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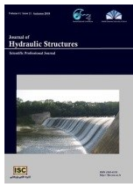

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Evaluation of Crisis Resolution Strategies for Groundwater Revival Plan Using Fuzzy Best - Worst Multi-Criteria Decision Model

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Abstract

The importance of the proper implementation of the Groundwater Revival Plan (GRP) as one of the key approvals of the Supreme Water Council has been doubled due to the escalation of the groundwater crisis in most of Iran's aquifers. Therefore, the implementation of GRP principles is the only way to overcome the crisis and the related challenges. In this study, the management crisis of Iran's groundwater resources is re-evaluated from the perspective of the administrative, social, and legal system with the GRP challenging approach. Then, the best-worst fuzzy multi-criteria decision model in Lingo9 software is developed by collecting the opinions of 23 GRP experts, based on three general criteria of change in administrative structure (C1), policy structure (C2) and modification of GRP legal structure (C3), which includes 18 sub-criteria. The results showed that timely and appropriate allocation of financial resources (S22), creating incentive packages for farmers to improve the cultivation pattern (S23) and creating serious efforts at all levels of management in the field of implementation, continuity, and removal of obstacles (S21) respectively with weights. 0.2247, 0.1098, and 0.0946 - with more than 40% of the total importance - occupy the first to third ranks.

Keywords: Groundwater Revival Plan, Best-Worst Fuzzy Multi-Criteria Decision Model, Water Resources Management.

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1. Introduction

Considering the conservation of water resources and their optimal use, along with addressing the development infrastructure is one of the serious challenges of developing countries in the world today [1]. Water is a vital and irreplaceable factor in human life [2]. Today, the importance of water has become even more prominent, given that more than two billion people are suffering from water shortages [3], Water scarcity in the 21st century is considered as a "major crisis" [1]. The water crisis refers to a situation in which water supply is less than demand in an area. The water crisis index in Iran is far more unfavorable than the world average, since it is located in arid to semi-arid climates [4]. In the Middle East, which has a political history based on water conflicts [5, 6], scientists have warned that severe water scarcity and desertification will occur in the future, and by 2050, even per capita available water will be reduced by 50% [7]. In Iran, water shortage is considered one of the important factors limiting sustainable development [8] and it is also predicted that Iran is going to be included in the list of countries that will face serious water shortages by 2025 [9]. In recent decades, the growing population and the water supply for food have caused serious conflict among operators of water resources. The limitation of these resources indicates their need for sustainable operation [10].

Unsustainable operation of groundwater is one of the main problems related to the structure of groundwater governance in Iran. In addition, increasing the declining trend of groundwater levels as well as growing the number of prohibited plains [and even critical prohibited plains] is considered as the main important challenges and to solve [11]. According to the United Nations' reports, those issues related to water scarcity and its usage management has been considered as the second global challenge after population growth ([12]-[13]). The world's freshwater resources are scarce; so that out of 100% of the world's volume of water, 97.5% is saline water and unusable. Therefore, only 2.5% is fresh water.

Iran has an arid and semi-arid climate, with an average annual rainfall of 252 mm, which is only one-third of the global average ([14]-[15]). On the other hand, the average evaporation rate is more than 179 mm (71% of Iran's total rainfall), which is three times the global rate [16]. Approximately 70% of precipitation occurs in the form of rain and the rest as snow ([17]-[18])]. The climatic situation and water resources of Iran indicate a serious limitation of water resources, so that 65% of Iran's area is located in the arid areas and 20% in the semi-arid and desert areas [19]. These areas include the main populating parts, like Iran's metropolises, in which water supplying rely on groundwater resources. In addition, only the 15% of its area is located in other climates as humid and semi-humid climates ([20]-[21]). Therefore, Iran's groundwater resources have become critical due to its excess withdrawal and successive droughts in recent years. The Intensification of groundwater level declining and its reservoir deficit i resulted into the prohibition of more than 307 areas out of 609 study areas. Although, in 1968, there were only 15 prohibited plains in Iran, in the last ten years, the increasing exploitation trend of groundwater has caused irreparable damage to the groundwater resources and intensified the depletion process [22].

Analyzing and studying the problems of water resources have been accomplished many times all around the world so far.

Ferrett and Ward [23] studied the effect of agricultural land use planning on groundwater quality. They discussed the role of toxins from agricultural activities in polluting groundwater and recommended the need for appropriate policies to prevent it.

Bhat and Blomquist [24] examined the water crisis in the Guadalquivir River Basin in Spain.

they suggested that the politics of management at the river basin level would affect the implementation of national water policies intended to promote integrated management.

Yang et al. [25] conducted a study on the variability of water resources due to changes in the amount of climatic parameters and concluded that irrigation conditions in China are directly affected by rainfall and evaporation rate. They also indicated that in the decades with more rainfall and less Evaporation rate, better irrigation could be possible.

Farajzadeh and hosseini [26] studied the water crisis of Nishabor. They analyzed the climatic, hydrologic, geologic and land use data of the plain aquifer. Their results indicated that Nishabor aquifer storage has water deficiency of about 200 million cubic meters and the areas with medium to high water crises cover about 50 percent of study plain. They proposed land use correction for the areas with crises in order to manage and control the intensity of water crises.

Mohammadjani and Yazdanian [27] analyzed and investigated the phenomenon of water crisis of Iran in both aspects of demand and supply of water. They drew the attention of policy makers on the importance of water resources management, and examined the international water indices and then explore the world outlook of water crises for 2050. Their results indicated that the agricultural sector in the present set-up, has utilized more than 90 percent of water consumption of Iran. However, due to structural drawbacks governing the agricultural sector, growing trend of population, rise in consumption of foodstuff, intensified constraints on exploitation of underground water resources, and Ex-inefficiency of water consumption in Iran, the trade deficit of this sector, has reached more than 8 billion dollars per annum. They stated that in the absence of implementing an appropriate policy framework for management of water resources, Iran would face a severe water crisis, and if the current level of consumption of water increases dramatically, these circumstances will get worse and subsequently the security and economic indices will be deteriorated .

They declared that improvement of demand management for water, particularly in agricultural sector through observing the optimal pattern of cropping in national- regional level, and more emphasis on application of virtual water index for finding the best pattern of production and trade for agricultural products and delineating more attention to the economic value of water, could pave the way to resolve the water crisis of Iran pro rata.

Alipour et al. [28] reviewed the status of groundwater revival plan in the critical prohibited plain of Neishabour as one of the pilot plains in Khorasan Razavi province of Iran. They proposed four scenarios to revive the aquifer based on available data and statistics.

Today, the increasing effects of climate change have caused its most plains into critical situation. The water-monitoring index of 21 provinces of Iran indicates that it is in the severe water stress. Only 10 provinces are in the tolerable water-monitoring index. Although, the Groundwater Revival Plan implementation, which is one of the approvals of the Supreme Water Council, as a solution ending to this crisis, has become mandatory for all regional water companies in Iran, this plan has challenges and problems that will not achieve the above goals [28]. In general, problems related to the management of water resources operation, particularly groundwater resources are not an emerging phenomenon in Iran. The reduction of the groundwater volume over the past four decades resulted in some unfavorable consequences followed by the increasing operation development of water resources. Iran's aquifers face an average volume deficit of 5.4 billion cubic meters annually. In the last half-century, groundwater reservoirs have faced a reservoir deficit of 110 billion cubic meters, of which more than 90 billion cubic meters in the last twenty years, 80 billion cubic meters in the last 15 years and 38 billion cubic meters in the last 7 years. This problem will build a very terrible future for the most parts of Iran [29]. The consequences of such unfavorable phenomenon, which is simultaneous with socio-economic development in Iran, are often ignored. A one-sided attention of agricultural development and non-observance of the optimal cultivation pattern are the main causes of the adverse phenomenon of continuous decline in the aquifers' water level in Iran.

The importance of groundwater resources is clear to everyone, considering the decisive role of groundwater in supplying water needed for various uses, including drinking, industry, and agriculture in different parts of Iran. Paying no attention to the quantitative and qualitative changes of these vital resources will have irreparable consequences for Iran and it is feared that the life and security of a large part of Iran will be endangered and a vague future will be formed for the people of Iran. Regarding to this issue and the approvals of the Supreme Water Council, Ministry of Energy presented a plan as the Groundwater Balancing Plan, which includes fifteen executive projects to deal with the water crisis implemented since 2015 throughout Iran [29]. Although almost 15 years ago, with the follow-up of the Ministry of Energy in 2005, the groundwater balancing plan was defined and credit rowed, unfortunately, the credit was performed from 2006 to 2014 without adapting to inflation. Therefore, most of the projects were stopped in 2010. The descending trend in the allocated funds in the groundwater balancing plan has exacerbated the consequences of reservoir deficit. Consequently, the Ministry of Energy presented its plans in the eighth session of the Supreme Water Council in 2012, so that it was initially proposed as a legal solution to unauthorized groundwater withdrawal and finally, presented as the Groundwater Revival plan [29].

The groundwater revival plan consists of 15 projects that were approved in the 15th session of the Supreme Water Council (Iran) on September 16, 2014.

The maintargets of Groundwater Revival Plan (GRP) are as follows:

- Increasing the participation of stockholders in water resources management;
- Balancing between water resources and consumptions;
- Protecting the water resources quantitatively and qualitatively;
- Increasing the productivity of water resources with sustainable operating of water resources;
- Clarifying authorized and unauthorized withdrawal of groundwater resources;
- Reducing the declining trend of groundwater level of aquifers;
- Establishing, promoting and institutionalizing the water resources management and operation;
- National Water Accounting with authorities in the Ministry of Energy;

This plan was presented in a 20-yeared plan with the priority of controlling the reservoir annual deficit of 5.4 billion cubic meters of Iran's aquifers. In addition to this plan, some tasks were specified for the Ministries of Energy, Agriculture, Industry-Mining-Trade, and the Ministry of Interior [29]:

1.1. Projects related to the Ministry of Energy

The 15 projects presented to revive the groundwater resources that have been approved by the Supreme Water Council followed as:

- drilling piezometric wells to complete the groundwater monitoring network in Iran's aquifers;
- Installing water resources measurement equipments for piezometric and exploratory wells to complete groundwater monitoring network;
- Preparing a balance sheet and updating the database of the study areas to prepare a

decision support model;

- Establishing a local water market in Iran to manage the plan and demand for water and implement the price mechanism and optimal water consumption;
- Buying low-efficiency agricultural wells to compensate the aquifers' deficit;
- Organizing water well drilling companies and installing GPS on drilling rigs to prevent unauthorized drilling;
- Increasing the life of water wells;
- Replacing the use of treated water instead of water extracted by agricultural wells in prohibited plains to use unconventional water resources to save groundwater resources;
- Strengthening and establishing patrol and inspection teams (PIT) throughout Iran using the private sector to apply more management in groundwater resources as well as installing smart water meters;
- establishing a monitoring and controlling system for water withdrawal to control consumption;
- Controlling, monitoring and blocking unlicensed wells which are harmful to public interests to compensate the predicted groundwater deficit;
- conveying the artificial recharging and flood spreading projects to use surface water recharging groundwater aquifers;

In order to manage the aforementioned projects, it is necessary to reform the project management structure in Iran's Water Resources Management Company (I.W.R.M.C) considering the importance of GRP to control and monitor the correct implementation of the projects regarding to the integrated water resources management [30].

1.2. Projects related to the Ministry of Agriculture

- Establishing water users' organization and providing their technical and financial support to create suitable conditions to hand over operation affairs to the operators and reduce government ownership affairs;
- Updating the National Water Resources Document (NWRD) to verify the water needs for crops and determine the cultivation pattern appropriate to the climate;
- Study and implementation of watershed management plans to preserve Iran's water and soil resources and reduce sediment production [31];

1.3. Projects related to the Geological Survey and mineral exploration of Iran

These projects include zoning and land collapsing hazards to study and control the reaction of the ground level to the groundwater withdrawal over time and the subsequent risks ([32]).

In this study, the management crisis of groundwater resources of Iran has been evaluated by providing criteria from the perspective of administrative, social, and legal structure with the challenging approach of groundwater revival plan. After that the effectiveness of solutions to existing challenges is evaluated Based on one of the latest multi-criteria decision models called the Fuzzy Best Worst Method (FBWM) as an innovation. This is despite the fact that previous research has not addressed this issue at all. Therefore, presenting solutions to solve the GRP problems and analyzing them with FBWM to get the solutions ranked is the scientific novelty of the present investigation.

2. Materials and methods

Achieving the goals of the groundwater revival plan will be difficult based on the challenges and difficulties. In this study, the groundwater revival plan was re-evaluated from the perspective of the administrative, social, and legal system considering integrated water resources management. In addition, the effectiveness of solutions to overcome the existing challenges was discussed as follows:

2.1 Change in the administrative structure

2.1.1 Equipping all agricultural and industrial wells with smart meters as soon as possible

Equipping wells with the automatic monitoring instruments such as smart water and electricity meters or smart volumetric meters is one of the effective tools in controlling the water withdrawal from such wells [33]. In case of equipping more than 75% of the wells with such equipments it can be possible to prevent excess withdrawal of agricultural wells, which have the main share in excess withdrawal from groundwater. Otherwise, the above-mentioned equipments will be only devices for reading the volumes of water, not controlling.

By the end of 2019, only a number of 2000 from 16,000 of authorized wells in Golestan province were equipped with smart meters to control the authorized withdrawal volumes. Meanwhile, more than 14,000 wells must be equipped with smart meters.

If it is accepted to install the smart meters on deep drilled wells to control the extracted water from deep aquifers, about 8600 wells will need to install smart meters. Since only 2,000 smart meters have been installed on priority wells in the last five years - about 400 per year - the minimum installation time is estimated to be more than 20 years, so this time is not reasonable and contradicts the groundwater revival plan. Therefore, providing financial resources allocated to install smart meters and accelerating the installation process as well as continuous data logging can be very efficient.

2.1.2 Matching patrol and inspection teams with the number of authorized and unauthorized water wells

If the total number of authorized and unauthorized wells in an office is considered 9,000 wells, it will be needed about five teams taking into account 22 working days per month and visiting seven wells daily. Because in Golestan province, the total number of authorized and unauthorized wells is amounting to 36,000, at least 40 patrol and inspection teams are needed to protect its water resources, but the number of patrol and inspection teams is currently 19 teams. Therefore, this number of patrol and inspection teams should be doubled at least because of the diversity of the tasks assigned; including supervising the water well drilling process, fulltime attendance in rural areas to prevent the drillings of unauthorized wells, investigation of public complaints, investigation of violations in the water resources field, the process of detection, arrest, and transferring unauthorized drilling rigs to predetermined sites.

2.1.3 Assigning special teams outside non-office hours (three teams in three shifts)

Since most of the violations in the groundwater sector such as unauthorized drillings of wells take place during non-office hours and holidays, GRP inspection teams can be defined in three 8-hour work shifts with continuous activity at all hours of the year in order to protect and preserve the vital resources of groundwater.

2.1.4 Separation of groundwater revival plan personnel from departments

It seems that the separation of GRP personnel from administrative staff can be productive in order to perform their duties efficiently because of the interference of the duties imposed by the managers of city offices with the inherent duties of patrol and inspection teams.

2.1.5 Organizing and commanding the teams in order to be monitored at all hours

Availability of relevant officials at all hours to monitor teams is another useful factor in implementing GRP. It is worth noting that this also requires funding and allocation of specific financial resources.

2.1.6 Attending of team officials at all hours

Like police guard officers and health-medical staff of hospitals that their attendance is essential in all hours of the day and night, attending of GRP officials at the location of teams will be useful at all hours of the year. Consequently, the attendance of three workshop managers in three work shifts is necessary to coordinate the teams.

in another hand, Coordination with relevant teams and police officials should be necessary in case of receiving public reports on the actions of profiteers in violations related to groundwater.

In addition, providing the necessary equipment for transporting drilling rigs to pre-designated parking lots and coordinating with parking lot officials will be one of the most important tasks of these managers.

2.1.7 Having a 3-digit dedicated telephone number to inform violations by people:

By creating a system for receiving and recording public reports on violations in the field of water resources - in the form of a 3-digit telephone number - it will be easier for the people to inform all subordinate departments of the ongoing violations .

In this regard, the informing process can be as follows:

- Installing advertising billboards in the city or village and inserting the telephone number on them,
- Informing the people by the provincial radio and television,
- Inserting the telephone number on the electricity bills of wells.

2.2 Change in the policy structure of the GRP

2.2.1 Creating a serious effort at all levels of management

Having serious participation in all levels of management and even senior managers in dealing with violations in the field of water resources management is the most important issue to remove obstacles to the GRP and prevent violations. Removing the obstacles to the GRP should be one of the main goals of managers.

2.2.2 Timely and proportionate allocation of financial resources

If the remuneration of the GRP personnel in different departments is paid on time, and their urgent needs of life are provided according to a logical routine, it will create double morale in the personnel and will be effective in GRP process.

2.2.3 Creating incentive packages for farmers to improve the cultivation pattern:

Because the use of wells' water in the agricultural sector has a major share in the use of groundwater resources, adjusting the use of groundwater resources in the agricultural sector is one of the most important issues based on integrated water resources management .In addition, the loss of groundwater resources in this sector is more than in other sectors. Therefore, modifying and changing the cultivation pattern, which in recent years has been discussed only by the relevant executive systems as a plan, has not been done by farmers so far.

Considering the principles of integrated management of water resources GRP is beyond a Simple System or even a Complicated System. A complex system is required in this regard, and this will only be achieved if farmers are persuaded to change their cultivation pattern. Consequently, proposing incentive packages and executive policies with the following priorities can be helpful:

- Providing incentive packages i.e., agricultural inputs for the cultivation of low water demanding crops.
- Providing free services and guaranteed purchase of low water demanding crops so that it is economically viable for farmers.
- Strengthening the insurance of agricultural crops to meets the economic needs of farmers.
- Reduction or elimination of import tariffs for high water demanding crops such as high-quality imported rice and reducing their prices.

2.2.4 Providing free facilities regarding the installation and implementation of modern irrigation systems

In ancient times, irrigation was done by simple methods. However, various scientific methods are being used for irrigation, and each of these methods will greatly contribute to the development of agriculture .

Irrigation should use those methods that both save water consumption and prevent soil leaching or damage. Unfortunately, the Farmers' insistence on not using modern irrigation methods has led to water losses in this sector [34].

Micro-irrigation is the slow application of water on, above, or below the soil by surface dripping, subsurface dripping, bubbler, and micro-sprinkler systems. Water is applied as separate or continuous drips, small streams, or miniature spray through applicators positioned along a water delivery line next to the plant row. In addition, the installation and implementation of modern irrigation systems, including sprinkler irrigation, especially Micro irrigation will play an important role in increasing irrigation efficiency .According to the very expensive costs of implementation of modern irrigation systems and the inability of most farmers to provide the relevant financial resources, supplying free facilities in this regard can be very helpful .

2.3 Change in the legal structure of the GRP

Reforming the judiciary system in order to intensify and equate the punishment of offenders in the field of water resources management, as well as changing the administrative structures and policy of the GRP, will be the other effective strategies in the GRP. The most important of these approaches are the following:

2.3.1 Accelerate the litigation process

At present, the court litigation process is slow because of the lack of judge numbers who have the necessary technical and engineering knowledge and the absence of special courts for special crimes as well as amending the judicial process.

2.3.2 Elimination of adjudication costs

Elimination of adjudication costs of the ongoing cases in the courts of Iran - in the legal prosecution stage - requires the serious cooperation of the senior managers of the judiciary and the executive system. This is because of the lack of timely financial resources in sending judicial cases by the Ministry of Energy that will slow down the judicial process.

2.3.3 Training Engineer Judge

Having judicial knowledge alone cannot be the solution to the problems of water resources. Therefore, if judges have knowledge of engineering and management of water resources, there is no need to justify them and defend judicial cases. Many of these issues will be resolved if judges with water resources knowledge are hired. Establishing special courts for violations in the field of water resources management

In accordance with the huge volume of violations in the field of water resources management and a large number of judicial cases in other social, economic and moral areas, as well as its social importance of acceleration, judges do not have enough time and effort in dealing with cases of water resources management violations. Therefore, the establishment of special courts for violations in the field of water resources management can be one of the most important issues.

2.3.4 Increasing the punishment of offenders dealing with water resources management crimes

Deterrent policies are practically ineffective due to the incompatibility of punishment of offenders dealing with water resources management crimes, then a modified procedure should be applied in this regard considering the other approaches presented.

2.3.5 Creating joint working groups of the Ministry of Energy and the Judiciary system officials to remove obstacles to the GRP

Creating a procedure unity between the Ministry of Energy and the Judiciary system officials based on the approvals of the Ministries of Agriculture and Interior as the joint working groups can solve many issues.

As the creation of special courts for violations, regarding to water resources management significantly increases the speed of the criminal justice process.

Therefore, forming an expert team that is not influenced by the political authorities will significantly solve the existing problems and obstacles of the GRP. Accelerating the litigation process will be significant in preserving vital water resources.

2.3.6. Permanent order of the prosecutor's office to dealing with violators

According to the past experiences of this article authors and the need not to waste time to obtain a prosecutor's order and prevent escaping relevant offenders, a permanent prosecutor's order under Article 30 of the Law on Fair Distribution of Water to reduce offenders and preventing their escape will play a major role.

2.4. Fuzzy best-worst MCDM method

2.4.1. Triangular fuzzy numbers

Prof. L. A. Zadeh put forward the Fuzzy set theory in 1965 [35]. The fuzzy set theory should solve the practical problems under an environment of uncertainty as an extension of classical set theory. A fuzzy set $\tilde{a}$ is a pair (U, m), where U is a set and $m: U \rightarrow [0, 1]$ is a $\mu_{\tilde{a}}(x)$ donated membership function. Element x in a discourse universe X can be mapped to a real number in the interval [0, 1] by referring to $\mu_{\tilde{a}}(x)$.

It should be noted that $\tilde{a} \in F(R)$ is a fuzzy number if:

- There exists $x_0 \in R$ such that $\mu_{\tilde{a}}(x_0)$ is equal to one;
- For any $\alpha \in [0, 1]$, $\tilde{a}_\alpha = [x, \mu_{\tilde{a}\alpha}(x) \geq \alpha]$ is a closed interval.

Here, R indicates the set of real numbers, and F(R) is the fuzzy set. In addition, a fuzzy number $\tilde{a}$ on R is defined as a triangular fuzzy number (TFN) if its membership function $\mu_{\tilde{a}}(x)$: $R \rightarrow [0, 1]$

Table 1. Transformation laws of decision-makers linguistic variables.

Linguistic terms	Membership function
Equally importance (EI)	(1 ,1,1)
Weakly important(WI)	(2/3 ,1, 3/2)
Fairly Important (FI)	(3/2 ,2, 5/2)
Very important(VI)	(5/2 ,3, 7/2)
Absolutely important(AI)	(7/2 ,4, 9/2)

Is identical to

$$\mu_{\tilde{a}}(x)=\begin{cases} 0 & x < l \\ \frac{x-l}{m-l} & l \leq x \leq m \\ \frac{u-x}{u-m} & m \leq x \leq u \\ 0 & x > u \end{cases} \tag{1}$$

Where l, m, & u are the lower, modal and upper support values of $\tilde{a}$ respectively, all of them are crisp ($-\infty < l \leq m \leq u < \infty$) numbers. A triangular fuzzy number can appear as a triplet (l, m, u). The readers should refer to [36].
For the basic operational laws of two triangular fuzzy numbers (TFN). The graded mean integration representation (GMIR) R ($\tilde{a}$) of a triangular fuzzy number ($\tilde{a}$) represent the ranking of triangular fuzzy number [37]. $\tilde{a}_i = (l_i + m_i + u_i)$, and the GMIR$R(\tilde{a}_i)$ of TFN $\tilde{a}_i$can be measured by

$$R(\tilde{a}_i) = \frac{l_i + 4m_i + u_i}{6} \qquad (2)$$

2.4.2. Fuzzy best-worst method

Fuzzy best-worst method is one of the newest approaches to multi criteria decision-making model that was presented by Rezaei for the first time in 2015[37]. According to this method it is assumed that there are N parameters for a research object and the fuzzy comparisons on these n parameters can be made according to decision-makers' linguistic variables (terms), such as 'Equally Important (EI),' 'Weakly Important (WI),' 'Fairly Important (FI),' 'Very Important (VI),' and 'Absolutely Important (AI).' Then, decision-makers' linguistic assessments must be transformed into fuzzy ratings (represented by TFNs), and the transformation rules are described in Table 1 [38]. The fuzzy matrix for comparison can then be obtained as follows:

$$\tilde{A} = \begin{array}{c} \\ c_1 \\ c_2 \\ \vdots \\ c_n \end{array} \begin{array}{c} \begin{array}{cccc} c_1 & c_2 & \cdots & c_n \end{array} \\ \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix} \end{array} \qquad (3)$$

In which $\tilde{a}_{ij}$ is the relative fuzzy preference of criterion i to criterion j, which is a triangular fuzzy number; $\tilde{a}_{ij}$= (1, 1, 1) if i = j.

- We can learn from the basic concept of BWM (readers should refer to [39]) that in order to obtain a completed matrix$\tilde{A}$, excuation of n fuzzy pair comparisons are not required.
- If i is the best element and/or j is the worst element, then a pairwise comparison $\tilde{a}_{ij}$ is known as a fuzzy reference comparison.
- For$\tilde{A}$, there exist completely 2n-3 ((n-2) Best-to-Others Fuzzy comparisons + (n-2) Others-to-Worst Fuzzy comparisons (+1) Best-to-Worst Fuzzy comparisons) Fuzzy reference comparisons required to be performed for Fuzzy BWM.

Using Fuzzy BWM, it is possible to evaluate both the fuzzy weights of criteria and the fuzzy weights of alternatives with respect to different parameters. The fuzzy comparisons on relative criteria should be made for assessing the fuzzy weights of criteria. In order to determine the fuzzy weights of alternatives with respect to different criteria, the related alternatives against each criterion should be compared fuzzily [35]. Eventually, the fuzzy ranking scores of alternatives can be extracted from the fuzzy weights of alternatives, compounded by the fuzzy weights of the same parameters, with respect to various parameters. Then you can calculate the crisp ranking scores of alternatives (if needed) using the GMIR method for optimal alternative selection. Hence, the Fuzzy comparison logic and method for determining the weights of parameters and alternatives are identical.

2.4.3. Comprehensive steps of fuzzy BWM

2.4.3.1. Step 1. Build the decision criteria system.

The system of decision criteria comprises of a collection of decision criteria, which is very crucial for carrying out the assessment on alternatives reasonably. Decision criteria values may reflect the output of the various alternatives. Assume there are n criteria for the decision $\{c_1, c_2, \ldots, c_n\}$[40].

2.4.3.2. Step 2. Determine the best (most important) criterion and the worst (least important) criterion.

In this step, decision-makers should identify the best criterion and the worst criterion based on the built-in decision criteria system. The highest criterion is c_B, and the worst criterion is called c_W[40].

2.4.3.3. Step 3. Execute the fuzzy reference comparisons for the best criterion.

For fuzzy BWM, the fuzzy reference comparison is very significant. As mentioned before, there are two parts to the fuzzy reference comparison:

One part is a pair comparison $\tilde{a}_{ij}$ where i is the best factor, and c_i is the best c_B criterion in this respect. Another is the pair comparison $\tilde{a}_{ij}$ where j is the worst element, and here c_j is the worst c_W criterion. The first part will be done in this phase. The fuzzy preferences of the best criterion over all the parameters can be calculated by using the linguistic terms of the decision-makers mentioned in Table 1. Instead, according to the transformation rules shown in Table 1, the obtained fuzzy preferences are transformed into TFNs. The obtained Fuzzy Best-to-Others vector is: [40].

$$\tilde{A}_B = (\tilde{a}_{B1}, \tilde{a}_{B2}, \ldots, \tilde{a}_{Bn}) \tag{4}$$

Where $\tilde{A}_B$ is the fuzzy Best-to-Others vector; $\tilde{a}_{Bj}$ is the fuzzy choice of the best c_B criterion over the criterion j, $j = 1, 2, \cdots, n$. Moreover, $\tilde{a}_{BB} = (1, 1, 1)$ [40].

2.4.3.4. Step 4. Execute the fuzzy reference comparisons for the worst criterion.

The other aspect of the fuzzy reference comparison will be carried out in this step. Through using the linguistic evaluations of decision-makers listed in Table 1, it is possible to decide the fuzzy preferences of all criteria for the worst criterion, and then to convert them into TFNs according to the transformation rules mentioned in Table 1. Others-to-Worst of the fuzzy vector can be extracted as: [40].

$$\tilde{A}_w = (\tilde{a}_{1w}, \tilde{a}_{2w}, \ldots, \tilde{a}_{nw}) \tag{5}$$

Where $\tilde{A}_w$ stands for the fuzzy vector Others-to-Worst. $\tilde{a}_{iw}$ reflects criterion i's fuzzy preference over the worst c_W criterion, i= 1 , 2, · · ·, n. $\tilde{a}_{WW}$ = (1, 1 , 1), can be learned.

2.4.3.5. Step 5. Determine the optimal fuzzy weights ($\widetilde{W}_1^*, \widetilde{W}_2^*, \dots, \widetilde{W}_n^*$).

The optimal fuzzy weight for each criterion is the one where $\widetilde{W}_B/\widetilde{W}_j = \tilde{a}_{Bj}$ and $\widetilde{W}_j/\widetilde{W}_W = \tilde{a}_{jW}$ should be available for each fuzzy pair $\widetilde{W}_B/\widetilde{W}_j$ and $\widetilde{W}_j/\widetilde{W}_W$.
To achieve these conditions for all j, a solution should be found where the maximum absolute gaps | $\widetilde{W}_B/\widetilde{W}_j - \tilde{a}_{Bj}$| and | | $\widetilde{W}_j/\widetilde{W}_W - \tilde{a}_{jW}$| are reduced for all j. It should be mentioned that the triangular fuzzy numbers $\widetilde{W}_B$, $\widetilde{W}_j$ and $\widetilde{W}_W$ in fuzzy BWM are somewhat different from those in BWM. For certain instances we like to use $\widetilde{W}_j = (l_j^W, m_j^W, u_j^W)$ to pick the best alternative [33]. Hence, for assessing the optimal fuzzy weights ($\widetilde{W}_1^*, \widetilde{W}_2^*, \dots, \widetilde{W}_n^*$) as follows, we can get the constrained optimization problem [40].

$$\text{Min } \max_j \{|\widetilde{W}_B/\widetilde{W}_j - \tilde{a}_{Bj}|, |\widetilde{W}_j/\widetilde{W}_W - \tilde{a}_{jW}|\}$$
$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} R(\widetilde{W}_j) = 1 \\ l_j^W \le m_j^W \le u_j^W \\ l_j^W \ge 0 \\ j = 1, 2, \dots, n \end{cases} \tag{6}$$

Where $\widetilde{W}_B = (l_B^W, m_B^W, u_B^W)$, $\widetilde{W}_j = (l_j^W, m_j^W, u_j^W)$, $\widetilde{W}_W = (l_W^W, m_W^W, u_W^W)$, $\tilde{a}_{Bj} = (l_{Bi}, m_{Bi}, u_{Bi})$ $\tilde{a}_{jW} = (l_{jw}, m_{jw}, u_{jw})$.
Equation (6) may be transferred to the following problem of non-linearly restricted optimization [40].

$$\min \ \tilde{\xi}$$
$$s.t. \begin{cases} |\widetilde{W}_B/\widetilde{W}_j - \tilde{a}_{Bj}| \le \tilde{\xi} \\ |\widetilde{W}_j/\widetilde{W}_W - \tilde{a}_{jW}| \le \tilde{\xi} \\ \sum_{j=1}^{n} R(\widetilde{W}_j) = 1 \\ l_j^W \le m_j^W \le u_j^W \\ l_j^W \ge 0 \\ j = 1, 2, \dots, n \end{cases} \tag{7}$$

Where $\tilde{\xi} = (l^{\xi}, m^{\xi}, u^{\xi})$.

Table 2. Consistency index (CI) for Fuzzy BWM

Linguistic term	Equally importance (EI)	Weakly important (WI)	Fairly Important (FI)	Very important (VI)	Absolutely important (AI)
$\tilde{a}_{BW}$	(1 ,1,1)	(2/3 ,1,3/2)	(3/2 ,2,5/2)	(5/2 ,3,7/2)	(7/2 ,4,9/2)
CI	3.00	3.8	5.29	6.69	8.04

Taking into account $l^{\xi} \le m^{\xi} \le u^{\xi}$, we assumed $\tilde{\xi}^* = (k^*, k^*, k^*)$, $k^* \le l^{\xi}$, therefore Eq. (7) can be modified as [40].

$$\min \ \tilde{\xi}^{*}$$
$$s.t.\begin{cases} \left|\frac{(l_B^W, m_B^W, u_B^W)}{(l_j^W, m_j^W, u_j^W)} - (l_{Bi}, m_{Bi}, u_{Bi})\right| \leq (k^*, k^*, k^*) \\ \left|\frac{(l_j^W, m_j^W, u_j^W)}{(l_W^W, m_W^W, u_W^W)} - (l_{jw}, m_{jw}, u_{jw})\right| \leq (k^*, k^*, k^*) \\ \sum_{j=1}^{n} R(\widetilde{W}_j) = 1 \\ l_j^W \leq m_j^W \leq u_j^W \\ l_j^W \geq 0 \\ j = 1, 2, \dots, n \end{cases} \quad (8)$$

The optimum fuzzy weights $(\widetilde{W}_1^*, \widetilde{W}_2^*, \dots, \widetilde{W}_n^*)$ can be achieved by solving Equation (8).

2.4.4. Consistency ratio for fuzzy BWM

Consistency ratio (CR) is an important measure for testing the degree of consistency of a pairwise comparison. The CR for the Fuzzy BWM is proposed in this section[40].
A fuzzy comparison is absolutely compatible when $\tilde{a}_{Bj} \times \tilde{a}_{jW} = \tilde{a}_{BW}$, where $\tilde{a}_{BW}$, $\tilde{a}_{Bj}$, and $\tilde{a}_{jW}$ are the fuzzy preference of the best criterion over the worst criterion, the fuzzy preference of the best criterion over the criterion j, and the fuzzy preference of the criterion j over the worst criterion, respectively[40].

- In fact, the criterion j relevant to pairwise comparison can be inconsistent.
- The consistency ratio is used to test how accurate a pairwise fuzzy comparison is.
- One can measure the CR for fuzzy BWM as follows.

According to Table 1, $\tilde{a}_{BW}$*'s* maximum possible fuzzy value is (7/2, 4, 9/2), which corresponds to the decision-makers given linguistic terms 'Absolutely important (AI).
If $\tilde{a}_{Bj} \times \tilde{a}_{jW} \neq \tilde{a}_{BW}$, meaning $\tilde{a}_{Bj} \times \tilde{a}_{jW}$, can be higher or lower than $\tilde{a}_{BW}$, there will be an inconsistency of a fuzzy pairwise comparison.
When both $\tilde{a}_{Bj}$ and $\tilde{a}_{jW}$ are equivalent to $\tilde{a}_{BW}$, the largest difference that occurs in $\tilde{\xi}$can be reached.
Considering the existence of the greatest inequality, the following equation can be obtained as per the equality relationship $(\widetilde{W}_B/\widetilde{W}_j) \times (\widetilde{W}_j/\widetilde{W}_W) = \widetilde{W}_B/\widetilde{W}_W$.

$$(\tilde{a}_{Bj}-\tilde{\xi}) \times (\tilde{a}_{jW}-\tilde{\xi}) = (\tilde{a}_{BW}+\tilde{\xi}) \quad (9)$$

Equation (9) can be written as to the maximum fuzzy incompatibility $\tilde{a}_{Bj} = \tilde{a}_{jW} = \tilde{a}_{BW}$.

$$(\tilde{a}_{BW}-\tilde{\xi}) \times (\tilde{a}_{BW}-\tilde{\xi}) = (\tilde{a}_{BW}+\tilde{\xi}) \quad (10)$$

Then we can derive Equation (10) as

$$\tilde{\xi}^2 - (1 + 2\tilde{a}_{BW})\tilde{\xi} + (\tilde{a}_{BW}^2 - \tilde{a}_{BW}) = 0 \quad (11)$$

Where $\tilde{\xi} = (l^{\xi}, m^{\xi}, u^{\xi})$, $\tilde{a}_{BW} = (l_{BW}, m_{BW}, u_{BW})$.
The maximum possible fuzzy value for $\tilde{a}_{BW} = (l_{BW}, m_{BW}, u_{BW})$,is (7/2, 4, 9/2), indicating $l_{BW} = 7/2$

, m_{BW} = 4 , and u_{BW}= 9/2.
It shows l_{BW}, m_{BW}, and u_{BW} 's maximum value, can't exceed 9/2.
In this case, if we use the upper boundary u_{BW} to measure the consistency index, this consistency index can be used by all objects (data) associated with TFN $\tilde{a}_{BW}$ to remain effective and workable as the consistency index corresponding to u_{BW} is the highest in interval [l_{BW} , u_{BW}]. In the meantime, $\tilde{\xi}$can also be defined by a crisp value$\tilde{\xi}$.
We may execute the same procedure for other cases such as $\tilde{a}_{BW}$= (5/2, 3, 7/2), $\tilde{a}_{BW}$ = (3/2, 2, 5/2), $\tilde{a}_{BW}$ = (2/3, 1, 3/2) , and $\tilde{a}_{BW}$ = (1, 1, 1). Hence, Eq. (10) can be modified to

$$\xi^2 - (1 + 2u_{BW})\tilde{\xi}+(u_{BW}^2\text{-}u_{BW})=0 \quad (12)$$

Whereu_{BW} = 1, 3/2, 5/2, 7/2, and 9/2, respectively.
The maximum possible ξ can be found by solving Equation (11) for different u_{BW} which is used as the consistency index for fuzzy BWM.
Table 2 lists the obtained consistency index (CI) with respect to the different linguistic words used by decision-makers for fuzzy BWM [40].

3. Discussion and results

3.1. Introduction of research criteria and sub-criteria

This research includes 3 main criteria and 18 sub-criteria, which are given in Table 3.

Table 3. Weight and final ranking of criteria

Criteria	Code	Sub-Criteria	Code
Change in the administrative structure of the GRP	C1	Equipping all agricultural and industrial wells with smart meters as soon as possible	**S11**
		Matching patrol and inspection teams with the number of authorized and unauthorized water wells	**S12**
		Assigning special teams outside non-office hours (three teams in three shifts)	**S13**
		Separation of groundwater revival plan personnel from departments	**S14**
		Organizing and commanding the teams in order to be monitored at all hours	**S15**
		Attending of team officials at all hours	**S16**
		Having a 3-digit dedicated telephone number to inform violations by people	**S17**

Criteria	Code	Sub-Criteria	Code
Change in the policy structure of the GRP	C2	Creating a serious effort at all levels of management	**S21**
		Timely and proportionate allocation of financial resources	**S22**
		Creating incentive packages for farmers to improve the cultivation pattern	**S23**
		Providing free facilities regarding the installation and implementation of modern irrigation systems	**S24**
Change in the legal structure of the GRP	C3	Accelerate the litigation process	**S31**
		Elimination of adjudication costs	**S32**
		Training Engineer Judge	**S33**
		Establishing special courts for violations in the field of water resources management	**S34**
		Increasing the punishment of offenders dealing with water resources management crimes	**S35**
		Creating joint working groups of the Ministry of Energy and the Judiciary system officials to remove obstacles to the GRP	**S36**
		Having a Permanent order of the prosecutor's office to dealing with violators	**S37**

3.2. FBWM method results

In this research, the FBWM method has been used to calculate the weight and importance of criteria and sub-criteria. The first step in this method is to determine the most important (best) and least important (worst) criteria and sub-criteria, which are based on the opinions of experts (including 23 experts) and the research background as follows:

- In the main plan, changes in the policy structure of the GRP (C2) were selected as the most important and changes in the legal structure (C3) were selected as the least important criteria in the field of water resources management.
- In the criteria C1, Matching patrol and inspection teams with the number of authorized and unauthorized water wells (S12) were selected as the most important criterion and having a 3-digit dedicated telephone number to inform violations by people (S17) were selected as the least important sub-criteria.
- In the criteria C2, timely and proportionate allocation of financial resources (S22) and Providing free facilities regarding the installation and implementation of modern

irrigation systems (S24) were selected as the most and least important sub-criteria, respectively.

- In the criteria C3, Increasing the punishment of offenders dealing with water resources management crimes (S35) and accelerate the litigation process (S31) were selected as the most and least important sub-criteria, respectively.

In the next step, the pairwise comparisons of the best criterion against other criteria (BO) and other criteria against the worst criterion (OW) were performed by 23 experts. Then the answers were integrated by the arithmetical mean method. Finally, the problem model was created by equation 8 and the following results were obtained:

3.3. Calculation of the weights of the main criteria

First, a nonlinear optimization model is developed in Lingo 9 software. The results are given in the following tables.

Table 4. Weight and priority of the main criteria

Criterion	Fuzzy weight	Definite weight	Normal weight	Priority
Change in the administrative structure of the GRP (C1)	(0.241,0.324,0.355)	0.315	0.318	2
Change in the policy structure of the GRP (C2)	(0.402,0.520,0.520)	0.500	0.506	1
Change in the legal structure of the GRP (C3)	(0.157,0.188,0.188)	0.174	0.176	3
consistency rate $=\frac{0.23}{6.112}=0.038$				

According to Table 4, the fuzzy weight is obtained directly from solving the model in Lingo software after calculating the weight of the main criteria. These fuzzy weights are then converted to a definite weight by equation (2).After that, the normalized weights are calculated by dividing each criterion weight to the sum weight. The results showed that the criteria C2, C1, and C3 with weights of 0.506, 0.318, and 0.176, respectively are the first to the third priorities. In addition, the consistency rate of the research is 0.038, which indicates the high compatibility of pairwise comparison.

3.3.1. Calculation of the weights of sub-criteria C1

According to Table 5, after optimizing the model for the C1 sub-criteria, prioritization of each sub-criterion is done according to its weight. Table 5 reveals that the sub-criteria S12, S11, S14, S13, S15, S16 and S17 with weights of 0.256, 0.169, 0.137, 0.135, 0.106, 0.104, and 0.093, respectively are the first to the seventh priorities. The consistency rate of pairwise comparisons is 0.036, which indicates an appropriate compatibility of pairwise comparison.

Table 5. Weight and priority of sub-criteria of C1

Criterion	Fuzzy weight	Definite weight	Normal weight	Priority
Equipping all agricultural and industrial wells with smart meters as soon as possible (S11)	(0.147,0.173,0.173)	0.169	0.169	2
Matching patrol and inspection teams with the number of authorized and unauthorized water wells (S12)	(0.209,0.264,0.264)	0.255	0.256	1
Assigning special teams outside non-office hours (three teams in three shifts) (S13)	(0.118,0.138,0.138)	0.135	0.135	4
Separation of groundwater revival plan personnel from departments (S14)	(0.114,0.142,0.142)	0.137	0.137	3
Organizing and commanding the teams in order to be monitored at all hours (S15)	(0.092,0.108,0.108)	0.105	0.106	5
Attending of team officials at all hours (S16)	(0.085,0.108,0.108)	0.104	0.104	6
Having a 3-digit telephone number to inform violations by people (S17)	(0.077,0.096,0.096)	0.093	0.093	7
Consistency rate=$\frac{0.234}{6.541}=0.036$				

3.3.2. Calculation of the weights of sub-criteriaC2

According to Table 6, sub-criteria S22, S23, S21, and S24 with weights of 0.444, 0.217, 0.187, and 0.152 respectively are the first to the forth priorities. The consistency rate of pairwise comparison is 0.045, which indicates the appropriate compatibility of pairwise comparison.

Table 6: Weight and priority of sub-criteria of C2

Priority	Normal weight	Definite weight	Fuzzy weight	Criterion
3	0.187	0.187	(0.168,0.190,0.193)	Creating a serious effort at all levels of management (S21)
1	0.444	0.443	(0.400,0.452,0.452)	Timely and proportionate allocation of financial resources (S22)
2	0.217	0.216	(0.176,0.220,0.241)	Creating incentive packages for

				farmers to improve the cultivation pattern (S23)
4	0.152	0.152	(0.136,0.154,0.157)	Providing free facilities regarding the installation and implementation of modern irrigation systems (S24)
Consistency rate $=\frac{0.274}{6.078}=0.045$				

3.3.3. Calculation of weights of the Sub-criteria C3

Table 7 reveals that the sub-criteria S35, S36, S34, S33, S37, S32 and S31with weights of 0.267, 0.147, 0.136, 0.127, 0.126, 0.114, and 0.082, respectively are the first to the seventh priorities. The obtained consistency rate also indicates the appropriate compatibility of pairwise comparisons.

Table 7: Weight and priority of sub-criteria of C3

Priority	Normal weight	Definite weight	Fuzzy weight	Criterion
7	0.082	0.082	(0.074,0.083,0.083)	Accelerate the litigation process (S31)
6	0.114	0.114	(0.095,0.115,0.129)	Elimination of adjudication costs (S32)
4	0.127	0.127	(0.107,0.129,0.137)	Training Engineer Judge (S33)
3	0.136	0.136	(0.103,0.129,0.198)	Establishing special courts for violations in the field of water resources management (S34)
1	0.267	0.267	(0.237,0.273,0.273)	Increasing the punishment of offenders dealing with water resources management crimes (S35)
2	0.147	0.147	(0.130,0.141,0.186)	Creating joint working groups of the Ministry of Energy and the Judiciary system officials to remove obstacles to the GRP (S36)
5	0.126	0.126	(0.096,0.123,0.166)	Having a Permanent order of the prosecutor's office to dealing with violators (S37)
Consistency rate $=\frac{0.407}{6.354}=0.064$				

3.3.4. The final weights of the sub-criteria relative to the target

According to Table 8, the sub-criteria (S22), (S23) and (S21) with weights of 0.2247, 0.1098 and 0.0946, respectively, have been assigned the first to third ranks. it should be mentioned that these three criteria are more than 40% of the total importance. in addition, the sub-criterion (S31) with a weight of 0.0144 has also gained the last rank among 18 sub-criteria. On the other hand, the sub-criterion timely and proportionate allocation of financial resources has got the first rank and the sub-criterion accelerate the litigation process has the last one in priority.

Table 8: Weight and final priority of the sub-criteria relative to the target

Final rank	The final weight of sub-criteria	The relative weight of sub-criteria	Sub-criteria	Criterion weight	Criterion
6	0.0537	0.169	s11	0.318	C1
4	0.0814	0.256	s12		
9	0.0429	0.135	s13		
8	0.0436	0.137	s14		
10	0.0337	0.106	s15		
11	0.0331	0.104	s16		
12	0.0296	0.093	s17		
3	0.0946	0.187	S21	0.506	C2
1	0.02247	0.444	S22		
2	0.1098	0.217	S23		
5	0.0769	0.152	S24		
18	0.0144	0.082	S31	0.176	C3
17	0.0201	0.114	S32		
15	0.0224	0.127	S33		
14	0.0239	0.136	S34		
7	0.0470	0.267	S35		
13	0.0259	0.147	S36		
16	0.0222	0.126	S37		

4. Conclusion

The critical situation of groundwater resources in Iran with an average annual reservoir deficit of 5.4 billion cubic meters has led to a reservoir deficit of 110 billion cubic meters. So that more than 80 percent of it has occurred in the last 20 years. The critical situation has led a restriction on more than 307 out of 609 study areas in the last half-century. The correct implementation of the Groundwater Revival Plan (GRP) with an integrated water resources management approach to reform the administrative, legal and policy structure will be the only solution to the crisis. Installation, implementation, and continuous reading of smart water meters are examples of the wise implementation of Groundwater Revival Plan. Based on the slow process of installation of the aforementioned equipment in most parts of Iran (e.g., installation of only 14% of wells with priority for installation in Golestan province by the end of 2019) it is practically impossible to seriously control the water wells withdrawal. Therefore, integrated water resources management can be achieved by providing financial resources and allocating capable contractors in order to accelerate the process of installation, implementation, and continuous reading of the above equipment. Creating incentive packages for farmers as the most important stakeholders in the water resources sector can include the preparation and distribution of fertilizers and pesticides to improve the cultivation pattern. To achieve the main goals of GRP some actions can be very helpful as follows:

- Providing incentive packages of agricultural inputs for the cultivation of low water demanding crops
- Providing free services and guaranteed purchase of low water demanding crops
- Strengthening the insurance of agricultural crops
- Reduction or elimination of import tariffs for high water demanding crops to reduce their prices
- Providing free facilities to install and implement the modern irrigation systems

In this regard, the Separation of groundwater revival plan personnel from departments, matching patrol and inspection teams with the number of authorized and unauthorized water wells will be one of the most important issues. Considering all the tasks assigned in this section, increasing the number of teams to at least twice the current situation in Golestan province is quite clear. This is while the activities of the patrol personnel and supervision take place only during office hours. While using the patrol and inspection teams and monitoring them at all hours of the year, it is possible to use the workshop officials at the location of the teams at all hours. Having a 3-digit telephone number to inform violations by people, most importantly, Timely and proportionate allocation of financial resources can be a source of double morale in the staff, which requires serious and collective efforts of all staff managers and even senior managers to remove obstacles and provide relevant funding.

to promote the GRP goals, Creating joint working groups of the Ministry of Energy and the Judiciary system officials to remove obstacles to the GRP, along with the change in the administrative structure and its policy-making, will be necessary.

In this study, the crisis management of Iran's groundwater resources is re-evaluated with the GRP challenge approach from the perspective of the administrative, social, and legal systems. Then, the Fuzzy Best-Worst multi-criteria decision model in Lingo 9 software based on three general criteria of change in the administrative structure of the GRP (C1), policy structure (C2), and modification of GRP legal structure (C3), which included 18 sub-criteria developed by collecting comments from 23 experts in GRP.

The results showed that from a general perspective, the criterion of change in the policy structure of the GRP (C2) with a weight of 0.506 is the first priority, so that the criteria of change in the administrative structure and reform in the legal structure with weights of 0.318 and 0.176 are in the second and third priorities, respectively.

The results of the sub-criteria comparisons also indicated that the sub-criteria of financial resources providing (S22), creating incentive packages (S23) and creating a serious effort at all levels of management (S21) occupy the first to third ranks with weights of 0.2247, 0.1098 and 0.0946, respectively. Moreover, these three sub-criteria consist of more than 40% of the total importance.

Therefore, it is recommended that the Ministry of Energy implement this plan vigorously throughout Iran, using its maximum power and with the cooperation and participation of all relevant agencies and organizations, including police, and departments involved in the judiciary system. In this regard, it should prioritize sub-criteria one to three (S21, S22, S23) in case of modification of the mentioned structures.

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