A Case Study to Select Wind Power Plant Site in India using Fuzzy Linguistic Modeling Integrated with VIKOR

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Abstract - *The selection of appropriate location for a wind power plant is a critical planning job which majorly affects the running cost of the plant while meeting the sustainable development goals for that area. As the installation cost for this project requires a huge investment and there are other attributes also for due considerations so it is a vital decision to take for choosing an efficient location for wind power plant. Availability of wind, wind speed, land cost, maintenance, connectivity, impact on environment, etc. are some of the potential parameters that helps in selection of appropriate site. So, considering the vitality of this issue, a study was carried out to adopt a fuzzy-VIKOR based assessment model for the selection of best locations in India for the installation of wind power plants.*

Key Words: Fuzzy, Linguistic Model, VIKOR, Wind Power, site selection, decision making, etc.

1. INTRODUCTION

The rational decision making is an imperative part of all science grounded professions, in which the experts implement their ideas to make informed decisions in a certain field. Every decision is made within a particular environment, which can be distinct as the collected information, choices, values and priorities available while taking decision. In present scenario, uncertainty is the key issue in process of decision making, and an essential aim in the investigation of decision is to contract the uncertainty. Modern robust decision efforts have ceremoniously assimilated uncertainty and criterion into the process of decision-making. Due to the involvement of the uncertainty and the multicity in the evaluation criterion; the fuzziness came into existence. An important role of decision making refers to the investigation of a finite set of options designated in terms of certain criteria for evaluation. These criteria can be benefits or costs in nature. The problem then pursues to rank the available choices in terms of their appropriateness for the decision-makers; when all the criteria are considered simultaneously. The ambiguities can lead to improper selection, subsequent in misleading solutions and improper conclusions. If it is built carelessly, the entire design can proceed on a bad track, resulting in a weak solution. This in turn wastes time, money, resources and energy. Therefore, the applicability of the most accurate and appropriate method in the right direction has become a challenging task for today's researchers. The present work aims to provide a strong, quantified MCDM level of satisfaction among decision makers and the ability to deal with ambiguous-incomplete information and uncertainty in real-life application such as site selection for wind plant. Wind energy is a rapidly growing renewable energy resource world with mean growth rate of 30%. The Ministry of New and Renewable Energy (MNRE) report states that India, with installed capacity of more than 35.62 GW in energy production from wind resources worldwide after USA, Germany and China (asonJuly31,2019) (Energy, MoNR) In fourth place. -2019).Setup costs are much lower for wind power than for hydro and solar plants. Advanced technological development has been done to achieve maximum power generation from the available wind source. According to the technology and resources available within India, it is estimated that the use of on-noise wind power can be increased to 102GW for electricity generation.

2. RESEARCH BACKROUND

The two important approaches to MCDM problems are highlighted in the literature, i.e. one is multiple attribute decision making (MADM) and another is multiple objective decision making (MODM). The main difference between aforesaid two approaches is that the MODM focuses on a continuous decision space aiming to achieve the best solution, with multiple objective functions simultaneously. This process involved searching for the best solution, in the given a set a conflicting objective. Moreover, the MODM problem is accompanying with the problem of design for optimal solutions through mathematical programming. In contrast, MADM denotes to decision making in the discrete decision places, and the focuses in on how to choose or rank the various predefined choices. The methods usually associated with the MODM approach are Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Techniques for Order Performance for Ideal Performance (TOPSIS), Outranking methods (Viz. ELECTRE, PROMETHEE, ORESTE) and Multi-attribute utility theory (MAUT) etc. are mainly included in the category of MADM. Similarly, some mathematical programming techniques such as linear programming (LP), genetic programming (GP) and mixed integer programming (MIP) are there. The classic MADM methods usually assume that all criteria and their respective weights are expressed in crisp values and thus, suitability ratings and ranking of alternatives can be met without difficulty. In the event of a real-world decision, the application of the classic MADM method can lead to serious practical hurdles from criteria such as uncertainty, incompleteness, faultlessness, or ambiguity in the data. In most of situations, the performance of criteria can only be expressed qualitatively or by using linguistic terms, which certainly calls for a more appropriate method to deal with. Classical MADM methods cannot handle such linguistic data effectively because finesse or dissipation is involved during the decision process. The first step is generally referred to as the rating process, which deals with the measurement of performance ratings or the degree of satisfaction with respect to all the attributes of each option. The overall rating reflects the global performance of each option, which can be achieved through the achievement of appropriate aggregation operations of all criteria involved in the decision. The second stage, ranking the alternative options by ordering the current options according to the resulting total performance rating obtained from the first stage.

2. OBJECTIVES OF STUDY

The major objectives of this research project include:

- To identify important factors responsible for the site selection process.
- Development of a conceptual hierarchical framework for factors affecting the site selection for the wind power plant
- To apply an optimal MCDM technique in order to improve and simplify the decision- making process for site selection of solar power plant.

Finally, after evaluation of this framework by MCDM technique to reach at a conclusion and select appropriate location

3. PROBLEM FORMULATION

- The site is evaluated by experts of different field and contains lots of jargons. Hence it is difficult to understand this by project managers who are involved in the construction of sites.
- It's hard to protect the independence of experts since there are undefined duties in the results of experts.
- A large number of criteria's and alternatives are a part of the evaluation process, so the matrix becomes difficult and complex to solve and to reach to a conclusion.
- The criteria's which are a part of evaluation process are qualitative properties and that needs to be converted into proper quantitative numbers with the help of proper and accurate theories.

A wide range of factors are involved in the decision-making process of wind farm, ranging from accessibility, availability of resources, economy and risks involved with the wind farm.

4. IMPLEMENTATION

Fuzzy has been applied to work out the weighting of qualitative and quantitative attributes affecting the location selection process. In addition, a ranking multi-attributes decision making method VIKOR has been implemented to rank the choice locations supporting their overall performance. A case study of location selection of a wind power plant in India has been proposed to demonstrate the applicability of the proposed method. This work illustrates the more systematic, effective and accurate decision support tool in order to select and assess the optimal site for wind power plant. Additional purpose is to assess the best option available or to assess the comparable precedence of individual option. The solution to such complications is the emphases of Multi-Criteria Decision Making (MCDM) in decision-making and informatics. Multi-criteria decision making is the decision making includes the multiple, generally contradicting and non-appreciable criteria is called multi-criterion, such as many more conflicting objectives, 'minimum cost' and 'maximum quality' are the real items of the daily concerns for the decision makers. In addition, some circumstances the conditions may be perceptible and imperceptible and invite vagueness in the process of decision making. In real-world, the decision-making conditions, the implementation of typical MCDM techniques faces serious practical hurdles, due to its intrinsic malfunctions or ambiguities inherent in criterion information. Now-a-days, FMCDM expanded massive attention in the real life applications. The widely applicable areas where the FMCDM are used as follows:

a) A project completion evaluation system
b) Accretion of market research data
c) A project maturity estimation system
d) Supply chain management
e) Assessment of weapon systems and many others

The extent of decision making has fascinated the attention for researchers, it quiet extremely contested as there is various MCDM approaches, and it may give diverse results when they are used on the similar data. This may have led to a decision making contradiction.

4.1 VIKOR

The VIKOR means 'VlseKriterijumskaOptimizacija I KompromisnoResenje', meaning that in late 1998 a multi-criteria optimization and compromise solution was developed by Opricovic. This methodology focuses on the ranking and selection of the best solution from a set of options that are associated with it. Multiple conflicting criteria. Furthermore, it becomes easier for decision-makers to reach a final decision by finding a compromise solution to the problem (nearest to the ideal). The main motive of VIKOR is to assess the positive-ideal solution (best value of alternatives under the given criteria) as well as anti-ideal solution (worst value of alternatives under the given criteria) in the search place. Lastly, alternatives are ranked in accordance with closeness of alternatives which are determined.

4.2 Linguistic variables

Variable whose values are expressed in words or sentences in a natural or artificial language is called as linguistic variable. The idea of a linguistic variable is very useful in dealing with situations that are too complex or that are not properly described in traditional quantitative expression. For example, 'height' is a linguistic variable whose values are 'very small', 'small', 'medium', 'large', etc. Fuzzy numbers can also represent these linguistic values.

5. METHODOLOGY ADOPTED

In this case study the following methodology was adopted. First of all, a list of potential and feasible sites for the installation of wind power plant in Indian cities was prepared. Then the appropriate evaluation criteria based on various factors was determined and the very next step was to constitute a group of decision makers to contribute their individual decisions. Then, a framework for available alternatives and criteria was established. Finally, the MCDM methods were applied to provide ranking to these available alternatives

6. CONCLUSION

This work sheds light on a new method, to solve site selection problems and select the best city through a multi-attributes group decision-making process under fuzzy environments. In the decision-making process, it is difficult for the decision maker to express ideas /opinions in numerical values because it produces indiscretion. Therefore, fuzzy set theory has been adopted to handle these types of problems because evaluation is defined in linguistic terms. This paper highlights on VIKOR under the fuzzy environmental method to deal with both qualitative and quantitative attributes and selected a suitable site for a wind power plant. Finally, the proposed method is a simple, flexible and systematic approach that can be applied in other decision-making problems.

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