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Weighting Model for Group Decision Support System: A Review

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ABSTRACT

This paper was conducted a survey of research findings related to decision-making in groups using weighting techniques This paper conducts a survey of research findings related to decision-making in groups using weighting techniques, therefore, a new weighting model can be proposed.. In order to make a decision, this model works based on the weighting parameters, criteria or decision makers (DM) to give ranking preference in the decision results. Weighting could be done objectively or subjectively by statistical calculations. Subjective weighting based on an understanding or expertise of the decision-making process, furthermore, a numerical value was needed to make it objective. The previous weighting models need to be modified for the development of group decision support systems (GDSS). It is required to accommodate the interests of all stakeholders to link the DM relationship. We formed several groups of weighting methods that currently use for the trend of group decision-making (GDM). It showed that the classical multi-criteria decision-making (MCDM) models are still dominant in solving GDSS problems, therefore, it was necessary to apply hybrid MCDM with an approach method of stakeholders models and social networks (SN) to improve decision model that has been applied in the previous research.

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1. INTRODUCTION

In this literature, we reviewed several weighting methods related to the problems of group decision support systems (GDSS) that aims to determine the number of weighting method used in decision-making from 2008 until 2016. The weighting is an important stage of the development model of GDSS to obtain a decision based on an assessment of alternative the parameters, criteria, and scoring [1]. The weighting process involves various factors by entering the value of scoring on each factor for decision-making [2]. The weight values are assigned to attributes such as parameter criteria and decision-maker (DM) to produce the ranking of individuals or groups [3]. The weighting may objectively be implemented using statistical calculations or subjectively by determining it based on certain consideration [4], [5]. The determination of weights in a subjective method generally based on an understanding of the expertise of the decision-making process, as some researchers believe that weight is an opinion considered to be different [1], [3].

The purpose of weighting is to express the influence of the decision results based on parameter and DM [6], [7]. Generally, decision-making uses parameters that are related to particular problems, in accordance with the appropriate level of interest influence from one parameter to another parameter to generate the decision function [8]. In the other side, the weighting model can use the direct or indirect technique to make a decision [9]. The direct weighting is aiming to produce the weight value or percentage based on knowledge of the parameters interests and DM used by stakeholders, while indirect weighting using the computational analysis methods to generate the weight values [9], [10].

The using of analytical models in weighting technique is very important in producing effective decisions for GDSS, (e.g. multi-criteria decision-making (MCDM) [11], hybrid MCDM [12], fuzzy hybrid [13], Delphi [14], weighted power–weakness ratio (wPWR), simple additive ranking (SAR) and Kendall–Wei method (KW) [15] and other weighting techniques). MCDM models are applied in several methods such as simple additive weighting (SAW) in [16], weighted product (WP) in [2], analytic hierarchy process (AHP) in [17] and Borda in [18] or with the approach of fuzzy multi-criteria decision-making (FMCDM) [19] (e.g. the application of FAHP, FTOPSIS or FSAW). This model can be combined with another fuzzy compilation for criteria assessment that is uncertain based on the interests of each DM. The parameter-criteria of weighting is used to produce an output of alternative decision for the individual from each decision makers (DMs). Furthermore, it needs weights in group to produce a group decision [14]. For the future works, new weighting techniques are required in performing the weighting of the parameter or each DM's weights, so that the weights used could be able to accommodate all interests of DMs in group decision-making (GDM) with a sensitivity analysis testing done [20] to determine the effect of decision result.

2. WIGHTING METHOD OF GDSS

GDSS is a computer-based system that supports a group or organization involved in a task or a common goal in providing an interface that can be used for groupware [21]. It aims to increase GDM process by eliminating the boundaries of communication both in terms of space and time, also provides a method for structuring decision analysis [8], [10]. The development of GDSS models require classification in decision-making as in Figure 1.

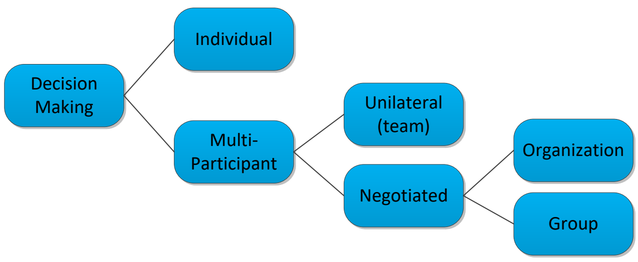

Figure 1. The classification of decision-making, [22]

The classification proposed in Figure 1 [22] divides the decision into two (2) parts are individual and multi-participants. Multi-participant decision-making has two branches, namely unilateral (team) and negotiated. Unilateral decision-making is interpreted as a decision where there is only one participant who has the authority to make decisions among some supporters to achieve certain goals. In the negotiated decision-making has the authority of the participants are divided into two (2) branches, namely the organization or group. Branch group means all the participants having similar authority in the decision-making process, while in the organization, group members work in an organization where every participant has a different authority [22].

In general, solving problems of GDSS uses weighting model with MCDM [11] or hybrid MCDM [23]–[25]. The weighting method with MCDM has been developed or combined by adding fuzzy set theory, as the theory developed in [16], [26]–[29]. The weight of decision shows the relative interest from each parameter and criteria in the rankings for an alternative decision. The important value of parameters based on the value of the weight given in the decision-making process [3], [9], [11], [30], the weighting basic needs the normalization process such as by adding the all parameter weight or DM's weight, in order to obtain the total value of the weights sum to 1. Based on the weight value of a decision matrix x size m x n, then the contents of those elements show x_{ij} that presents rating of an alternative $A_i = (i = 1,2, \dots, m)$ against the criterion $C_1 = (j = 1,2, \dots, n)$. This stage performed in the DM weighting to affect the interests or power of each DM based on stakeholder theory [31].

MCDM find out the interest weight of each criterion to applied GDSS model based on the effect on the interests of benefit and cost, as in SAW, Borda and other. Another GDSS weighting model is the model of social networks (SN) that has developed [32] to link the relationship between DMs [33]. Other concepts in weighting based on the relationship of each DM's influence in decision-making are also required based on the expert opinion or social relationships of each DM. In group decision-making, each DM has weight values which are averaged with other DM weights, according to the criteria related [34]. Furthermore, future development in the weighting of each DM can be integrated with the model of stakeholder affecting the interests of other DM. The previous model involved multi-stakeholders or groups that have similar interests in the power of influencing other decision-makers or interest from different fields for mutual collaboration with the same goal [35], [36]. This model mapped by the grid of power and interest in the policy of decision-making in an organization's decision-making [37].

3. RESULTS AND ANALYSIS

3.1. Discussion Result

Some weighting techniques for decision support were weighting with subjective opinion of experts [38], weighting of subjective and objective of each DM [16], subjective weighting [39], the weighting with agent-interest approach [27], weighting with Bayesian networks [34], the weight of fuzzy GDM, [28], the adjustment weights of experts [9], multi-spatial [40], the rule of thumb (RT) weighting, [41], the determination of average weight [42], the improvement of average weight [43], the hybrid weighting [23], modifying the weights [44], the linguistics weighting [45], argument value for the weights [46], the weighting between participants [47].

In [38], it was used a similarity weighting based on the deal of DM to provide comprehensive information of all the experts who have different and subjective opinions in decision-making. The methods used were method for Determining the Objective Weights of Experts Based on Evidence of Similarity (DOWEBES) and Basic Probability Assignment (BPA). The weakness of this study was no further explanation in the process of weight normalization and no explanation of the weight results of each expert to produce alternative decisions. While in [39] building method on a subjective weighting to the problem of ranking and measurement of criteria value so that it could be used in GDM. According to [39] subjective weighting method (SWM) was effective if it had a different expertise in the delivery of the weight values. Furthermore, the model weighting based on the expertise of DM was also developed by [34] for the modification of the weighting involving several experts with Bayesian networks (BN) method, such as the problem of weighting preprocessing and doing pairwise comparisons of each variable criterion. The use of Entropy method in [14], [23], [44] for the subjectivity-objectivity weighting, parameter was used in other decision-making problems to fill the weight value.

In [16] presented a model of the new GDSS with fuzzy multiple attributes decision-making (FMADM), namely fuzzy simple additive weighting system (FSAWS). The FSAWS methods were used to solve facility selection problems that had objective and subjective attributes. This model could be used to integrate fuzzy set theory (FST), factor rating system (FRS) and SAW. The weakness of this study was no any accommodation of DM's interest to produce alternative. The same problems were done by [26] and [16] for site selection criteria using fuzzy TOPSIS in weighting. The weakness in [26] showed no amount of DM in generating alternative decisions so that it was required the weight of each DMs in GDM.

In [27], it modified the weights of multi-interest agent on a fuzzy group decision-making (FGDM) with weighting model based on the similarity methods of fuzzy matrix after (FAM) and the negotiation of agent negotiation weight. The methods used were Entropy and goal programming (GP) to determine the objectivity of any DM's weight who had different interests. The weakness of this study was no ranking process explanation for the results of a real alternative in the decision-making group. According to [18], to create a FGDM model, it could be using Borda method. The GDSS model did modifications to Borda method for weighting process in completing the subjectivity and objectivity, such as the method of fuzzy complementary pairwise comparison weighting (FCPCW), fuzzy range weight (FRW), fuzzy entropy weight (FEW) and Delphi. The weakness of this study was having less criteria in completing weighting GDSS so that it required more criteria to link criterion used in each DM's.

The weighting model on multi-criteria in GDM with fuzzy has been done by [28] in making decisions as a group to choose a supplier. According to [28], each DM's had different weights in the GDM, so that it was required multi-criteria fuzzy weighting process on the issue of fuzzy matrix to justify the decision. In resolving this issue, [28] modified the model of fuzzy sets into GDM using fuzzy logarithmic priority (FLP), fuzzy least squares (FLS) and fuzzy square root (FSR). The weakness of this study was no process of updating the weighting according to the method proposed, so that the proposed model could be used for weighting parameter and GDM in generating decision alternatives. Meanwhile, according to [48], MCDM fuzzy models could solve risk management issues in a group decision support. Besides Entropy, the method used [48] was an interval-valued intuitionistic fuzzy values (IVIFVs) and OWA to be modified into a method of continuous ordered weighted averaging (COWA). The IVIFVs method was used to obtain the average weight used in OWA score. This study focused on the improvement of the model of multi-criteria group decision-making (MCGDM) for the rankings, so that this model could solve risk management problems more effectively. The weakness in this model was the requirement of integration in each method, so that the average weight could use the appropriate parameter based on the selection of each DM's. The method of interval-valued had also previously been done by [49] to generalize the concept of hesitant fuzzy sets (HFS) in the method of interval-valued hesitant fuzzy sets (IVHFS).

In [50], it was used geometric aggregation operator (GAO) based on weighted geometric to form generalized interval-valued trapezoidal fuzzy numbers (GITFN) on multiple-attribute group decision-making (MAGDM). While [51] created a new Entropy weighting by using interval type-2 fuzzy TOPSIS to choose suppliers. In the use of interval-value models by combining TOPSIS method was also performed by [52] to make Atanassov's intuitionistic interval-valued fuzzy numbers (A-IVIF) method in choosing a supplier issue. The use of Entropy method was also carried out by [48] to create a model of continuous weighting in getting the interval weight values between the value fuzzy. While the results of the study in [53], it was required interval values to generalize Entropy by crossing on the GDM issue by involving a range of experts' knowledge and the weight attribute based on the fuzzy value in supplier selection problem for the industry. According to [53], to maximize the models that were considered effective in MCGDM preference with unknown attribute weights, it could use the weights of experts based on interval-valued intuitionistic fuzzy environments (IVIFEs). In [54], it combined Borda with fuzzy quantifier linguistic to create a new method in the vector weight in the linguistic value, so that the model was compared with operator weighted averaging (OWA) and the vector weighted averaging (VWA). The results in group, in [54] used linguistic quantifier (LQ) and a variable weight called the method of quantifier guided variable weight average (QG-VWA).

The expert weighting adjustment methods were necessary to fix the weights directly used in GDM models, such as the method of adjustment algorithm of experts' weights [9]. In combining their respective weights of each expert, the combined parameters were required to produce alternative group decision. The weakness of this study, the weight of each linked DM was not used in the same time on the rank group decision, so that it was necessary to be fixed to get an appropriate weighting based on the criteria used by DM. While model selection criteria and weighting in [41] used the rule of thumb (ROT) for the best parameter selection and weighting filling according to the DM. This weighting method was considered to be flexible in the direct weighting. The weakness on direct weighting was the possibility of unfair filling in weight values by engaging the common parameter of each DM's.

Weighting also required a hybrid model of MCDM in combining AHP and Entropy to optimize the value of DM weight based on programming objective [23]. The initial weight was required to be updated by using the method of gray correlation degree (GCD) such as the result of individual decision and group decision. Furthermore, adaptive algorithms and linear weighting were used to fix the weighting method in a group, so that it could be more optimized in decision-making. In [55], it also performed hybrid MCDM with AHP, SAW and technique for order preference by similarity to ideal solution (TOPSIS) for selection of electrical agencies. In [25], it also performed hybrid in MCDM model by combining the method of SAW, TOPSIS and grey relational analysis (GRA) to produce a test of methods comparison. While [42] and [56] defined positive ideal solution (PIS) by using TOPSIS to find the average result of group decision and in [43] to determine the weight of an uncertain group decision. The proposed model that was developed would be compared to determine the average individual decisions from each DM with other methods.

In [40], it combined AHP and GIS for multi-spatial parameter weighting in determining the location of landfills. This study used AHP in parameters weighting for pairwise comparisons and alternatives ranking, so that it recommend the right location. While in [57], it combined AHP and Preference Aggregation (PA) Method based on Data Envelopment Analysis (DEA) to optimize decision-making in GDM. In [58], it synthesized the best local priority vector in individual on the AHP-Group decision-making. According to [58], in the individual assessment, it was also required individual assessment integration (aggregating individual judgments), by using the method of aggregating individual judgments (AIJ) and the method of eigenvector (EV) in GDM, it would show consistency of the AHP weights. The different weighting was done in [59] in making the model of GDSS. This research used a two-stage algorithm to build consensus AHP-group decision-making. The two-stage algorithm was to make a model of convergence, so that it was advisable to reach agreement among individuals and sub-groups in decision-making between groups. The first stage used the method of logarithmic least square (LLS), EV and clustering. Then, the second stage used a model of consensus and convergence model of weighted geometric mean (WGM). The weakness of both problems used [59] was the requirement to incorporate the results of each DM's weight in order to accommodate the interests of all DMs.

In [44] and [60], it was to make modifications to weighting method AHP with TOPSIS and Grey method. These two researchers modified weighting in the method of AHP by applying TOPSIS method, grey theory and Entropy method to develop the problem of multiple-criteria group decision-making (MCGDM).

While TOPSIS method used to find the ideal distance of the positive and negative of the value weights used in AHP based on the results of pairwise comparisons on predefined criteria. The Grey theory and Entropy methods used to perform comparisons with TOPSIS method so that it could be shown the strength of the proposed model. The purpose of this model was to minimize subjectivity and vagueness in determining the weights of DMs. The weakness of the model [44] was it could not accommodate the interests of all DMs to determine the parameters or criteria. Meanwhile, according to [60], it was required a decision model using AHP to be integrated with the Grey-TOPSIS on the issues of Content Management System (CMS) for information technology project. The weakness in [60] was no appliance of the GDM model, where research results did more comparison on every criterion, and it did not use Entropy method as it was done by [44] for minimizing subjectivity of the criteria.

In a study of [61], it created a prototype for repairing weight of AHP method to be guided ranked AHP (GRAHP) in the GDSS to complete the tender evaluation issues. This model connected one DM to other DMs group involving many evaluators as assessor of tender activities, so that these models could determine the strategic decisions in groups to make a fair decision. The weakness of the model and the algorithm proposed was no detail explanation of normalization process of weighting and ranking using GRAHP method to produce alternative group decision. This model needed to be modified again so that it could produce weight in group that had link between each evaluator in accordance with parameters similarity and interests of DMs.

In [45], it created a new method to solve the problem of MCDM on both the criteria value and criteria weighting using information of linguistics and weight. According to [45], the use of equal weight to each DM's in decision-making could produce an effective alternative. Each DM's determined weighting based on the value of individual linguistic similarities, so that it could solve the problem of multi-criteria group decision-making (MCGDM) with grey relational analysis (GRA), TOPSIS, AHP, and linear programming (LP). In a study [45], it was also proposed improvements of TOPSIS weighting in positive and negative ideal with 2-tuple linguistic projection (TL-P), tuple linguistic positive ideal solution (TL-PIS), 2-tuple linguistic right negative ideal solution (TL RNIS) and 2-tuple linguistic left negative ideal solution (TL-LNIS). The weakness of this study was no explanation how to get the weight of DM in accordance with interests influence, so that it required further model to modify the weighting method based on the influence of the interests and power of each DM. In [62], it was used intuitionistic fuzzy number (IFN) and dynamic intuitionistic fuzzy weighted averaging (DIFWA) in GDM. While approach in approach [63], it built GDSS by some kind of linguistic preference relations using linguistic weighted arithmetic averaging (LWAA), linguistic arithmetic averaging (LAA) and linguistic weighted geometric averaging (LWGA) for making methods in reaching consensus between individual preferences and group opinion.

In [64] and [65], it was used a model of Hesitant fuzzy preference relations (HFPRs) for GDM issue. The deviations priority on weighting in the model of HMPRs in GDSS could decreae weight on HMPRs to make decisions not optimal [64]. While at [65], it did modification to HFPRs priority weight model on GDM to describe the evaluation information that was undecided and did not complete the process of GDM. This model could convince the hesitant DM in giving weight values, so that the concept could be applied to DM's problems who did not have a standard weight [65]. This model aimed to stabilize initial weight value to become real alternative ranking that could be used. The weakness of HMPRs model, it still needed to link the relationship between DMs, so that the new weight based on the weight criterion was able to accommodate all interests of DMs.

In [14], to create a weight model for the determination of two layers in decision-linguistic environment. Each expert as a DM had a objective weight on the issue of complex multi-attribute large-group decision-making (CMALGDM). The model used in [14] also proposed a decrease in the variance model weighting and Entropy weighting models to determine the weight of experts in a cluster and cluster weights. The completion methods of this study was using the method of two-layer weight of determination (2TL) to complete CMALGDM. Meanwhile, according to [66], it was required to do a combination of objective and subjective weighting preferences, such as the weighting of attributes based on the method of statistical variance (SV) and SAW. Furthermore, these models performed DMs weighting based on TOPSIS [67] and Delphi-AHP then combined by evaluating the operator linguistic weighted arithmetic averaging (LWAA) [66]. The problem done by [66] was to select the appropriate vendor cloud computing on the needs of the industry. The testing of this model was by using a comparison with the classical model of GDM with the proposed model. The weakness of the model [14] and [66] were requirement to accommodate models of weights in group by adding another method.

In [29], it was conducted an approach to GDM with incomplete information based on the power of geometry operator and trigular FAHP. According to [29], to conduct an investigation on some models of multiple-criteria group decision-making (MCGDM) on any DM was required a preference value of alternatives and criteria based on trigular fuzzy sets to form an inversed matrix comparison. The trigular operators used was to fix the MCDM models, thus becoming more effective to use extents analysis method (EAM) and triangular AHP (TAHP) to incorporate into carrier triangular fuzzy power geometric (TFPG) and triangular fuzzy weighted power geometric (TFWPG). The parameters used in this issue consisted of criteria for social welfare, environmental protection, technology security and economic benefits. The scoring had a 4x4 matrix for being used parameter-criteria weighting. The weakness of triangular fuzzy AHP (TFAHP) proposed was parameter-criteria that were few in number and were still necessary expertise to assess the parameters associated with the social and economic impact of any DMs as done by [16].

According to [68], in order to improve relations between MCDM and FMCDM model, it was required a comparison of simple methods in the use of MCDM for decision-making, so that it could be seen that the model proposed for the FMCDM modification was relatively easier than for FSAW model. Methods weighting was also carried out by [16] to simplify the model FRS, while in [26] modified FSAW with FTOPSIS to select center location of the distribution. In [15] performed weighting technique by using weighted power-weakness ratio (wPWR) for multivariate MCDM index and find out the comparison ranking results in decision-making. The index value of wPWR/PWR was proposed to select the winner of the strongest in a tournament, and would adapt to solve problems on MCDM. Then the next ranking process by using a simple additive ranking (SAR) and Kendall-Wei (KW) method thataimed to find out separated criteria in weighting. According to [15], the comparison of wPWR and PWR required other methods to improve multi-criteria weighting method. The comparison of TOPSIS method was also conducted by [24], [69]. In [69], it was done a search of ther method considered deviant in a heterogent MCGDM models and based on inadequate information. According to [69], to compare the MCDM models with several multi-criteria method, it was required in selecting the right issues that were considered to be strategic such as the problems of natural sciences, social sciences, economics, management and others, so that it could use TOPSIS method with fuzzy sets and triangular fuzzy numbers (TFNs), hesitant fuzzy elements (HFEs) and Hesitant fuzzy linguistic term sets (HFLTSs). This problem used 4 DMs and 7 criteria to produce 4 alternative decisions. The result of the respective DMs was compared to generate a group decision together. The weakness of this paper was taking the relationship between DMs to unify a criterion used by each DM's. While TFNs with MCDM models was also conducted by [29] which combined the relationship between DMs and other DMs. While [24] conducted a comparison to make the MCDM weighting models by using TOPSIS and SAW methods that could be applied to the problem of making decisions in the expert system. The weakness in [24], it did not do a weight comparison with the new method proposed, so that it did not show the improvement of new model proposed by using TOPSIS and SAW.

In [70] GDM was conducted making model with fuzzy linguistic preference relations and methods of cooperative games (CG). This model had a weighting approach for GDM problems involving expert group to give weight to the initial vector. In algorithm drafting, this weighting reduced the end result error of convergence that was needed by each expert group. According to [70] the benefits of using this algorithm could optimize GDM models that were built to produce an alternative ranking that considered to be objective. It was known that comparison of vector weighting on iteration value and initial weight had a different preference differences, such as making the repetition of initial weight to be effective. The weakness of this model was requirement to change the weights value based on common parameters which each DM's had so that initial weight value could become the new weights. In a study [46] providing value argument to the weighting of each group involving multiple decision makers for a multi-stakeholder decision-making. Multi-decision-making was a team in DM group in stakeholders who did not have special interests, while the committee system was a group of decision-making based on the participants as stakeholders who were special memberships. The method used was intuitive additive weighting (IAW) by screening each DM's in decision-making. The study also did seek equality for weighting parameter selection. While [5] did a combination weighting method to streamline the subjectivity and objectivity of this model that could affect problems that were composites using the numeric logic (NL) and adjustable mean bars (AMB). The NL methods were used to improve the accuracy of the weight of expert, while AMB was the approach in visual through a MCDM weighting process for DM who had less experience or who did not have the expertise. The problem scenario was expected to accommodate the level of interest and knowledge of each DM's. The proposed model was examined by the modified method of digital logic (MDL) to determine the accuracy of the NL method used by the DM expert. The method for ranking used TOPSIS in finding out decision alternative of each DM's. The weakness of the proposed model [5], it did not link the parameters of the relationship between DMs who had expertise with other DMs who were considered to have no expertise.

In [71], to make modifications to TOPSIS method with fuzzy set and Entropy to produce DM weight. The proposed model was intuitionistic fuzzy TOPSIS (IFT) with test comparison of classical TOPSIS and fuzzy TOPSIS, and also between the method of Entropy and fuzzy Entropy. The combination of TOPSIS method, fuzzy TOPSIS and Entropy was also carried out by [44], while [14] combining Entropy with AHP to produce any agreement of DMs for determining the weight. There were 30 criteria and 3 DMs to finish the issue of uncertainty and subjectivity in the decision-making in selecting suppliers of oil and gas industry through the project tender in research Wood [71]. The testing of this model used a sensitivity analysis to determine changes in the weights of each DM, if it was done with other methods. Based on many criteria used, it may be a weakness in the matrix process of decision-making and become the force based on various criteria to make decisions according to preference of DM. The weakness of this study was at linking parameter-criteria carried out by the respective DMs to get a new weight value. While in [72], it was working on hybrid FMCDM by using fuzzy approach to determine the highest priority in the selection of appropriate electrical knowledge expertise in delivering value weights.

In [73], it used the value of the interval to solve the problem of different weighting of each criterion and DMs. According to [73], to create a new weighting method based on MCDM analysis of GDM could use the approach of interval-valued hesitant fuzzy-multicriteria weighting and ranking sets. While the resulting model [73] is an interval-valued fuzzy Hesitant multicriteria-weighting and ranking (IVHF-MCWR), so that the model of IVHF-MCWR was tested to produce the rankings of GDM with TOPSIS method. The output of this study was also in the form of improved TOPSIS methods becoming IVHF-TOPSIS method. In a study [73], it had the same closeness to the [53] using interval-valued fuzzy Hesitant. Meanwhile, according to [47], to evaluate information from a variety of participation in a number of large groups needed new GDSS models to accommodate participants' opinion between groups. Models that was conducted by [47] explained how to create a model of GDM in large scale or large group decision-making (LGDM), so that the model of LGDM could solve problems that involved inter GDM or stakeholder group. This ranking analysis problems used PROMETHEE II to alternative methods, while the method of weighting used was interval-valued intuitionistic fuzzy number (IVIFN) and continuous-interval data ordered weighted averaging (C-OWA), as used in [48]. While on [74] improving the subjective weighting method to produce common weight to produce an update weight that can accommodate the interests of all DMs. Weighting scenario of the problem in this paper had a weight which was then integrated into the group and ranking alternative group decision were used to be modeled together. The weakness in this study, it did not provide any opportunity for GDM to combine the same parameters and criteria, so that the same parameters are required additional weight based on the common interests of the respective DMs or between GDM. Summary of research in the literature review was used to develop the model further weighting in the group decision support systems. As Table 1 grouping methods of weighting in the GDSS annually performed as follows:

Table 1. The summary of grouping methods based on weighting problems

Year	Citation	Methods	Contribution and Result
2008	[16]	FSAWS, FST, FRS, SAW	• Generate method of FSAWS. • Simplify the FRS models from previous studies.
	[38]	BPA, DOWEBES Method	• Set goals together based on the weight of DM expertise to produce decision group on alternatives. • Each weight will be compared to the expertise of each DM.
	[63]	LWAA, LAA, LWGA	• GDM is based on some kind of linguistic preference relations using LWAA, LAA and LWGA. • Methods for achieving consensus among individual preference and opinion of the group.
2009	[26]	Fuzzy TOPSIS, FST, FRS, SAW	• Modify models of FSAWS conducted by [16] with fuzzy TOPSIS method. • Generate fuzzy TOPSIS weighting method is simpler for the selection of distribution center locations.
	[18]	Fuzzy MCDM, Borda, Delphi, FCPCW, FRW, FEW	• Modify the Borda method to solve the problem of subjective and objective. • Involve multi-decision makers in the weighting.
2010	[40]	AHP, GIS	Combining AHP and GIS in multi-spatial weighting to visualize alternatives.
	[34]	BN	• Weighting by BN models. • Generate average weights used in group decision.
	[28]	FLP, FLS and FSR method	• Modify the fuzzy method with the FLP, FLS and FSR. • Bringing together different weights opinion of each DM. • Weighted MGDM models with fuzzy environment.
	[9]	Algorithma adjustment and experts weights	• Improving and normalizing weight of each expert use group decision. • Produce experts algorithm weights.
2011	[41]	Rule of Thumb (RoT)	Flexibility of DM in selecting parameters and fill weights for decision alternatives.
	[42]	TOPSIS	Defining the profit and loss in PIS and NIS as an average weight of the results of group decision.
	[39]	SW	Make SW method for ranking problems and measurement of criteria values.
2012	[43]	TOPSIS, New-TOPSIS	Extension TOPSIS based on the problems that are uncertain at GDSS to determine the relative interests.
	[57]	AHP, PA Method	Combines AHP and PA based on DEA method.
	[50]	Interval-valued trapezoidal, Fuzzyset, GAO, MCDM	Using GAO based on weighted geometric to establish GITFN on MAGDM.
	[52]	TOPSIS, A-IVIF	A-IVIF method to solve the problem of choosing a supplier with TOPSIS.
2013	[58]	AHP, eigenvector (EV) method	• Combines the AIP and the AIJ. • Modify the AHP in the decision-making of individuals into groups.

Year	Citation	Methods	Contribution and Result
2014	[59]	AHP, LLS, EV, clustering	Modifications AHP method by combining the logarithmic least square method, eigenvector and clustering to produce weight evenly on each DM.
	[23]	Algorithm adaptive, AHP, Entropy, Grey correlation, Linear weighting	• Conduct a hybrid model of weighting individual and group. • Generating optimal weight and flexible in decision-making on all six DMs.
	[44]	TOPSIS, AHP, grey theory and Entropy	• Minimize subjectivity and vagueness in determining the weights. • Generate method Wage (e.g. Weighting with AHP, Grey numbers and Entropy).
	[49]	IVHFS	HFS generalize the concept of the method IVHFS.
	[51]	Entropy, FTOPSIS	Creating a new Entropy weighting method with interval type-2 fuzzy TOPSIS.
	[48]	Fuzzy, IVIFVs, Entropy, OWA, C-OWA	C-OWA provides a method for continuous weighting.
	[60]	AHP, Fuzzy AHP, TOPSIS, Grey theory, Fuzzy TOPSIS, Grey-TOPSIS	Doing hybrid models to determine the distance of the weight of any methods used in each criterion.
	[45]	GRA, TOPSIS, AHP, LP	Fixing the weighting TOPSIS with 2TL-P, TL-PIS, 2TL-RNIS and 2TL-LNIS.
	[64]	HMPRs	Repair weighting process based doubts any DMs in giving weight values.
	[62]	IFN, DIFWA	The use of intuitionistic fuzzy number on approach to group decision.
2015	[14]	2TL, AHP, Delphi, Entropy, Variance, DEA-DA	• Improving a model weights the determination of the two layers of the linguistic environment with the DEA. • Propose a model of objective and subjective weighting. • Make CMALGDM models.
	[29]	Fuzzy, AHP, TFPG, TFWPG	• Creating a new method in the MCDM with TFPG and TFWPG. • Combining preference value in the group decision.
	[53]	Fuzzy set, Entropy, IVIFEs	• Effectiveness MCDM for preference MCGDM with attribute weights that are unknown. • Using weights experts based on IVIFEs.
	[55]	AHP, SAW and TOPSIS	Produce hybrid MCDM method for electrical problems.
	[68]	SAW, FSAW, AHP, FAHP, TOPSIS, FTOPSIS	• Improving relations with FMCDM and MCDM models for comparison. • Looking for the effectiveness of the two models proposed.
	[15]	PWR, SAR, KW	Looking for weaknesses and strengths in the assessment of the weight of the tournament participants.
2016	[72]	Triangular Fuzzy Numbers (TFN), FMCDM	GDSS using Fuzzy approach to determine the highest priority on the issue of election of electricity that has knowledge and ability based on the given parameters.
	[46]	IAW	Screening group decision maker for the group decision argumentation.
	[5]	TOPSIS, AMB, NL, MDL	• Combines the weighting method to accommodate DMs. • Involving DMs expertise or do not have the expertise.
	[71]	Fuzzy TOPSIS, Entropy, IFT	• Comparing classical TOPSIS and Fuzzy TOPSIS with Entropy. • Complete the issue of uncertainty and subjectivity in the decision-making.
	[24]	SAW, TOPSIS	Conducting comparatison of weighting method to be applied to the problem of decision-making expert system.
	[25]	SAW, TOPSIS, GRA.	Doing hybrid MCDM with SAW, TOPSIS and GRA.
	[66]	SV, LWAA, TOPSIS, SAW, AHP, Delphi	• Integrating SV models to develop the model. • MAGDM by combining use LWAA operator.
	[65]	HFPR, FPRs, Goal programming	Stabilizing initial value weights originally considered to be inconsistent from each DM.
	[73]	IVHF-MCWR, TOPSIS	Creating a new weighting method and model of the rankings for GDM using Hesitant interval-valued fuzzy sets.
	[47]	PROMETHEE II, IVIFN, C-OWA	Creating a LGDM model for multi-GDM.
2017	[74]	Weight Update, TOPSIS, SAW	Modification of subjective weighting methods to produce weights that can accommodate the interests of all DMs.

Based on the summary of the weighting problems presentation for GDM, it was necessary to classify the weighting model of previous researchs. It was known that growing trend in decision-making on the various weighting techniques could be seen in Table 2 in accordance with grouping method of the previous research.

3.2. Analytical Result of Weighting Methods

The survey research has been done based on the previous research of 2008 until 2017 relating to the problem of weighting criteria in GDSS to generate an alternative decision. The problem of decision-making was found to have a tendency to modification the fuzzy MCDM model and classical MCDM or performing hybrid on both models. The combination of these models aimed to streamline the decision involving several DMs using multi-attributte to analyze the results of the group decision. Beside MCDM, the other methods of weighting are e.g. fuzzy environment, grey method, Delphi method, etc to fix the problem of GDSS. In weighting Table 2, we also presented classification of weighting method for decision-making based on weighting method of fuzzy MCDM environment, MCDM and other methods, as the results of the analysis in Figure 2.

Table 2. The Classification of weighting models in decision-making

Cite	Fuzzy MCDM				MCDM						Fuzzy Environment	Grey Analysis	Delphi	Others
	Fuzzy AHP	Fuzzy TOPSIS	Fuzzy SAW	Fuzzy Entropy	AHP	TOPSIS	SAW	Borda	Entropy	OWA				
[16]			√				√				√			√
[38]												√		√
[63]														√
[26]		√	√				√				√			√
[18]	√	√	√					√			√		√	√
[40]					√									√
[34]														√
[28]											√			√
[9]														√
[41]														√
[42]						√								
[39]														√
[43]						√								
[57]					√									√
[50]											√			√
[52]						√					√			√
[58]					√									√
[59]					√									√
[23]					√				√			√		√
[44]					√	√			√			√		
[49]														√
[48]									√	√	√			√
[60]	√	√		√	√	√			√		√	√		
[45]					√	√						√		√
[64]														√
[14]					√				√				√	√
[73]						√					√			√
[29]					√						√			√
[53]									√		√			
[55]					√	√	√							
[68]	√	√	√		√	√	√				√			
[15]														√
[72]	√	√									√			
[46]														√
[5]						√								√
[71]		√							√					√
[24]						√	√							
[25]						√	√					√		
[66]					√	√	√						√	
[65]											√			√
[73]						√					√			√
[47]										√	√			√
[74]						√	√							√
Total	4	6	4	1	13	15	8	1	7	2	17	6	3	32

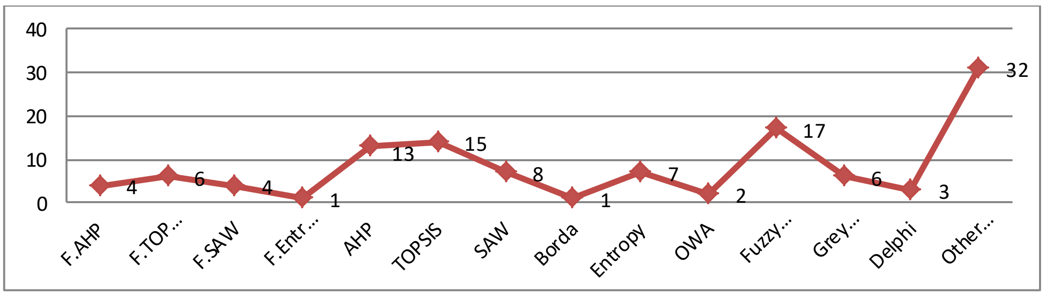

Figure 2. The Distribution of weighting method in the GDSS

Based on the use of GDSS model weighting, it is known that model of MCDM widely used than FMCDM, but MCDM model is less than other model. Based on the various methods used by the researchers, MCDM is more widely used, while the non-MCDM is the most used of weighting method in developing GDSS, as seen in Figure 3.

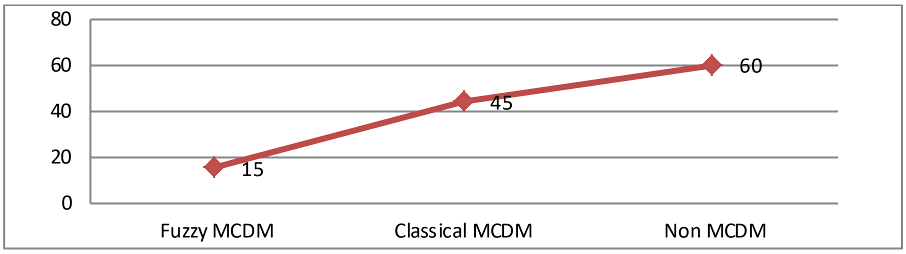

Figure 3. The Model of weighting in the GDSS

Based on Figure 3, in the model of GDSS weighting, there were few studies conducting combination and integration to methods for improving the classical MCDM model, such as improved SAW with FST, FRS, resulting in a new model called FSAWS. Modifications in the MCDM models were also found in [60] to determine the distance of the weight of each of the methods used in each of the criteria using AHP, Fuzzy AHP, TOPSIS, Fuzzy TOPSIS, Grey-TOPSIS. In this paper, we also give attention to the paper [68] which used classical MCDM models and FMCDM on some methods of SAW, FSAW, AHP, FAHP, TOPSIS, FTOPSIS to find the effectiveness of both the multi-criteria. Some of the researches that we know, from 2008 to the end of 2016, focused on a combination MCDM and FMCDM or with other models such as the method of fuzzy environment. As well in [18] improved Borda method by using FCPCW, FRW, FEW and Delphi. In [14], the Delphi method was used to improve the weighting method of AHP and Entropy. Until 2016, in [66] conducted a combination of methods TOPSIS, SAW and AHP that to be integrated with Delphi and SV in developing MCDM models on GDSS problems. We noted there were no studies that did a combination FMCDM or MCDM with SN for improving stakeholder model and parameter weights and DMs that had any relationship based on common parameters DMs-criteria, so that it could develop a new model of GDSS.

4. CONCLUSION

Generally, the previous research to obtain the hybrid by combining or adding several methods to improve the previous method of weighting. We reviewed opportunities to develop the weighting method with other techniques, in order to improve the weighting models based multi-criteria involving social aspects. Based these, the combination of MCDM model or fuzzy by using SN approach stakeholder model was required. These new hybrid models were considered to be necessary to improve the previous research of GDSS model that may accommodate the interests and power of each DM.

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