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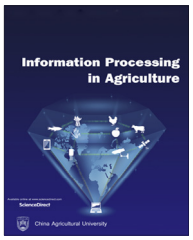

Selecting the most appropriate tractor using Analytic Hierarchy Process – An Iranian case study

Sherwin Amini [a,*], *Mohammad Amin Asoodar* [b]

[a] *Department of Biosystems Engineering, Ferdowsi University of Mashhad, Mashhad, Iran*
[b] *Department of Agricultural Machinery and Mechanization Engineering, Khuzestan, Ramin Agriculture and Natural Resources University of Khouzestan, Iran*

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ABSTRACT

With regard to the importance of selecting an appropriate tractor in rural areas which is one of the main tasks for most farmers, the aim of this study is to select the best tractor in Ghaemshahr and Ahvaz cities of Iran. The methodology of the paper is descriptive-analytic and data were collected through library and field works (interviews and questionnaires). The statistic population of this study was 25 tractors in Ghaemshahr and Ahvaz, in that 15 tractors were chosen randomly, and the data were analyzed using AHP (analytic hierarchy process). The results showed that the maximum effect regarding the selection of tractor belonged to the maintenance with 49.4% and the minimum went to ergonomic effect with 7% in Ahvaz and the maximum effect was related to price with 29.6% and the minimum went to ergonomic effect with 6.8%. ITM285 and Romania 650 with 83% were the best tractors in Ahvaz and John Deere 6150 with 83% was the best tractor in Ghaemshahr city. Incompatibility ratio for all the comparisons was zero, so the criteria are completely compatible with the aims and options.

1. Introduction

Selection is a broad comparison of suppliers using a common set of criteria and measures. However, the level of detail used for examining potential suppliers may vary depending on a firm's needs. Studies conducted on Danish farms show vast differences in machine costs, ranging from 3000 to 7000 DKK ha1 [21]. This clearly emphasises the importance of developing methods for choosing the optimal machinery.

The Analytic Hierarchy Process (AHP) is a method of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales [32,33]. It has been one of the most widely used multiple criteria decision-making tools [40]. It is used by decision makers and researchers, because it is a simple and powerful tool [15]. In fact, the hierarchical structure of AHP methodology is able to measure and synthesize a variety of factors of a complex decision making process in a hierarchical manner, making it simple to combine the parts in a whole. A bibliometric research [41] found that the number of publications related to MCDM – Multi-Criteria Decision Making/MAUT–Multi-Attribute Utility Theory – increased 4.2 times from 1992 to 2006. This phenomenon can be mostly attributed to a relevant growth of the publications focused on AHP and EMO – Evolutionary Multi-Objective Optimization.

Putting together an ideal machinery system is not easy. On the other hand, the limitation of resources in agriculture shows the importance of appropriate technology selection

* Corresponding author.
E-mail address: sh_am21@stu.um.ac.ir (S. Amini).
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to optimize the limited and expensive resources in agriculture. Conquering technical and climate limitations as well as temporal constraints, mechanical technologies provides the possibility of increasing the acreage and the production of the agricultural sector. In fact, mechanical technologies make possible the application of research findings in different agricultural branches. As a result, agricultural mechanization has become an undeniable necessity for increasing productivity use in other inputs [13].

AHP has been applied in different fields such as planning, alternative selection, resource allocation, and optimization [24]. The uniqueness of AHP is its flexibility to be integrated with different techniques like linear programming, QFD, and fuzzy logic [12]. This enables the user to extract benefits from all the combined methods, and hence, achieve the desired goal in a better way [40].

In this study it is focused on the agricultural machinery selection which is the important part of the machinery management decision. Among the agricultural machines, tractors are handled. Tractor is one of the most important tools on acreage and plays an important role in agricultural production. The purchase of a tractor and associated equipment need substantial investment. The result of improper tractor selection can be costly. For example when a relatively small tractor is chosen for a large land, it's faced with long hours in the field, excessive delays and premature replacement whereas a relatively big tractor can result in excessive operating and overhead costs [36].

Many researchers have used AHP for different purposes, for example, Ahadi and Ghazanfar-Rad [1] used it for selecting the best rolling stock provider, Kahraman et al. [22] used a fuzzy AHP for choosing the best provider in Turkish White factory; decision makers could determine the priority and preference for selecting a provider using fuzzy logic variables. The triangle fuzzy numbers were used in the method and the analysis of development method was used for analyzing paired comparisons. Kilincci and Onal [23] used a fuzzy AHP method for selecting the provider. This choice was based on the customers' satisfaction. Russo and Camanho [29], in their study as "Criteria in AHP: a systematic review of literature", tried to develop a systematic review of literature on the real cases that applied AHP to evaluate how the criteria are being defined and measured. In the 33 cases selected, they mainly used literature to build the criteria and AHP or Fuzzy AHP to calculate their weight, while other techniques were used to evaluate alternatives. Tam and Tummala [38] have used AHP in vendor selection of a telecommunication system, which is a complex, multi-person and multi-criteria decision problem. They have found AHP to be very useful in involving several decision makers with different conflicting objectives to arrive at a consensus decision. The decision process as a result is systematic and reduces time to select the vendor. Byun [10] used an extended version of AHP in the selection of a car; he focused on two issues: one issue combines the pairwise comparison with a spreadsheet method using a five-point rating scale and the other issue applies group weights to consistency ratio (CR). AlKhalil [2] used AHP to select the most appropriate project delivery method as key project success factor. The model developed using AHP was found to be easy to use and allows the owner to consider all decision-relevant factors. Choughle and Ravi [14] have proposed variant process planning of castings using AHP-based nearest neighbour algorithm for case retrieval. Ayag [7] has proposed a hybrid approach to machine-tool selection through AHP and simulation.

Mehta et al. [25] developed a Decision Support System (DSS) to select a tractor and its matching equipment for different soils and operating conditions. Zhou [44] proposed a new comprehensive assessment method, which combines neural networks and support vector machine based on Particle Swarm Optimization (PSO). Grisso et al. [18] used tractor test data for selecting farm tractors. García-Alcaraz et al. [17] proposed hybrid and multi-attribute approach to assess a set of agricultural tractors based on Analytic Hierarch Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. Bol and Mohammed [8] developed a mathematical model for farm machinery selection. Osman [27] developed a model for optimization of farm machinery management by linear programming.

Lin and Yang [24] developed a model for the selection of the most suitable machine from a range of machines available for the manufacture of particular part types. In their study, there were four main criteria: machine procedures, lead time, labor cost, and operation shift; and three alternatives: conventional machines, NC machines, and flexible manufacturing cells. Tabucanon et al. [37] developed a decision support framework designed to aid decision-makers in selecting the most appropriate machines for flexible manufacturing systems (FMS). The framework consists of two main stages. The first stage, called as the pre-screening stage, narrows down all possible configurations using AHP. The second stage uses a goal programming (GP) model. Yurdakul [43] presents a model that links machine alternatives to manufacturing strategy for machine tool selection. In his study, the evaluation of investment in machine tools can model and quantify strategic considerations by using the AHP method. On the other hand, Cheng et al. [11] claim that although AHP is an effective tool for management decision-making, it can be defective if used improperly. Wang et al. [42] suggest a fuzzy multiple-attribute decision-making model to assist the decision-maker in dealing with the machine selection problem for FMS. A linear 0–1 integer programming model for machine tool assignment and operation allocation in FMS is proposed by Atmani and Lashkari [6]. Their model determines the optimal machine-tool combinations and assigns the operations of the part types to the machines (minimizing total costs of processing, material handling, and machine setups). A machine tool selection problem similar to ours is addressed by Arslan et al. [5] and a multi-criteria weighted average approach is proposed.

Uma Devi et al. [39] in their study as "Vendor Selection Using AHP" propos an analytic hierarchy process model for selecting the best vendor among the alternatives. The choice of the right vendor is a crucial decision with wide ranging implications in a supply chain. The proposed model can help the firm in selecting the efficient vendor. AHP is multicriteria decision making tool that takes into account both qualitative and quantitative criterias.

The general points and considerations for an appropriate selection in the view of Almasi et al. [3] are as follows:

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