Simple Additive Weighting Methods of Multi-criteria Decision Making and Applications: A Decade Review

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Abstract

Various multi-criteria decision making (MCDM) methods have been proposed to solve diverse applications of decision problems. One of the MCDM methods is additive weighting-based method. However, this method is not explicitly disseminated and its applications are not well-received by many MCDM enthusiasts. This paper presents a review of the applications of simple additive weighting (SAW) and fuzzy simple additive weighting (FSAW) from 2003 to 2013. Two classifications of individual approaches and integrated approaches were made in this paper. Related articles appearing in international journals from 2003 to 2013 are gathered and analyzed. From the observation, it was noticed that ten out of nineteen articles or fifty-two percent applied SAW or FSAW in the management selection process. This review provides the most prevalent application of the methods and also aids researchers in choosing the appropriate applications of SAW based methods. This paper would offer useful information for other researchers since it provides the latest evidence about SAW and FSAW.

Keywords: Simple Additive Weighting, Fuzzy Simple Additive Weighting, Decision Making, Multi-criteria

1. Introduction

Decision making becomes an integral part in our daily lives and will be used for complex problems including problems with multiple conflicting criteria. Multi-criteria decision making (MCDM) is a well-known decision making process based on the progression of using methods and procedures of multiple conflicting criteria into the management planning process [1]. In other words, MCDM refers to making decision in the presence of multiple, numerous and usually conflicting that involve numbers of criteria. MCDM provides a step by step procedure for which a consensus decision can be made by a group of decision makers. This well-defined procedure can reduce the amount of arguments or conflicts involved. MCDM plays an important role in solving complicated problems. The development of MCDM discipline is closely related to the advancement of computing technology. With this development, it is possible to conduct systematic analysis of complex MCDM problems. Furthermore, the extensive use of computing software has generated a huge amount of information, which makes MCDM increasingly important and useful in supporting decision making.

In literature, multiple attribute decision making (MADM) and multiple objective decision making (MODM) are two basic approaches to MCDM. There exist a number of methods in each of the mentioned approaches. Pohekar and Ramachandran [2] pointed out that every method has its own characteristics and the methods can also be classified as deterministic, stochastic and fuzzy methods. Carlsson and Fuller [3] made an extensive review on MCDM and categorized it into four major categories. One of the categories is value and utility theory approaches. This second category is built around methods which utilize various ways to assess the relative importance of multiple attributes and alternatives. Under this category, most the methods were concentrated on weight determination. It comprises simple additive weighting (SAW), analytic hierarchy process, fuzzy conjunctive/disjunctive methods, fuzzy outranking methods and max-min methods. It seems that the methods of SAW and fuzzy simple additive weighting (FSAW) are the MCDM methods that used for weight determinations and preferences. Churchman et al., [4] were the first research utilized the SAW method to cope with the portfolio selection problem. This method is also known as a weighted linear combination or scoring method. It is simple and the most often method used multi-attribute decision technique. The method is
based on the weighted average using arithmetic mean. An evaluation score can be calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by the decision makers followed by summing of the products for all criteria. The advantage of SAW method is that it is a proportional linear transformation of the raw data. It means that the relative order of magnitude of the standardized scores remains equal.

A newly invented, FSAW is an extension of SAW whereby fuzzy numbers are used rather than crisp numbers. Zadeh [5] pioneered the use of Fuzzy Set Theory to address problems involving fuzzy phenomena. FSAW is the modified version of SAW where it utilizes trapezoidal fuzzy numbers to show any imprecision in scores and weights. Its computational procedures involve several fuzzy arithmetic operations [6]. FSAW applies fuzzy weighting to approach individual decision makers in considering the professional experience or authority importance of each decision makers in its procedure. These SAW and FSAW are other types of MCDM but have not gained much attention due to its limitations in computational reliability and applications.

There are many studies used MCDM and applied to various selection problems. One of the most extensive reviews on MCDM and its application to supplier selection was by Ho et al., [7]. This review was meant to determine the approaches that prevalently applied in supplier selection process and also to evaluate the criteria that are normally used in supplier selection. Analytic hierarchy process was the most popular approach in the solving supplier selection problems. Agarwal et al., [8] also made a review of various MCDM approaches for solving supplier evaluation and selection problems from 2000 to 2011. Abu-Taha [9] managed to collect more than 90 published papers on MCDM analysis in the renewable energy. However, all these reviews were meant to observe the general MCDM methods and its application to various knowledge domains without focussing to a particular method of MCDM. To the best of the authors’ knowledge, there have been no reviews about SAW or FSAW and its applications in recent years. This paper aims to review the methods of SAW and FSAW and its various applications from year 2003 until 2013. This paper is organized as follows: Section 2 and Section 3 describe the individual and integrated approaches on the SAW and FSAW methods respectively. Section 4 provides an analysis of all the methods found and discusses the methods and their applications in the perspective of popularity. A short conclusion is made in Section 5.

2. Individual Approaches

A single approach that was used SAW and FSAW to solve various problems is defined as individual approach.

2.1. Simple Additive Weighting (SAW)

Huang et al., [10] studied Multi-Attribute Utility Theory (MAUT) where it elicits an individual decision maker’s preferences for single attributes and develops a utility function by the mathematical formulation to add up the preferences of the entire set of attributes when evaluating alternatives. The method SAW is a common aggregation method of MAUT for decision makers, which does not consider the different preferential levels and preferential ranks for each decision maker’s assessment of alternatives in a decision group. This method seems too intuitive in achieving the consensus and commitment for group decision aggregation. They performed a comparative analysis to compare proposed approaches to the SAW model. To investigate the satisfaction levels of the final two resulting group decisions, a satisfaction index was used. In this research paper, the preferential differences denoting the preference degrees among different alternatives and preferential priorities denoting the favorite ranking of the alternatives for every decision maker were both considered and aggregated to construct the utility discriminating values for assessing alternatives in a decision group. For better understanding about the subjective perceptions of decision makers while examining the results obtained from the two approaches for the second practical case, a feedback interview was conducted. The results show that the proposed approach is able to achieve a more satisfying and agreeable group decision than the SAW method.
Shameli et al., [11] presented a practical model for information security risk assessment. The model is based on MCDM and uses fuzzy logic. Risk assessment is a complicated process normally found in a complex organization which involves a lot of assets and it is a major part of the Information Security Management Systems (ISMS) process. To access the risks and get the practical results, the fuzzy logic is an appropriate model. The authors applied the famous and widely utilized SAW methods in their research. The TOPSIS model was used to compare the results. The evaluation process in the proposed model is divided into two levels: managerial and operational. At the end of this research, the models gave the same results. For best results, they got help from experts for each threat and domain. This model was performed completely in the section of information technology of a supply chain management company and the results show it is efficient and dependable.

Afshari et al., [12] applied SAW in their research to solve personnel selection problems in Iran. In this paper, it considered an actual application in personnel selection by using the opinion of experts. The data used in this model were gathered from five experts. A questionnaire was used to collect data in one of the telecommunication companies in Iran using the scale values of 1 to 5. The authors applied seven criteria where they were qualitative and positive for selecting the best amongst five personnel which later being ranked. The criteria were able to work in different business units, past experience, team player, fluency in a foreign language, strategic thinking, oral communication skills and computer skills. Results of SAW approaches show that P3 is the best personnel to be selected. The limitation in this research paper is that SAW ignores the fuzziness of executives’ judgment during the decision-making process.

### 2.2. Fuzzy Simple Additive Weighting (FSAW)

Deni et al., [13] used FSAW method for selection of a high achieving student at faculty level. The data were obtained from the Faculty of Engineering, Udayana University. There were six criteria taken into consideration in the selection of high achieving students. Grade point average (GPA), TOEFL score (English language score), the number of papers that were ever made, a number of seminars/workshops which have been followed, a number of committees which have been followed and the number of awards owned were the selected criteria. Some of these criteria have high levels of valuation. Each criterion was defined as a priority assessment weighting (W) in the selection of high achieving students. The weight used consists of five fuzzy numbers which ranking from Very Low (VL), Low (L), Medium (M), and High (H) to Very High (VH). The researchers implemented FSAW method in a system. The system was used on the inputting form of high achieving student criteria values. The user would fill the forms with the value of each criterion and the system then process these values in accordance with the calculation of FSAW method. The system processed the input that eventually comes out with the result. Every student was determined by their student ID. The result of this research shows that the FSAW method can be used in the selection process of high achieving students. The FSAW used simple weighting calculation that can provide the best decision.

Gupta and Gupta [14] analyzed an existing system of vendor rating. The authors noticed that most organizations used SAW for vendor rating. However, they attempted to use the fuzzy decision making method for the purpose. The authors make comparison between the existing vendor rating system; SAW, FSAW and fuzzy TOPSIS for rating the vendors. Results obtained show that fuzzy TOPSIS is more helpful in rating the vendors effectively. The authors decided that fuzzy TOPSIS is the best method because the good point is it can be used for qualitative as well as quantitative criteria. Fuzzy TOPSIS also can deal with decision making problems in linguistic environments. From this study, the authors summarized that the Fuzzy TOPSIS is more useful when there are a large number of criteria and alternatives.

Kumar et al., [15] implemented FSAW in the selection of an appropriate maintenance strategy for material handling equipment in Punj Lyord plant Gwalior (India). Experts weights were assigned to linguistic variables and these linguistic variables were translated into triangular fuzzy numbers to the MCDM problem. Five experts were chosen for this research, six maintenance strategies and ten evaluation criteria. The six maintenance strategy meant is corrective maintenance, preventive
maintenance, condition based maintenance, opportunistic maintenance, predictive maintenance and breakdown maintenance. Ten evaluation criteria are quality, spare parts inventories, purchasing cost of spare parts, maintenance labor cost, reliability, safety, maintenance time, facilities, the cost of supporting equipment, and environment. The authors calculated the different priority weights of each criteria and strategy by using the FSAW method after the construction of the hierarchy. The result of applying FSAW proved that breakdown maintenance is the best maintenance strategy for material handling equipment.

Lin et al., [16] applied FSAW in their study with the objective to determine health examination institution (HEI) location selection in Taipei Metropolitan. Effectively, FSAW had been used to deal with the subjective and objective (qualitative and quantitative) criteria. This is being formed by integrating fuzzy set theory, factor rating system and SAW. Peculiarly, the procedure considers the expert experience or authority importance of each decision maker under group of decision making conditions. They employed systematic FSAW to investigate six criteria for selecting a new HEI location in Taipei Metropolitan. Among six criteria chosen, the investment cost is treated as an objective criterion evaluated by using the data of the real estate acquisition cost in the current market. In addition, FSAW evaluates the individual decision maker, which allows the investors to consider the expert experience in location selection or the proportion of investment. Through the study, FSAW clearly can be applied to solve the facility location selection problems.

Abdullah and Jamal [17] modified fuzzy simple additive weight (FSAW) decision making model to describe the applications of a fuzzy decision making method in ranking indicators of Health-Related Quality of Life among kidney patients in a Malaysian government funded hospital. Four experts consisting of a medical officer and three nurses were selected as decision makers to obtain information regarding health related condition of chronic kidney disease patients over eight health related quality of life indicators. The volunteer group of experts were required to rate the regularity of experiencing health-related problems in linguistic judgment among the patients. The aim of the modifications was to accommodate the objective of the research and also to simplify the computational procedures while maintaining the originality of FSAW. They used five linguistic variables as input data in a modified version of FSAW decision making model. The authors define all the decision makers as having an equivalent weight where it means all the decision makers are equally authoritative. In this proposed method, criteria and alternatives are replaced with indicators. It is relatively straightforward and eventually reduced the computational cost. The modified six-step method was successfully identified the weights for indicators and possible to achieve the extent of decision makers’ opinions on the stage of health related quality of life experienced by the patients. The outcome of this survey shows that the indicator of role-physical recorded as the lowest problematic level while the indicator of mental health recorded as the highest problematic level experienced by patients. The ranking represents the impact of the indicators of health quality especially of the chronic kidney disease patients.

Kabassi [18] presented a fuzzy MCD, FSAW and applied it for evaluating personalized software. Specifically, she applied FSAW theory for the evaluation of a Geographical Information System (GIS). The GIS is the system where it has the ability to process information about its users in order to adapt its interaction to each user dynamically. By using the linguistic terms, the proposed system has been evaluated in comparison to a standard GIS. These terms were further translated to fuzzy numbers in order to compute a crisp value for each GIS aggregating all the criteria taken into the account. The authors describe how a fuzzy MCDM theory can be used for evaluating a personalized GIS. The evaluation results showed that personalizedGIS described surpass a standard GIS in selecting the information that is most useful for a certain user.

Chou et al., [19] proposed FSAW that integrates fuzzy sets theory, the factor rating system and SAW to solve facility location selection problems by using objective and subjective attributes under group decision-making conditions. They applied FSAW to deal with qualitative and quantitative dimensions. The process of FSAW was considered the importance of each decision maker and then the total scores for alternative locations are derived by homo/heterogeneous group of decision-maker. The
examples from Liang and Wang [20] and Liang [21] were used as two examples to describe the facility location selection in the proposed system.

Rajaie et al., [22] proposed a simple multi-criteria system to assist decision makers in the decision process of ranking contractors. This system uses FSAW that are based on the theory of fuzzy logic. The mentioned method was utilized in a real construction project in Iran which is in a large structure stadium accommodation about 10000 spectators in Semnan. Firstly, the fuzzy weight of each criterion is computed. The criteria were weighted according to the owners managers’ opinions and construction expert’s opinion, if necessary. The eight criteria to evaluate the contractors are experience, management capability, financial stability, and previous experience in similar or related work, the number of projects currently being handled by the company, safety and health standards, technical and management personnel and technical ability. The study evaluates seven contractors. The model utilizes triangular and trapezoidal fuzzy numbers to assess the contractor’s suitability with respect to each criterion. Then, the authors use the FSAW to rank the contractors. Part of this study analyzes their effect on contractors’ score by varying them in order to evaluate the influence of the criterion weights. The results proved that by using FSAW method, the contractor’s final scores are not overly sensitive to the weights. Therefore, the authors conclude that this method is especially recommended for particular users.

3. Integrated Approaches

Integrated approaches are defined in cases where more than one approach was used to solve various MCDM problems.

3.1. Integrated SAW Approaches

3.1.1. Integrated SAW and Sensitivity Analysis

Memariani et al., [23] applied a new method for sensitivity analysis of MADM problems so that by using the proposed method and changing the weights of attributes, one can determine changes in the final results of a decision making problem. This sensitivity analysis applied to SAW technique. In this paper, the authors consider three alternatives and four attributes whereby two of these attributes are cost type and the other is profit type. For the study conducted, shifting the weight of one attribute can affect the weight of other attributes and the final score of all alternatives also changed. Normally, the attributes chosen for decision making are conflicting; it’s implied that the improvement at one attribute may result in the deflation of other attributes. Also, weight can be assigned by considering the relative importance of attributes. As a conclusion, the change in the value of weight of one attribute leads to change in ranking of alternatives.

3.1.2. Integrated SAW and TOPSIS

Chen [24] used SAW and the technique for order preference by similarity to an ideal solution (TOPSIS) as the primary structure to deal with interval-valued fuzzy evaluation information. The author presents SAW-based and TOPSIS-based multi-criteria decision analysis (MCDA) methods and conducts a comparative study through computational experiments by applying an interval-valued fuzzy framework. Numerous random problems of different sizes were generated and computed to compare the solution results yielded by the interval-valued fuzzy SAW and TOPSIS methods for different score functions and conditions of criteria importance. The author conducts a comprehensive study to compare the ranking orders of the alternatives, including analysis of the average Spearman correlation coefficients and the contradiction rate of the best alternative. The data are randomly generated to form MCDA problems with all possible combinations of 4, 6, 8, 22 alternatives and 4, 6, 8, 22 criteria. From the correlations and contradictions rates obtained in the experiments, there is suggestion that evident similarities exist between the interval-valued fuzzy SAW and TOPSIS rankings.
3.1.3. Integrated SAW, (A, B, and C) ABC Analysis and Statistical Clustering

Hematyar [25] combined fuzzy approach with traditional ABC, SAW and statistical clustering based on the data from main transformers for classifying the gas power plant spare parts. The aim of this research is to provide a technique to classify the spare parts by fuzzy approach. The investigation was carried out at Gas Power Plant in Iran and data were collected by interviewing, studying documents and analyzing numerical data. From the results, inventory managers and decision makers are satisfied with this method. The methods become more understandable by the use of linguistic variables and results become more acceptable when weight is considered for each criterion. The source also stated that it is not an easy task for decision maker to rank all criteria and classify all parts when the number of criteria or parts is large.

3.1.4. Integrated SAW, TOPSIS and Artificial Neural Network (ANN) Method

Manokaran et al., [26] analyzed and ranked the employees’ performance by using TOPSIS and SAW methods. Validation of ANN method is the extension of this research paper. There are two objectives stated in this paper. The first objective is to compare the various MCDM tools to decision-making problems. While the other objective is to determine parameter analysis that compared with other methods and the mathematical approach of solving the problem with both the function. The authors conduct a questionnaire and survey among the employees and only the dominant factors were considered for this study. Different methods were analyzed and based on the evaluation of weight, the grades were given. By using ANN method, the obtained results are validated. Results show that TOPSIS method is quite capable and computationally straight forward to evaluate and choose the significant effect of stress from a given data. The employees with high performance level are ranked by comparing the results obtained from TOPSIS, SAW and ANN.

3.2. Integrated FSAW Approaches

3.2.1. Integrated FSAW and FAHP

Kiris and Ustun [27] applied fuzzy MCDM approaches which are fuzzy AHP and fuzzy SAW to the portfolio selection problem in a crisis environment. This approach is simple and practical so that it can support decision makers in uncertain and vague environment. Fuzzy MCDM used to evaluate nine stocks taken from ISE. These stocks were chosen from different sectors while the dimensions and criteria of the problem were defined by investors. The stocks chosen are Althinyldiz, Arcelik, Aygaz, Ford Otoson, Izmir Demircelik, Kartonsan, Kelebek Mobilya, Nuh Cimento and Pinar Sut. The first step to conduct the proposed method was screen performance indexes of the stocks to determine the criteria for constructing a hierarchical framework of performance evaluation. Next, to determine the weights of criteria according to two investors’ preference, the writers decided to apply fuzzy analytic hierarchy process (FAHP). Fuzzy SAW was applied to rank the performances of the stocks and lastly the authors construct a portfolio by using the performances of the stocks. By using linguistic terms, the performance of alternatives for each criterion was analyzed. Finally the portfolio proportions were proposed based on the performance.

3.2.2. Integrated FSAW, Delphi Method and Fuzzy Linguistic Evaluation

Afshari Reza et al., [28] implemented FSAW model for project manager selection in MAPNA Company, one of the largest companies in Iran. This paper also conducts multi-criteria decision making (MCDM) method as part of an extensive research. Since project manager selection is another tough and complex issue among decision making problems, they demonstrate a framework to assist a group of decision makers to use linguistic variables for rating candidates. FSAW had been employed in order to reach the goal of their study which is to identify the best candidates among participants in the project manager selection. The project manager selection case was used in order to test the validation of FSAW model to choose the right project manager for a project manager position in a project based company. Nevertheless, the authors developed a hybrid model for manager selection by using a new
systematic model consists of Delphi method, fuzzy linguistic evaluation and fuzzy simple additive weighting method. The usefulness of this method is proven by the experts and the result show that this model is quite reliable in selecting project managers.

3.2.3. Integrated FSAW, FAHP and FTOPSIS

Eshlaghy et al., [29] proposed a conceptual approach to evaluate the perceived service quality dimensions such as service quality (SERVQUAL) gap between two types of banks which are Public and Private Islamic Bank in Iran. This paper considers four private and public banks according to the criteria meant. They also rank these characteristics of each Private and Public Islamic Bank service. The objective of their paper is to introduce Fuzzy TOPSIS. The authors develop an evaluation model based on the Fuzzy Analytic Hierarchy Process (FAHP), Fuzzy Technique for Order Performance by Similarity to Ideal Solution (FTOPSIS) and Fuzzy Simple Additive Weighting (FSAW) methods. Fuzzy Analytic Hierarchy Process (FAHP) is used to compute the relative weight of the chosen evaluation indexes while FTOPSIS and FSAW were respectively adopted to rank the four banks. The information was gathered through a questionnaire where the sample includes 192 customers of private Islamic banks and 192 customers from public Islamic banks. As a result, by using these methods it was found that service quality in private banks ranked higher than public banks, where it is caused by the privatization of state banks.

3.2.4. Integrated FSAW under T-numbers

Zmeškal and Dluhošová [30] designed FSAW method type model to deal with the multiple attribute financial level evaluation. The authors used fuzzy sets of T-number types, extension principle and $\varepsilon$ -cut methodology. They present model methodology of FSAW type under T-numbers with non-fixed data preciousness and it is also a simple additive weighting version. The criteria considered in this study are profitability, liquidity and leverage. Weights of criteria and data preciousness are expressed linguistically and each term is similar to a T-number. Without considering the data of different preciousness, the authors compare the results with the other same problem where the detailed data are not for the sake of conciseness is introduced. The result proved that it is present and very significant in financial and as a conclusion, it could be suitable to model and include the degree of preciousness data parameter in fuzzy multiple attribute decision models.

4. Observation

In this paper, nineteen journal articles, which appeared in the period of 2003 until 2013, using the SAW and FSAW models are collected (searched via IEEE Xplore, Science Direct, Springer and Wiley). Nevertheless, no SAW and FSAW related articles were found during 2003 to 2007. It was observed that most of the authors of the collected journals were affiliated with management and engineering departments. Most of the articles discussed SAW and FSAW and its applications to various application domains including supply chain management, personnel selection problems, project manager selection and facility location selection. Detailed percentages of the applications are shown in Figure 1.
It can be seen that SAW and FSAW methods are largely employed in management selections such as supplier selection, personnel selection problems, project manager selection and facility location selection. The articles related to management selections are about fifty two percent. Information technology and health fields contributed eleven percent. The application in engineering and education fields contributed five percent. It is good to mention that there were also several articles that did not offer any specific applications. These groups of articles were focused on proposing new SAW and FSAW by integrating with other decision making methods.

Compared to other MCDM methods such as AHP and TOPSIS, SAW and FSAW have not gained favor amongst researchers. However, there is a trend of growth in the study that applied SAW and FSAW models for the last 3 years (2010-2013). It is anticipated that the number will keep increasing in the coming years because of the importance of these two models in solving MCDM problems in various fields of applications. Reviews of SAW and its applications according to individual and integrated approaches are summarized in Table 1 and Table 2.

### Table 1. SAW method and Applications

<table>
<thead>
<tr>
<th>Technique</th>
<th>Authors</th>
<th>Year</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAW</td>
<td>Huang et al. [9]</td>
<td>2013</td>
<td>Comparative analysis with no application</td>
</tr>
<tr>
<td></td>
<td>Shameli et al.</td>
<td>2012</td>
<td>Information security risk assessment</td>
</tr>
<tr>
<td></td>
<td>Afskari et al.</td>
<td>2010</td>
<td>Personnel selection</td>
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</table>

### Table 2. Integrated Approaches of SAW and Applications

<table>
<thead>
<tr>
<th>Technique</th>
<th>Authors</th>
<th>Year</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated SAW and Sensitivity Analysis</td>
<td>Memariani et al.</td>
<td>2009</td>
<td>No specific application</td>
</tr>
<tr>
<td>SAW and TOPSIS</td>
<td>Chen</td>
<td>2012</td>
<td>Comparative analysis without application</td>
</tr>
</tbody>
</table>
Summary of the review for FSAW and its application are presented in Table 3 and Table 4.

**Table 3. FSAW method and Applications**

<table>
<thead>
<tr>
<th>Individual Approaches</th>
<th>Authors</th>
<th>Year</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSAW</td>
<td>Deni et al.</td>
<td>2013</td>
<td>Selection of high achieving students</td>
</tr>
<tr>
<td></td>
<td>Gupta and Gupta</td>
<td>2012</td>
<td>Vendor evaluation in a supply chain</td>
</tr>
<tr>
<td></td>
<td>Kumar et al.</td>
<td>2013</td>
<td>Maintenance strategy selection problem</td>
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<td></td>
<td>Lin et al.</td>
<td>2010</td>
<td>Health examination institution location selection</td>
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<tr>
<td></td>
<td>Abdullah and Jamal</td>
<td>2010</td>
<td>Ranking indicators of health quality of life among kidney patients</td>
</tr>
<tr>
<td></td>
<td>Kabassi</td>
<td>2009</td>
<td>Evaluate a personalized geographical information system</td>
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<tr>
<td></td>
<td>Chou et al.</td>
<td>2008</td>
<td>Facility location selection</td>
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<tr>
<td></td>
<td>Rajaie et al.</td>
<td>2010</td>
<td>Evaluation of construction contractors</td>
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</table>

**Table 4. Integrated Approaches of FSAW and Applications**

<table>
<thead>
<tr>
<th>Integrated Approaches</th>
<th>Authors</th>
<th>Year</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSAW and FAHP</td>
<td>Kiris and Ustun</td>
<td>2010</td>
<td>Stocks evaluation and portfolio selection</td>
</tr>
<tr>
<td>FSAW, Delphi and fuzzy linguistic evaluation</td>
<td>Afshari Reza et al.</td>
<td>2012</td>
<td>Project manager selection</td>
</tr>
<tr>
<td>FSAW, FAHP and FTOPSIS</td>
<td>Eshlagly et al.</td>
<td>2011</td>
<td>Ranking public and private Islamic banks</td>
</tr>
<tr>
<td>FSAW under T-numbers</td>
<td>Zmeškal &amp; Dluhošová</td>
<td>2010</td>
<td>Evaluation of company financial level</td>
</tr>
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</table>

5. Conclusions

This paper has provided a literature review on methods of simple additive weighting (SAW) and fuzzy simple additive weighting (FSAW) and its applications from 2003-2013. The review classified the published articles into individual approaches and integrated approaches. This review has found that generally these two methods were mainly applied to management selections. It is concluded that the dissemination of SAW and FSAW has not yet widely reached to researchers. However, recent growing trend of integrated approach may shed some light to these two methods as it is easily integrated with other MCDM methods. With this review, it is hoped that more developments of SAW and FSAW methods could be seen in the future.

6. Acknowledgement

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7. References


