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Evaluation of Benefit-Cost Analysis of South Khorasan Artificial Recharge Dams Based on Water Demand Scenarios

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Abstract

Currently, South Khorasan province is facing a crisis of water resources and consumption. So that many of the plains of the province have been banned after continuous decline, and as a result, consequences such as the subsidence of the plains and the reduction of the useful volume of aquifers have occurred. To implement the process of artificial recharge, estimating the benefit-cost of the plans are very important and must be done with sufficient accuracy. In this research, the measurement of benefit-cost, and the discount rate were compiled in a systematic way, and the value of each artificial recharge option was determined using the basis of measurement, and after comparing with other options, the option with the lowest price has been selected. Among the three scenarios: 1) artificial recharge with the aim of increasing the groundwater level; 2) Harvesting water from recharge and using it in the agricultural sector and 3) Using a part of recharged water in different consumption sectors and increasing the level of groundwater. The results of the investigations showed that according to the Shapley value, the third scenario (with a value of 567.92) has a higher priority than the other scenarios, therefore, the implementation of artificial recharge plans with the sole aim of increasing the groundwater level will not be suitable. It should be noted that not paying attention to the economic aspect of such plans will cause them to be ineffective in the long run due to the lack of compensation for implementation and operation costs.

Keywords: Artificial Recharges, Benefit-Cost, Birjand, Water Demand Scenarios

1. Introduction

In recent years, South Khorasan province has also faced a crisis of water resources. The extensive groundwater table decline during the last ten decades has increased the number of "prohibited plains," where drilling of new wells is banned Artificial recharge (AR) is the process whereby surface water is directed purposely underground to augment natural replenishment of groundwater reserves. In other words, artificial recharge can be defined by the designed operation for transferring water from the ground to the aquifer. During this process, the water from rain and runoff reaches the aquifer with human intervention. Artificial recharge can be performed through ponds, river recharge, creek, flooding or flood distribution, nutrition pit or injection wells (Todd and Mays, 2004). It is very important to implement the artificial recharge process and selecting the appropriate method requires carefully. There are other criteria in the implementation of artificial recharge site, such as: permeability, hydraulic conductivity, saturated layer thickness, rainfall, slope and salinity (Wang et al., 2023). Also, the results show the reduction in the maximum exploitation rate along with a 50% drop in the groundwater level play an effective role in decreasing the optimal exploitation amount (Maghsoudi et al., 2023). Morovati et al. (2011) investigated the treated urban wastewater for the artificial recharge of plains without surface water flow. Lalehzari et al. (2014) researched on the characteristics of the Shahrekord aquifer, such as the flow thickness and hydrodynamic coefficients in different parts of the plain, and investigated the implementation of artificial recharge injection with reuse water of Shahrekord. Shahraki et al. (2017) analyzed the economic benefits of these scenarios by examining water development projects in the Pishin dam basin in a 20-year period. According to the results obtained in the reference scenario, the amount of allocation water for Bahukalat agriculture, drinking and environment sections were about 29, 7, 8 and 30 million cubic meters, respectively.

In another study, Maskey et al. (2022) showed that artificial recharge adds economic benefits by (1) reducing the combined costs of water shortage and surface water storage and (2) by increasing hydropower revenue. This study provides a benchmark tool to evaluate the economic feasibility and water supply reliability impacts of artificial recharge in California. Nahvinia et al. (2008) evaluated the artificial recharge project of Siojan wastewater of Birjand city. The results showed that the recharge of the groundwater table has increased the piezometric level of the groundwater and encouraged the farmers by preventing the dryness of the Qantas and the lack of water in the wells and better utilization of the agricultural wells. Also, the chemical quality of the water in the region has been improved and the salinity of the groundwater table has been declined. Bagheri Dadokolaei et al. (2018) in their research investigated the determination of the optimal design of artificial recharge ponds. They used the ratio of income to the cost of ponds to choose the best alternative for designing artificial recharge ponds. Dehghani et al. (2017) while investigating the performance of these systems in terms of recharge, presented a model-based framework based on several quantitative indicators such as recharge efficiency and flood alleviation rate to investigate the performance of artificial recharge systems.

Given the high cost of construction of artificial recharge projects, the economic evaluation of artificial recharge plans is of great importance. For this reason, the construction of these types of projects should be managed cost and increase the benefit-cost ratio. In the present study, the assessment of the benefit-cost analysis of the South Khorasan artificial recharge designs will be examined based on the scenarios of water consumption. It should be noted that so far the consequences and economic effects of artificial recharge projects on the status of the country's aquifers have not been evaluated. In this study, firstly, the effects of inflation rate on the improvement of aquifer status of multiple targets of artificial recharge projects, including aquifer recharge and the use of water produced in the agricultural sector, have been evaluated. In previous researches, it has always been tried to examine the success rate of the artificial recharge plan from different aspects separately. In fact, the evaluation of artificial recharge systems is an inseparable part of the stages of study, construction and operation steps. Therefore, following the implementation of artificial recharge plans, the evaluation of the effectiveness of the mentioned systems in different fields is considered. Including the study of the effect of artificial recharge on water resources, economic and social effects, soil characteristics, environmental issues of artificial recharge plans, issues related to hydraulic and flood control and the effect of such plans on the vegetation of the region are investigated (Kowsar, 2008); so far, no suitable model has been presented for the purpose of economic evaluation of such projects considering different scenarios of water production and consumption. In this research, an attempt will be made to evaluate the artificial recharge plans of South Khorasan province by economic analysis.

2. Material and Methods

South Khorasan province, the most eastern province of Iran, with an area of 150,800 square kilometers which is located in a dry and semi-arid climate. Birjand is the capital of South Khorasan Province. It is the first city in Iran which was equipped with a water supply network to distribute and is limited from the north to Razavi Khorasan, from the west to Yazd, Isfahan, and Semnan provinces, and from the south to Kerman, Sistan and Baluchistan provinces.

South Khorasan province was established in 2004 with the presence of 4 cities separated from Great Khorasan based on country divisions. Currently, this province has 11 counties 28 cities, 25 districts, 61 villages. The cities of this province include Birjand, Ghayenat, Tabas, Ferdous, Nehbandan, Sarayan, Sarbisheh, Darmiyan, Boshruyeh, Khosuf and Zirkouh. 11 artificial recharge projects have been constructed at south Khorasan. Figure 2 shows the situation of artificial recharge projects.

Fig. 1. Map of South Khorasan province cities

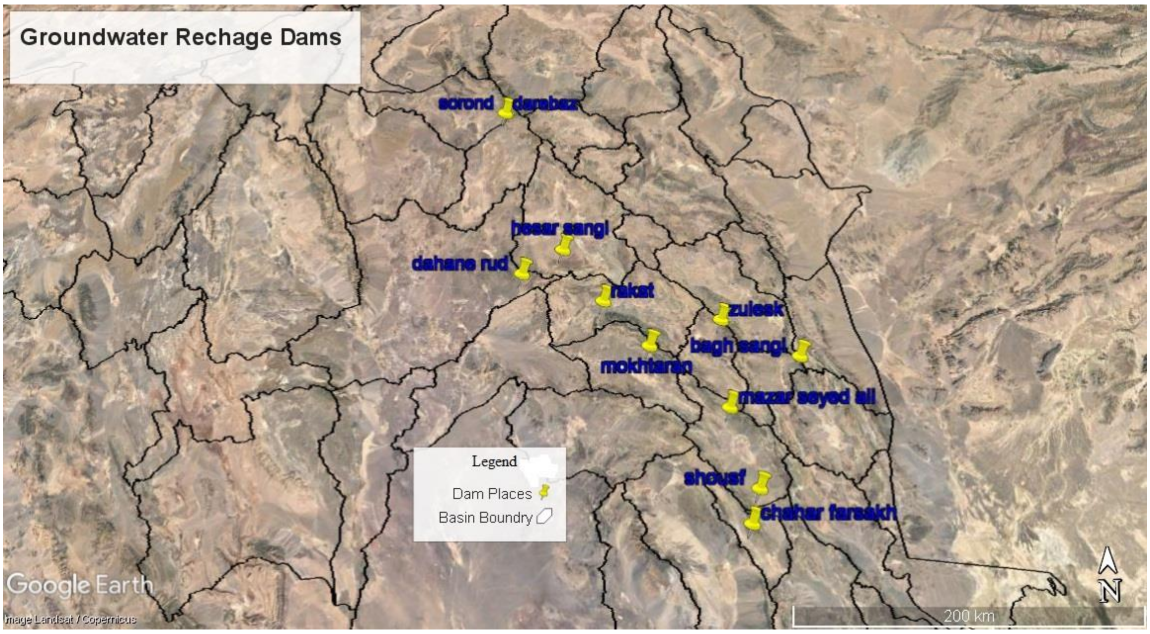

Fig. 2. Situation of artificial recharge projects in South Khorasan province

In the first step, artificial recharge schemes were identified in South Khorasan province. Then, the types of economic variables of water production from the year of start to the end of artificial recharge structure, including design items construction; Annual operation and maintenance costs will be reviewed according to miscellaneous costs.

In the next step, the benefits obtained from artificial recharge plans including the following scenarios will be examined:

- Determining the value of the net benefit of available water in case of an increase in the groundwater level;
- Determining the value of the net profit of available water in order to harvest water resulting from recharge and its consumption in the agricultural sector (calculation the price of agricultural water in each region);
- Determining the value of the net profit of available water in the case of using part of the recharge water in the agricultural sector as well as artificial recharge.

According to the basic rule of benefit maximization, in which increasing the total value of scarce resources is assumed to be desirable, actions (such as the construction of MAR systems) should be undertaken if their total benefits exceed total costs. Cost–benefit analysis (CBA) is addressed in microeconomic textbooks and some dedicated books. Environmental CBA is a specific area of investigation, which includes issues of water quality and supply (Boardman et al., 2017).

The underlying goal of CBA is allocative efficiency. Policies should be adopted or investments made only if they provide net positive benefits. The policy or investment that yields the greatest net benefits should be selected. A limitation of CBA is that goals other than economic efficiency (e.g., equity and national security) may be of relevance to the policy. CBAs are not performed in a moral vacuum and the social desirability of a particular set of costs and benefits may be a consideration. However, even if decisions are not made solely on the basis of CBA, decisions should at least be informed by CBA such that it is at least an input into the decision-making process (Pearce et al., 2006).

CBAs are commonly performed using the net present value (NPV) method, which considers both the initial investment in the project and benefits and costs expected to be achieved or incurred over the life of the project. The current value of incomes and expenses with the discount rate r is obtained from Eqs. 1 and 2:

$$PV_{TR} = \begin{cases} TR_1 \left[\frac{1-(1+i)^N (1+r)^{-N}}{r-i} \right] \rightarrow i \neq r \\ \frac{N_0 TR_1}{1+r} \rightarrow i = r \end{cases} \quad (1)$$

$$PV_{tc} = \begin{cases} TC_1 \left(\frac{1-(1+j)^N (1+r)^{-N}}{r-j} \right) \rightarrow j \neq r \\ \frac{N_0 TC_1}{1+r} \rightarrow j = r \end{cases} \quad (2)$$

where r is interest rate, i is change percentage; TR_1 is the first profit, TC_1 is the first cost, PV_{TR} is present value of cash flows; PV_{tc} is present value of costs, and N is length of the life's plan . After calculating the current value of the plan's annual income and expenses, which change every year at rates of i and j percent, respectively, to calculate the net present value (NPV), Rate of Return (ROR) and benefit-cost ratio of the project, the following equations will be used:

$$NPV = PV_{TR} - PV_{TC} - TC_0 \quad (3)$$

$$B/C = \frac{PV_{TR}}{PV_{TC} + TC_0} \quad (4)$$

$$PV(ROR) = 0 \rightarrow TR_1 \left[\frac{1-(1+i)^N (1+r)^{-N}}{1-i} \right] - TC_0 - TC_1 \left[\frac{1-(1+j)^N (1+r)^{-N}}{r-j} \right] = 0 \quad (5)$$

where, TC_i is annual maintenance costs, TR_i is annual cash flows, TC_0 is initial fixed costs, j is cost growth rate, I is revenue growth rate, r is discount rate, and N is length of the life's plan.

In the next step, the benefit-cost of artificial recharge plans will be examined based on the previous scenarios using Shapley's method. The Shapley value is a solution concept used in game theory that involves fairly distributing both gains and costs to several actors working in coalition. Game theory is when two or more players or states are involved in a strategy to achieve a desired outcome or payoff. The mathematical expression of Shapley value is in the form of Eq. 6:

$$Xi = \sum_{i=S}^{\infty} \frac{(|S|-1)!(|N|-|S|)!}{|N|!} \left(v(s) - v(\frac{S}{\{i\}}) \right) \quad (6)$$

In this regard, Xi is the amount of allocated profit resulting from water harvesting for a specific consumption sector I, |S| The number of combined states of water consumption in different consumption sectors from S, |N| is the total number of states, V(S) is the value of the combination of consumption in different sectors of S, and v(S/{i}) is the value of the coalition of S without a consumption sector i.

In the final step, the cost benefits of the combined modes of consumption in different sectors will be examined. The mode that benefits the cost of the plan more than 1 and also more than other modes will be selected as the real price of water. As mentioned, this research includes the evaluation of 11 artificial recharge plans throughout South Khorasan province. For each artificial recharge plan, there are three consumption states: recharge only to improve the groundwater level (state

S1), recharge and harvesting water in the agricultural sector (state S2), and the combination of states S1 and S2 will be taken as state S3 in the form of Eq. 7:

All possible situations :{S1}; {S2}; {S3}. (7)

The first step in the cost-benefit analysis of different plans is to calculate the value of characteristic functions for each of the three states formed in the previous section. The characteristic function *V* for each state calculates the maximum value of the state by considering other states. For non-combination states (v(S1) and v(S2)) and combination values will be v(S3). The characteristic function will be presented for all possible states. Based on the available results of the possible states, managers will decide whether the combination of states will be achieved a desired and profitable outcome or not.

3. Results and Discussion

CBA, requires that planners identify different options to achieve goals. In principle and in practice, the available resources and various technical options of how to use these resources to achieve the desired goal should be determined, as mentioned in the previous section, these options are as follows:

1. Using artificial recharge plans only to increase the level of groundwater;
2. The use of artificial recharge plans in order to harvest water from recharging and use it in the agricultural sector;
3. The use of artificial recharge schemes in order to harvest part of the recharged water for consumption and also to improve the groundwater level.

In the benefit-cost analysis of the above three options, the options with the highest value are selected. The amount of annual recharging of the artificial recharge plans of South Khorasan province and also the finished price are as described in tables (1 and 2).

In order to make the calculation of the volume of water supply easy and smooth, all the artificial recharge plans have been considered as a single artificial recharge plan for the province. It should be noted that in order to make the price list of all the projects the same, it is intended for the year 2006 and in the form of a single plan for the whole province's aquifer. It should be noted that in order to reduce the complexity of the calculations, all the aquifers of the province are considered as a single aquifer.

Table 1. The amount of annual recharge of artificial recharge plans

No	Project Name	Useful life of the project	Annual recharge rate (million cubic meters)*
1	Chaharfarsakh Recharge dam	50	1.53
2	Artificial Recharge of Baghsangi	50	0.4
3	Artificial Recharge of Dahanerood	25	1.2
4	Artificial Recharge of Derehbaz	30	0.074
5	Hesarsangi Recharge dam	50	1.35
6	Artificial Recharge of Mokhtaran	30	2
7	Artificial Recharge of Rakat	40	0.5
8	Shosf Recharge dam	50	0.6
9	Artificial Recharge of Mezar Seyed Ali	30	2
10	Sarand Recharge dam	30	1.5
11	Artificial Recharge of Zolesk	30	1.5

*These numbers are based on information of hydraulic structure maintenance office of South Khorasan Regional Water Company.

For the economic analysis of the artificial recharges, the duration of the construction was one year and the duration of the plan operation was considered to be 30 years. In this 30-year period, an average annual interest rate of 10% and an average annual inflation rate of 30% were predicted (based on central bank). For the purpose of economic analysis, three scenarios have been studied for all the structures of the province.

3.1. Scenario 1: Artificial recharge plan only to increase the groundwater level

In the first scenario, the amount of recharge from artificial recharge plans is estimated to be 12.65 million cubic meters per year according to the duration of their operation. Taking into account the implementation and operation costs of the project, the cost of recharge each cubic meter of water was calculated as 2561 Iranian Rials (Regional Water Company of South Khorasan, 2019).

Table 2. The final price and costs of artificial recharge plans (Regional Water Company of South Khorasan, 2019)

No	Project Name	The total price of water in 2006 (Iranian Rials per cubic meter)*	Annual cost of operation (million Iranian Rials)*	Total credit spent (million Iranian Rials)*	Year of operation	Year of start project	Year of study
1	Chaharfarsakh Recharge dam	3150	50	4600	77	75	71
2	Artificial Recharge of Baghsangi	1520	25	2675	86	85	84
3	Artificial Recharge of Dahanerood	2278	25	3500	81	79	76
4	Artificial Recharge of Derehbaz	1230	25	2700	90	87	85
5	Hesarsangi Recharge dam	2101	50	2260	89	87	84
6	Artificial Recharge of Mokhtaran	2830	25	4200	86	84	84
7	Artificial Recharge of Rakat	4052	25	1400	80	75	74
8	Shosf Recharge dam	5780	50	13500	86	83	76
9	Artificial Recharge of Mezar Seyed Ali	1289	25	2400	77	76	72
10	Sarand Recharge dam	1626	25	2340	76	74	70
11	Artificial Recharge of Zolesk	2320	25	3240	86	84	84

**These numbers are based on information of hydraulic structure maintenance office of South Khorasan Regional Water Company.

So, taking into account the ratio of benefit-cost equal to one value of each cubic meter of recharged water has been considered about 2500 Iranian Rials. The assumptions and results of the calculations are presented in Tables 3 and 4. According to scenario 1, the final price of water at the end of the exploitation period will be 214625 Iranian Rials per cubic meter. It should be noted that the average short-term inflation rate of the country is assumed to be 18%.

Table 3. Assumptions used for scenario 1

No	Characteristics	Value
1	Inflation / short-term increase in costs	30%
2	Inflation/long-term increase in costs	18%
3	Water price increase (liquidity)	16%
4	Internal rate of return on investment	22.5%
5	Tax rate	0%
6	Conversion factor of permeable water to removable water	0.8%
7	Number of years of the time series	30
8	bringing in the investor; billion of Iranian Rials	10
9	basic price of water production; Iranian Rial per cubic meter	2500

3.2. Scenario 2: Water Harvesting from recharge and its consumption in consumption sectors

In order to investigate the final price of water in artificial recharge with the aim of harvesting water from recharge and its consumption in consumption sectors in the equivalent period of 30 years were presented in tables 5 and 6. Based on this scenario, the final price of water at the end of the exploitation period will be 309060 Iranian Rials per cubic meter.

Table 4. The price of produced water in the period of 30 years in scenario 1 (Horizon 2036)

Plan period (year/s)	The final price of water (Iranian Rials per cubic meter)	Plan period (year/s)	The final price of water (Iranian Rials per cubic meter)
1	2900	16	26870
2	3364	17	31169
3	3902	18	36156
4	4527	19	41941
5	5251	20	48652
6	6091	21	56436
7	7066	22	45466
8	8196	23	75941
9	9507	24	88091
10	11029	25	102186
11	12793	26	118538
12	18480	27	137501
13	17214	28	159501
14	19964	29	185021
15	23164	30	214625

3.3. Scenario 3: Harvesting of water from recharge for consumption and also increasing the ground water level

In order to investigate the total price of water in artificial recharge in order to harvest part of the recharged water for consumption and also to increase the groundwater level for a period of 30 years, the total price of water production is presented in Tables 7 and 8.

Based on this scenario, the final price of water at the end of the exploitation period will be 261842 Iranian Rials per cubic meter. In this scenario, the number of years with negative financial turnover will be 26 years.

Table 5. Assumptions used for scenario 2

No	Characteristics	value
1	Inflation / short-term increase in costs	30%
2	Inflation/long-term increase in costs	18%
3	Water price increase (liquidity)	16%
4	Internal rate of return on investment	22.5%
5	Tax rate	0%
6	Conversion factor of permeable water to removable water	0.8%
7	Number of years of the time series	30
8	bringing in the investor; billion of Iranian Rials	50
9	basic price of water production; Iranian Rial per cubic meter	3600

Table 6. The price of produced water in the period of 30 years in scenario 2 (Horizon 2036)

Plan period (year/s)	The final price of water (Iranian Rials per cubic meter)	Plan Period (year/s)	The final price of water (Iranian Rials per cubic meter)
1	4176	16	38693
2	4844	17	44884
3	5619	18	52065
4	6518	19	60395
5	7561	20	70059
6	8771	21	81268
7	10174	22	94271
8	11802	23	109354
9	13691	24	126851
10	15881	25	147147
11	18422	26	170691
12	21370	27	198001
13	24789	28	229682
14	28775	29	266431
15	33356	30	309060

In order to check the benefit-costs of each scenario, the benefit-cost tables of each scenario are presented below (Tables 9 to 11). In the third scenario, taking into account water for agricultural purposes, the amount of recharge will decrease to 95.6 million cubic meters in 30 years; but a volume equal to 382.4 million cubic meters is allocated for agricultural purposes.

Table 7. Assumptions used for scenario 3 (up to the horizon of 2036)

No	Characteristics	Value
1	Inflation / short-term increase in costs	30%
2	Inflation/long-term increase in costs	18%
3	Water price increase (liquidity)	16%
4	Internal rate of return on investment	22.5%
5	Tax rate	0%
6	Conversion factor of permeable water to removable water	0.8%
7	Number of years of the time series	30
8	bringing in the investor; billion of Iranian Rials	30
9	basic price of water production; Iranian Rial per cubic meter	3050

Table 8. The price of produced water in the period of 30 years in scenario 3 (Horizon 2036)

Plan period (year/s)	The final price of water (Iranian Rials per cubic meter)	Plan Period (year/s)	The final price of water (Iranian Rials per cubic meter)
1	3538	16	32781
2	4104	17	38026
3	4761	18	44111
4	5522	19	51168
5	6406	20	59355
6	7431	21	68852
7	8620	22	79869
8	9999	23	92647
9	11599	24	107471
10	13455	25	124666
11	15608	26	144613
12	18105	27	167751
13	21002	28	194591
14	24362	29	225726
15	28260	30	261842

In the current conditions of the region, based on the calculations made in the agriculture report, each cubic meter of water for agricultural purposes will generate an income equal to 9220 Iranian Rials, and according to the value of 3050 Iranian Rials calculated for each cubic meter of recharged water, by converting these incomes and construction costs and the exploitation of facilities for the base year, the benefit-cost ratio in this scenario is equal to 0.82. Due to the fact that the value of artificial recharge projects are public benefit, as a result, the ratio of benefit-cost in all projects is smaller than one. In order to compare the projects with each other, Shapley's method has been used, which is discussed below.

Table 9. Evaluation results of the first artificial recharge scenario

Title	Value
Total recharged water (MCM)	478
Agricultural Consumption (MCM)	0
Mean annual recharge (MCM)	15.93
Average Agricultural Consumption (MCM)	0
Average income from recharge (billions of Iranian Rials)	1195
Average income from agriculture (billions of Iranian Rials)	0
Project revenues (billions of Iranian Rials)	1195
Project costs (billions of Iranian Rials)	1941.8
Net value of the project (billions of Iranian Rials)	-746.85
Benefit-cost ratio	0.62

Table 10. Evaluation results of the second artificial recharge scenario

Title	Value
Total recharged water (MCM)	0
Agricultural Consumption (MCM)	382.4
Mean annual recharge (MCM)	0
Average Agricultural Consumption (MCM)	12.75
Average income from recharge (billions of Iranian Rials)	0
Average income from agriculture (billions of Iranian Rials)	3525.7
Project revenues (billions of Iranian Rials)	3525.7
Project costs (billions of Iranian Rials)	2141.8
Net value of the project (billions of Iranian Rials)	1383.9
Benefit-cost ratio	1.65

Table 11. Evaluation results of the third artificial recharge scenario

Title	Value
Total recharged water (MCM)	95.6
Agricultural Consumption (MCM)	382.4
Mean annual recharge (MCM)	3.2
Average Agricultural Consumption (MCM)	12.75
Average income from recharge (billions of Iranian Rials)	239
Average income from agriculture (billions of Iranian Rials)	3525.7
Project revenues (billions of Iranian Rials)	3764.7
Project costs (billions of Iranian Rials)	1991.8
Net value of the project (billions of Iranian Rials)	1772.9
Benefit-cost ratio	1.89

Considering that the projects are for public benefit, the value of each cubic meter of water at the end of the 30th year will not be the only criterion. Using the Shapley value to compare the scenarios based on the value of each scenario compared to the other scenarios. As shown in Table 12. The value of the combination scenario, that is, the first and second scenario, is 359.9 and 194.5 billion Iranian Rials, respectively, and the third value is 567.92 billion Iranian Rials. In this case, the best option for implementing artificial recharge plans will be the third scenario.

Table 12. Shapley value of scenarios (billions of Iranian Rials)

Scenario	The benefit of The scenario	The value of the scenario
Scenario 1	2519.7	359.9
Scenario 2	389	194.5
Scenario 3	1135.84	567.92

4. Conclusion

In Iran, artificial recharge (AR) of aquifers is considered a primary supply-side measure to combat the widespread over-exploitation of groundwater, especially in the aquifers of the eastern provinces of the country. In such a situation, a water-deficient province like South Khorasan province should make the most of the minimum rainfall. One of the most traditional methods of rain water harvesting to improve groundwater resources is various artificial recharge methods. To implement the process of artificial recharge, determining the area, choosing the appropriate method and estimating the benefit-cost of the plans are very important and must be done with sufficient accuracy. Usually, the government's intention of developing construction plans, especially in the field of water supply, is not only to achieve economic efficiency, but they also pursue other goals. Although artificial recharge projects do not seek economic efficiency, they are considered public benefit. However, for the stability of these structures, it is necessary to examine the status of their benefit-cost. It is also necessary to remember that in some conditions, such as insufficient market and insufficient savings and investment, it is not even possible to achieve the efficiency of a dynamic economy. The issue of distribution efficiency or so-called social justice is not included in the issue of economic efficiency. Therefore, in order to ensure economic efficiency, social justice, optimal growth and increase in income, it should be taken into consideration in the evaluation process of construction projects.

In this research, cost and benefit measurement were compiled in a systematic way. In this research, the value of each artificial recharge option was determined using the basis of measurement, and after comparing with other options, the option with the lowest final price was selected. Among the three scenarios: 1) artificial recharge with the aim of increasing the groundwater level; 2) Harvesting water from recharge and its consumption in the agricultural sector and 3) Using a part of recharged water in different consumption sectors and increasing the groundwater level, the third scenario has the highest benefit-cost ratio. In order to choose the method of artificial recharge, one should pay attention to social, economic and other issues in the region. In this research, in addition to the aspect of increasing the groundwater level, water usage has also been paid attention to in order to the development of agriculture. The results show that the final price of water at the end of this exploitation period will be 261842 Iranian Rials per cubic meter. Shapley value has been used to select the best option, according to the Shapley value, the third scenario (with a value of 567.92) has a higher priority than other scenarios, therefore, the implementation of artificial recharge plans only with the aim of increasing the groundwater level will not be suitable. It should be noted that not paying attention to the economic aspect of such plans will cause them to be ineffective in the long run due to the lack of compensation for implementation and operation costs.

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6. Disclosure statement

No potential conflict of interest was reported by the authors

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