Prioritization of Water Consumption Management Strategies in Water Distribution Networks Using Multiple Criteria Decision Making Method of Fuzzy Analytic Hierarchy Process (Case Study: Tehran)

M. Tabesh[1*], E. Ali-Bariany[1], S. S. Motevallian[1], A. Roozbahani[2], S. Beygi[1]

[1] School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran
[2] College of Abourayhan, University of Tehran, Tehran, Iran

ABSTRACT: As the volume of renewable water resources has been significantly decreased and developing new water resources are faced with serious limitations, there has been a change of emphasis in management practices from supply-sided to demand-sided approaches in most regions of the world. Water consumption management strategies seek to reduce water consumption and establish a reasonable and sustainable balance between water supply and demand. In this paper, a multi-attribute decision-making method and an algorithm is developed for selecting water consumption management strategies for water distribution networks. To demonstrate the applicability of suggested method, a case study is conducted in Tehran in which different water consumption management strategies are prioritized using Fuzzy Analytic Hierarchy Process (FAHP) and based on water and wastewater experts' judgments. Applied strategies are performing educational programs among water users, non-revenue water reduction, increasing water price and using water-saving appliances. Furthermore, decision criteria used in this study are costs, time of implementation, water user's satisfaction, the volume of non-revenue water and water-saving efficacy. To evaluate the impact of uncertainties lied in the model on final results, a sensitivity analysis is performed in terms of changes in the weight of decision-makers' judgments and the shape of fuzzy membership functions. Finally, the non-revenue water reduction is gained the first rank among all water consumption management strategies. The results of this study show that in case of high degree of fuzzy uncertainties and dearth of sufficient quantitative data, the presented method can be employed as a robust decision-making tool by urban water managers.

1- Introduction

Nowadays optimal operation of water and water resources management is vital. The lack of sufficient drinking water is a major problem worldwide especially in arid areas with low rainfall. In this paper, a multi-attribute decision-making framework for strategic planning of water consumption management is presented.

Abrishamchi et al. [1] made an attempt to put into practice the multi-criteria decision making technique of compromise programming for a real urban water management case study in the city of Zahidan in Iran. The results obtained reveal that the method is capable of being employed by decision-makers for comprehensive urban water management studies [1]. Morais and Almedia [2] proposed a group decision-making model based on PROMETHEE V method for leakage management strategy, which took into account the viewpoints of four stakeholders, selecting feasible options and considering the available budget as constraint. Thus, this strategy is the combination of options that will efficiently meet technical, socio-economic and environmental criteria to achieve sustainable development [2]. The analytic hierarchy process was analyzed in the context of benefits, opportunities, costs and risks by Delgado-Galvan et al. [3]. The main conclusion was that water supply managers and authorities should shift direction from purely economic policies based on passive leakage control towards new social and environmental policies that consider more proactive actions [3].

In this paper, a multi-attribute decision-making method and an algorithm is developed for selecting water consumption management strategies for water distribution networks. To demonstrate the applicability of suggested method, a case study is conducted in Tehran in which different water consumption management strategies are prioritized using Fuzzy Analytic Hierarchy Process (FAHP) and based on water and wastewater experts' judgments.

2- Methodology

In this paper an efficient calculation method of the new consistent matrix and its corresponding vector of priority either after introducing a new decision element or after

Table 1: Final ranking of alternatives based on experts' judgments

Strategy	Point	Rank
Non-revenue water reduction	34	1
Educational programs	27	2
Increasing water price	23	3
Using water-saving appliances	15	4

withdrawing an obsolete element is introduced. This method by using Buckley (1985) method, determines fuzzy priorities of comparison ratios with trapezoidal membership functions [4]. The geometric mean method was employed to calculate the fuzzy weights for each fuzzy matrix and these were combined in the usual manner to determine the final fuzzy weights for the alternatives.

3- Case study

Using fuzzy hierarchical analysis, four scenarios were chosen and ranked for water consumption management strategies in Tehran water distribution network. At first equal weight was applied to all decision-makers. This weighting was chosen as a base then later, different sets of weights were generated for each decision makers. In this way, the effect of weighting decision makers' comments, from the base to the end of the ranking can be seen. In order to evaluate the effect of uncertainties on the final response, sensitivity analysis was performed on the model components.

4- Results and discusion

Different water consumption management strategies were ranked using Fuzzy Analytic Hierarchy Process (FAHP) and based on water and wastewater experts' judgments that final ranking of water consumption management strategies are shown in Table 1.

According to the obtained results the non-revenue water reduction and educational programs are the best strategies. It is recommended that, in future studies on priority options in the present study, assessments and analyzes of economic, social and environmental to be implemented.

References

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