, Spain
[d] Department of Industrial Engineering, Instituto Tecnológico de Orizaba, Orizaba, Mexico

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ABSTRACT

Site selection for companies is a complex and unstructured problem that must be analyzed carefully and properly, since a localization error could drive to bankrupt. This problem has been discussed widely and effectively using multi-attribute methods in a manufacturing context, but it has been little studied in agribusiness. The goal of this work is a methodological approach oriented to evaluate optimal locations of new agri-food warehouses. Furthermore, a literature review is developed, analyzing the location problem and the attributes and techniques most widely used applied to agribusiness, and a case-study is presented in order to exemplify the methodological proposal. The multi-attribute technique called Analytic Hierarchy Process has been selected as the basis for the research, and it is applied to the real case study analyzed: the selection of a site for a new banana distribution warehouse. Six generic criteria have been analyzed: accessibility to the area, distance, cost, security of the region, local acceptance of the company, and its needs. The process includes the assignment of attributes to each one of the generic criteria, as well as the assessment of their importance levels. Three different areas of Guadalajara, Jalisco, and Mexico DF have been evaluated for the case-study, and the methodological proposal has been utilized to determine the best option.

1. Introduction

1.1. Research context

One of the most important and difficult decisions posed to an investor who wants to promote a new company building is the identification of the location. The same problem is faced when an investor already well established in the market wishes to expand the business and seeks for a location for a new plant or branch. In both cases, the investor faces the same problem; however, those getting involved in this process for the first time are the ones who perceive a higher sense of risk and uncertainty when making this kind of decisions.

Since this kind of decision-making is not too common and always presenting special features, it can be asserted that it is a complex and unstructured problem, because there is no consensus among the experts regarding the multiple aspects that must be taken into account, the techniques to be used, and who are the responsible people to make the decision.

Due to the complexity of this selection problem, an investor should follow the course lead by several questions that assure the proper placement of the new company building or branch. Some of these questions are associated to: Which are the features or variables that should be taken into account when assessing a new placement as an alternative to establish a new company building or branch? Which are the most widely used techniques in the process of assessment and selection of a new placement location? Which are the main problems that an investor faces when selecting a new placement location? Which are the main mistakes that can be made when selecting a new placement location? (Osanloo and Ataei, 2003).

Uncu et al. (2002) assert that the location of a company building should take into account the current market in global terms, the changing conditions of the market, and a long list of environmental macro-factors linked to technological, economical, socio-political and legal changes, etc. In the same way, there is a long list of micro-factors, mainly composed of environmental and ecological aspects. Furthermore, it should be taken into account which kind of

* Corresponding author. Address: Department of Mechanical Engineering, University of la Rioja, Edificio Departamental, C/Luis de Ulloa, 20, 26004 Logroño, La Rioja, Spain. Tel.: +34 941 299 524; fax: +34 941299794.
E-mail address: julio.blanco@unirioja.es (J. Blanco).

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client will receive the service or product, as well as if the production is focused on a local or foreign environment. Besides, it is necessary to consider aspects such as the quality of the commodities, availability of qualified work force, competitors and suppliers.

Finally, the selection problem of a location of the new building involves the simultaneous assessment of several alternatives. There is also the possibility of buildings located in several distant places, since in the current globalized system there are many trade agreements between countries, such as the Free Trade Agreement between Mexico, the United States and Canada, the European Union, Mercosur, the GATT, and the like. It is quite common to see companies sponsored with foreign funds which are located in another country, according to certain commercial strategies that seek closeness to the clients, specialized work force, lower costs, and higher availability of resources and commodities for the production processes.

The objective of this paper is to generate a multi-criteria and multi-attribute assessment model that allows selecting the ideal location for warehouses for perishable agricultural products. In the implementation of the case study selected for application of the methodology, all the above stated circumstances are present; but the criteria and attributes presented in this research can be applied, in general, to any land field selection process.

In the coastal zone of Michoacán, Mexico, there is a wide group of farmers devoted to the plantation of banana. The local market is exhausted. The association of farmers has decided to establish a new distribution warehouse with different locations, with distances higher than 300 kilometers from the production site and with elevated options of exportation. And finally, the product (bananas), being perishable, requires special facilities for its preservation.

1.2. Site selection methods

Nowadays, there are different techniques for the decision making in the optimization of the selection process of the ideal location of production plants. The techniques more commonly used are (Au et al., 2006): Expanding the classification or scoring methods (Hoffman and Schniederjans, 1996); Analytic Hierarchy Process – AHP (Yurimoto and Masui, 1995; Liu et al., 2008; Dey and Ramcharan, 2008); Linear programming – LP (Brimberg and Revelle, 1999; Schmidt and Wilhelm, 2000); Heuristic (Rönnqvist et al., 1999) and Simulation (Chakravarty, 1999). Similarly, the multi-criteria mapping is also used, within which stands out the Technique for Order of Preference by Similarity to Ideal Solution – TOPSIS (Liang and Wang, 1991; Mahamid and Thawaba, 2010; Onut et al., 2010; Semih and Seyhan, 2011) and Analytic Network Process – ANP (Felice et al., 2012).

However, the techniques used in the process of assessing and selecting new sites, require experience and knowledge from the evaluators about the several alternatives considered. Taking advantage of the accumulated knowledge and expertise, artificial intelligence and expert systems are being used in the decision-making for searching the appropriate solutions (Banar et al., 2007). In the same way, since a few years ago Decision Support Systems (DSS) are being brought supported by the On-Line Analytical Processing (OLAP) System and Data Mining (DM) System, as a basic element of consultation where a quick response is always needed. Finally, it is worth noting the use of the Simple Additive Weighting (SAW) method.

Table 1 presents a literature review including authors, dates, methodology used and journal that publishes on the subject area. It is observed that AHP is one of the most used methodologies in the studies that have been conducted to assess new sites (see Fig. 1).

2. Materials and methods

The study adopts AHP methodology, developed by Thomas Saaty in 1980. According to Saaty (1992, 1993), it is considered ideal and consistent with the objective of creating a methodology for selecting the ideal location of warehouses for perishable agricultural products, since it belongs to the family of multi-criteria and multi-attribute techniques, and also due to the wide options for creating attributes, sub-attributes, and decision alternatives. Likewise, in this technique, the attributes involved in the assessment process have a subjective and appreciative character according to the perception of the evaluator who causes its wide acceptance in terms of conducting an assessment when the subjectivity values are elevated.

2.1. STEP 1: Attributes that an ideal location must meet

A detailed study has been made (shown in Table 2) to make a list of the main attributes suggested by 18 authors, who have researched the problem of site location for agricultural and industrial processing plants. The attributes are sorted descending from more to less cited. It can be seen that 16 of the 18 cites make reference to the road accesses of the location under assessment. Likewise, it is observed that the closeness and purchase capacity of the customers is a very important factor and requires further analysis. Moreover, the local labor force available is of great importance, as well as its training and expertise and the cost that it may imply. Finally, it is necessary to review the concept of *tax facilities* offered by the different administrations of a country.

2.2. STEP 2: Identification of problems and errors

During the selection process of new work locations, every company usually faces the following problems (Coretz, 2008), these problems present a temporal sequencing, due to the decision making by the management team of the company:

1st. There are numerous potential sites or rather excessive alternatives for the same issue.
2nd. There are also differences in risk perception by the people involved in the decision-making process.
3rd. The management board wants to meet a number of multiple objectives, quite often conflicting.
4th. These shared objectives are intangible or difficult to quantify.
5th. There is a wide variety of interests in the people responsible for the decision-making.
6th. There is a need to analyze and assess the environmental, economic and technological impacts.
7th. There are possible delays and problems in building permits and licenses.
8th. There are different perception values when assessing the compensations granted by local, state, and federal governments.
9th. When the alternatives are too distant from the place of origin of the investment funds, cultural aspects of the new location should be taken into account (gender and equity issues, customs and traditions, etc.).

On the other hand, it is also necessary to control and minimize the number of errors that are frequently made during the selection process of a new work location, based on previous experiences and generated knowledge. Below, they are shown in a categorized way the mistakes more commonly made, which the AHP model should minimize.