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A decision support system for agricultural machines and equipment selection: A case study on olive harvester machines

Ashkan Hafezalkotob[a,*,1], Aida Hami-Dindar[a,b,1], Naghmeh Rabie[a,1], Arian Hafezalkotob[c,2]

[a] College of Industrial Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran
[b] College of Agriculture & Natural Resources, University of Tehran, Iran
[c] Department of Mechanical Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran

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ABSTRACT

Olive is considered as one of the most important and useful products, but the traditional harvesting methods are failing to fulfill the current need; therefore, it is crucial to make the olive harvesting mechanized. In order to expedite the olive harvesting mechanization process, the engineers have designed various machines and equipment, which have their own special advantages. Now, the main challenge is to select the best olive harvesting machine to develop and improve the economic conditions in agricultural field to maintain the food demand. In the present study, we intend to present a decision support system to aid decision-making about olive harvesting machines. To achieve this target, we evaluate six candidate machines with nine important criteria and classify them into three groups: beneficial, non-beneficial, and target-based criteria. For weighting the criteria, the best-worst method is applied, and because of having target criterion in the selection problem, the decision matrix is normalized by the target-based technique. Finally, using two proposed methods, target-based MULTIMOORA and WASPAS, we select the best harvesting machine. In addition, we employ dominance method to integrate the resultant rankings of harvesting machines.

1. Introduction

Nowadays, due to growing population and the simultaneous increase in food demand, the traditional farming technique is turning out to be mechanized, thus eventuating in a remarkable progress in the agricultural field. Today, multifarious machines and equipment are available for different agricultural processes, especially for product harvesting in which the selection of best machine considering the efficiency and other factors is a real challenging issue for farmers. Such an example is olive harvesting. Olive is regarded as one of the most significant products in many countries such as Spain, Italy, Greece, Turkey, and Iran. However, due to the difficult and time-consuming manual harvesting process, various machines have been devised for harvesting.

In the present study, we aim to present a decision support system (DSS) to aid decision-making about olive harvesting machines. In this regard, we consider six machines and equipment as the alternatives and also some effective factors as selection criteria. These six machines are hand-held comb harvesters, side-pass comb harvesters, straddle harvesters, side-by-side shakers, umbrella shakers, and tractor-mounted shakers. In Section 4, we have introduced these olive harvesting machines and discussed their special features and mechanisms in detail.

In the model, we consider different quantitative and qualitative criteria to find and select the best machine. In traditional multiple criteria decision-making (MCDM) methods, criteria are divided into beneficial or non-beneficial, but the target-based MCDM method applied in our model, beneficial, non-beneficial, and target-based values for criteria are considered. The target-based criterion is neither beneficial nor non-beneficial but a specified quantity is required for it. After normalizing the decision matrix, we apply the best-worst method (BWM) which is based on experts' opinions to determine the weights of different criteria. In BWM, the experts assess the importance of each criterion in relation to the best and worst criteria. In our proposed model, the experts are asked to evaluate the criteria considering their significance in olive harvesting machines. Finally, we employ target-based MULTIMOORA and weighted aggregated sum product assessment (WASPAS) methods to rank our alternatives. Actually, we prefer to apply the target-based normalization techniques in place of

* Corresponding author.
E-mail addresses: a_hafez@azad.ac.ir, hafezalkotob@iust.ac.ir (A. Hafezalkotob), aida.hami71@ut.ac.ir (A. Hami-Dindar), naghmeh724rbk@gmail.com (N. Rabie), ar_hafezalkotob@azad.ac.ir (A. Hafezalkotob).
[1] Postal address: College of Industrial Engineering, Islamic Azad University, South Tehran Branch, Entezari Aly, Oskoui St, Choobi Brg, Postal-Code: 1151863411, Tehran, Iran.
[2] Postal address: Department of Mechanical Engineering, Islamic Azad University, South Tehran Branch, Ahang Ave, Mahalati Blv, Tehran, Iran.

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traditional norms because it is more suitable for criteria of harvesting machine selection.

The rest of the study is organized in four sections. An extensive literature review related to machine selection, BWM, MULTIMOORA, and WASPAS is presented in Section 2. In Section 3, the DSS is developed by incorporating the target-based method and BWM with MULTIMOORA and WASPAS. In addition, an algorithm is also provided in this section to elucidate the steps of each method. In Section 4, by presenting a real numerical example of olive harvesting machine selection, the results of the methods are compared and the rankings of alternatives are presented. Section 5 put forward the conclusion remarks of this study and directions for future investigations.

2. Literature review

2.1. Survey on applications of MCDM methods in machine selection

Over the past few years, many researchers employed different MCDM methods in machine selection process. Dağdeviren (2008) proposed an integrated approach of analytic hierarchy method (AHP) and the preference ranking organization method for enrichment of evaluations (PROMETHEE) to select the milling machines for an international company. Taha and Rostam (2011) presented a machine tool selection problem in flexible manufacturing cells using fuzzy analytic hierarchy process (F-AHP) and artificial neural network (ANN). In their study, the authors implemented ANN to verify the results of F-AHP (PECAR program) and predict the ranking of alternatives. Aloini et al. (2014) applied a peer-based adjustment to intuitionistic fuzzy multi-criteria group decision making with TOPSIS method (peer IF-TOPSIS) for a packaging machine selection problem. The researchers selected the intuitionist fuzzy weighted averaging (IFWA) operator to combine the opinions of decision makers for rating the criteria and alternatives. Khandekar and Chakraborty (2015) proposed an MCDM method using the fuzzy axiomatic design approach to select the most suitable material handling equipment (MHE). Çakır (2016) demonstrated an integrated method of fuzzy simple multi-attribute rating technique (SMART) and fuzzy weighted axiomatic design (FWAD) approach to specify the best continuous fluid bed tea dryer. Karim et al. (2016) incorporated AHP and TOPSIS methods for selecting the best suitable machine. Wu et al. (2016) extended a multi-criteria group decision making (MCGDM) method relying on the fuzzy VIKOR approach for optimal CNC machine tools selection. Ozfirat (2015) solved a tunneling machine selection problem using the F-AHP. Sahu et al. (2015) developed VIKOR approach using fuzzy computation and included both qualitative and quantitative criteria for a CNC machine tool selection problem. Hafezalkotob and Hafezalkotob (2017b) introduced an extension of the VIKOR method based on interval ratings of alternatives on criteria and interval target values of criteria. They utilized the proposed method for two practical cases of punching machine and continuous fluid bed tea dryer.

2.2. Survey on best-worst method

BWM is a multi-criteria decision-making method for specifying the weights of criteria. Rezaei (2015) developed BWM by applying best-to-others and others-to-worst vectors. The most profitable criterion should be compared with other criteria. Moreover, other criteria should be compared to the cost criterion. Many researchers have applied it in decision-making problems. Rezaei (2016) evaluated the consistency ratio of BWM in MCDM problems. Rezaei et al. (2016) expressed that any firm's competitive advantage can easily be affected by supplier selection, thus they employed the conjunctive screening for pre-selection and chose BWM as a pioneer MCDM method for the selection phase. Gupta and Barua (2016) propounded that it is not effortless to transmit the socioeconomic conditions of a developing country. The micro, small, and medium enterprise should concentrate on promising entrepreneurs and innovators to stand out the global competition; hence, they applied BWM to discover the main enablers in the field of technological innovation. Rezaei et al. (2016) stated that the airlines perform freight transportation in a hub and spoke structure. In bundling freight, there are three options; hence, it can be considered as an MCDM problem. So they assessed the most useful configuration with respect to the three key performance indicators using BWM method. Sadaghiani et al. (2015) studied how to moderate the gap in the Oil and Gas operating environment by evaluating the dimensions of the external forces. They also discussed the moderating gap could play a significant role in a sustainable supply chain management strategy. They employed BWM method in their research to evaluate the circumstances of the external forces. Ghimire et al. (2016) incorporated the discrete choice experiment and BWM method in their model to compare the implementation shares of stress-tolerant, low-maintenance, and low-cost turf grass criteria. Salimi and Rezaei, 2016 examined the incorporating inputs and outputs for a successful collaborative Ph.D. project using BWM method.

2.3. Survey on WASPAS method

In this section, we have reviewed the recent studies on WASPAS method. Chakraborty and Zavadskas (2013) discussed that WAPAS has the strength to rank the alternatives accurately. Keshavarz Ghorabaee et al. (2016) stated that the crux of green supply chain management is to decrease the harmful environmental effects at all levels of supply chain. They explicated a novel viewpoint based on WASPAS and the concept of interval type-2 fuzzy sets. Zavadskas et al. (2015) suggested that it is necessary to evaluate the houses to make them energy-efficient and fulfill the human demands. The authors exploited the WASPAS method for determining the internal environment of six apartments. To choose the best shopping center, Turskis et al. (2015) introduced a fuzzy multi-attribute performance measurement framework incorporating WASPAS with fuzzy values and AHP. Vafaeipour et al. (2014) used WASPAS approach to rank cities according to the numbers of solar power plants. Zavadskas et al. (2014) expressed that WASPAS is more accurate than weighted sum and weighted product models (WSM and WPM). In addition, the researchers also developed a type of WASPAS for the unsteady decision-making environment. Zavadskas et al. (2012) remarked that the selection of a suitable MCDM is one of the crucial parts of computer-aided multiple criteria decision-support system. They examined the accuracy of recent methods for raising the ranking accuracy of alternatives by considering WSM and WPM. Dėjus and Antuchevičienė (2013) believed that the suitable solutions for occupational safety rely on a number of criteria like dangerous factors, so they proposed WASPAS method in this context. Zavadskas et al. (2015) assessed the functionalities of WASPAS method for parametric optimization of non-traditional machining processes.

2.4. Survey on MULTIMOORA method

MULTIMOORA is a robust MCDM approach developed by Brauers and Zavadskas (2010) which has been widely used in engineering problems. Liu et al. (2014) stated that handling of healthcare waste is one of the main challenges of large cities. They extended the MULTIMOORA method based on interval 2-tuple linguistic terms for rating the healthcare waste treatment technologies. Brauers et al. (2014) aggregated different criteria using aforementioned method for their multi objective problem. Baležentis and Zeng (2013) developed MULTIMOORA method by using type-2 fuzzy sets. Kildiene (2013) used this method for evaluating opportunities for construction enterprises. Baležentis et al. (2012) extended the fuzzy MULTIMOORA based on linguistic logic under group decision making by aggregating subjective evaluations of decision makers. Hafezalkotob et al. (2016) developed the method by applying interval numbers based on the fuzzy logic concept. They indicated that the decision-makers can effectively use the

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