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Management of Water Resources and Sustainability of Segzi Plain, Isfahan, Iran

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Abstract: Currently, water input is very valuable, it should be used optimally. Planning for optimal use of water and soil resources will protect these resources as well as bring about increased production, growth in the income of farmers, and rural economic prosperity. This study was performed with the aim of improving management of water resources on Isfahan Plain lands using typical and linear goal optimization techniques. In this research, using these techniques, optimal allocation of water and prioritization of cultivation patterns in water consumption have been examined. In this research, the effects of low irrigation on the products of the system cultivation patterns were also evaluated. The results indicate that Option 16 with profit on consumed water 0.33 has had the greatest financial efficiency, while Option 22 shows the lowest financial efficiency with a value of 0.22. The findings of this research suggest that the planning axis (water profit and productivity or sustainability in use of groundwater resources) plays a key role in the process of managing and allocating the system water resources.
Keywords: water resource management, linear optimization, Isfahan irrigation system

1. Introduction

As Iran is located in a warm and dry region, most plains of Iran require proper management of water resources and optimization of water consumption, so that they can maximize exploitation of limited water resources (Nahvi et al., 2017; Akram et al., 2013). A sustainable water management policy for agricultural irrigation is to promote water use in such a way that society's needs are met to the extent possible now and in the future. Linear Programming (LP) and principal components analysis have long been used to select descriptive variables for relating runoff to climate and watershed descriptors (Alley, 1993; Fan et al., 2015; Shen et al., 2017). Statistical prediction methods, on the other hand, rely on past historical data for prediction (Wang et al., 2015; Daghighi, 2017; Jin et al., 2015). LP approaches were always used to obtain optimal strategies, such as water-allocation patterns, crop-planting plans, and canal-expansion schemes, with an objective of maximizing net benefit. One of the main solutions in the agriculture sector as the largest consumer of water resources is conjunctive use of surface and groundwater resources. Undoubtedly, launching a suitable and optimal cultivation pattern can have a significant effect on reducing water consumption and elevating profits in an agriculture system (Yin et al., 2016; Daghighi et al, 2017; Salazar et al., 2012). The main aim of this research is development and application of a model for surface and groundwater resources and achieving an optimal cultivation pattern.

2. Case Study

Segzi plain is located in the Eastern of Isfahan province in the center of Iran and is about 40 km from Isfahan city center (31 23'N, 51 7'E to 32 55'N, 51 56'E), Climate of zone of De Martonne methods is dry. In order to do this research, 5 profiles as a vertical transect were studied in 2017.

3. Methods and Materials

The general structure of fractional multi-objective goal programming model was formulated as shown in equation 1.

Eff. $\{\frac{\sum_i \quad N_i X_i}{\sum_i \quad W_i X_i}, \frac{-\sum_i \quad GW_i X_i}{\sum_i \quad W_i X_i}\}$

where i is number of products (i = 1,2,…), N_i is the net profit of i_{th} product except for water cost, X_i is the area under cultivation for the i_{th} product in the region (hectares), W_i is the total water consumed for the i_{th} product along the cultivation season (10^2 m^3/ha), GW_i is the groundwater used in the region for the i_{th} product (10^2

m^3/ha), $\frac{\sum_i N_i X_i}{\sum_i W_i X_i}$ is the total profit to the total water consumed (productivity), and $\frac{-\sum_i GW_i X_i}{\sum_i W_i X_i}$ is the total groundwater to the total water consumed

linear programming (LP2) for minimizing use of groundwater. According to the authorities of irrigation affairs of the region, if the extent of withdrawal is reduced by 25% in comparison with the current value, the water balance of the plain reaches zero.

4. Results and Discussion

In this study, the following 22 options were studied. The first option is the typical cultivation pattern of the region including wheat, barely, alfalfa, cotton, and cucurbits (tomato, eggplant, and pumpkin). The current total area under cultivation in the region is 52455 hectares. Currently, the maximum area under cultivation is allocated to barely and then to wheat with respective values of 13500 and 13075 hectares.

In the second to tenth options, different reductions in groundwater have been applied, and the profit and areas under cultivation have been compared with each other. These options have been propounded to preserve or improve the situation of groundwater aquifers. In these options, the extent of reduction was considered from 60% to 0%. The total groundwater volume for this purpose varies between 179.44 and 448.61 million m^3 per year in the second to tenth options.

In the eleventh to sixteenths options, elevation of withdrawal from groundwater was dealt with to examine the trend of changes in the profit and areas under cultivation. This increased withdrawal was incremented by up to 25%, i.e. up to 560.76 million m^3/year. In these options, increased groundwater withdrawal causes excessive pressure to groundwater aquifers.

16th to 22nd options have been allocated to different low irrigations. By implementing low irrigation by up to 40% and calculation of the performance value, the area under cultivation grew up to 74165 hectares. This area means 41% increase in the area under cultivation.

Table 1. Introduction of the studied options and their areas under cultivation

options	μ	Dehydration rate	Total cultivated area under ideal condition	Total cultivated area under deficit conditions
1	-	-	-	-
2	0.4	0	-	-
3	0.5	0	-	-
4	0.6	0	-	-
5	0.7	0	-	-
6	0.8	0	40699	40904
7	0.85	0	40699	40904
8	0.9	0	40699	40904
9	0.95	0	40699	40904
10	1	0	40699	40904
11	1.05	0	40699	40904
12	1.1	0	40699	40904
13	1.15	0	40699	40904
14	1.2	0	40699	40904
15	1.25	0	40699	40904
16	1	0	47578	41463
17	1	10	50437	41700
18	1	15	52927	41700

19	1	20	56655	41700
20	1	25	59394	41700
21	1	30	61163	41700
22	1	40	74165	41700

According to water authorities of Isfahan Plain, if groundwater withdrawal decreases by around 25% in comparison with the previous year, i.e. it reaches 336.46 million m^3 per year, the extent of plain withdrawal and feed becomes equal and the aquifer level remains constant. Thus, across all LP2 options, the groundwater level is constant and was defined as 336.46 million m^3 for groundwater.

Based on the goal values obtained from solving the above linear models (LP1, LP2), using goal programming, the composition and area under cultivation of the region's crops have been provided in Table 2. These values are intermediate limits for obtaining the maximum profit and minimum water consumption. Indeed, attempts have been made to achieve the maximum profit by consuming minimum level of groundwater. Options 2 to 5 cannot be solved by goal programming as their goals are in contradiction to each other. The goal value for all options 6 to 15 is a constant value, thus the profit and areas under cultivation are equal. In these options, groundwater withdrawal has been variable and ranges between 0.8 of the current withdrawal in Option 2 and 1.25 times as large as the withdrawal in Option 15. This suggests that the volume of groundwater withdrawn reaches from 448.89 in Option 6 to 560.76 million m^3 in Option 15.

Table 2. the composition and area under cultivation of region's crops in the linear programming method (hectares)

products	Option	wheat	barley	forage corn	alfalfa	cucurbits	cotton	total
1	current	13075	13500	8500	4450	12700	230	52455
6	μ=0.8	9100	9100	1750	1750	17000	1999	40699
7	μ=0.85	9100	9100	1750	1750	17000	1999	40699
8	μ=0.9	9100	9100	1750	1750	17000	1999	40699
9	μ=0.95	9100	9100	1750	1750	17000	1999	40699
10	μ=1	9100	9100	1750	1750	17000	1999	40699
11	μ=1.05	9100	9100	1750	1750	17000	1999	40699
12	μ=1.1	9100	9100	1750	1750	17000	1999	40699
13	μ=1.15	9100	9100	1750	1750	17000	1999	40699
14	μ=1.2	9100	9100	1750	1750	17000	1999	40699
15	μ=1.25	9100	9100	1750	1750	17000	1999	40699
16	RI=5	9100	9100	7628	1750	17000	3000	47578
17	RI=10	9100	9100	10487	1750	17000	3000	50437
18	RI=15	9100	9100	11000	3727	17000	3000	52927
19	RI=20	12468	9100	11000	4087	17000	3000	56655
20	RI=25	13294	9100	11000	6000	17000	3000	59394
21	RI=30	15063	9100	11000	6000	17000	3000	61163
22	RI=40	28065	9100	11000	6000	17000	3000	74165

It is deduced that by increasing exertion of low irrigation, the performance of the crops has diminished, where the descending slope of these changes is different across different products. For example, at water stress of 5%, the minimum crop reduction was related to cotton. In this crop, by applying 4% low irrigation, we only observed 4.2% reduction. This means that cotton performance under complete irrigation conditions from decreases from 3056.56 to 3922.48 kg/hectares under stress 4% conditions. At this stress, the maximum performance reduction was related to barely, which indicated 5.8% reduction, reaching 3459.53 from 4731.62

kg/hectares. Indeed, the most sensitive crop at the water stress level of 4% is barely, while the most resistant is cotton. In other products, we observe 3.4% reduction.

5. Conclusion

The extent of surface water allocated across all options is 141.92 million m^3/year, which responds to a small part of the plain's irrigation demands. The extent of current groundwater withdrawal is 448.61 million m^3/year. Considering the droughts in recent years, it has caused a dramatic decrease in the water table level of this plain.

The results indicate that Option 16 has had the maximum financial efficiency with profit-to-water consumed of 0.33, while Option 22 shows the minimum financial efficiency with the value of 0.2225. Also, Option 22 with groundwater-to-total water consumed of 0.5518 and Options 6-16 exert the minimum and maximum pressure to groundwater resources, respectively. This suggests that although increased groundwater withdrawal causes incremented profit, as it also leads to elevated consumption of water resources, it will bring about diminished water productivity.

References

[1]. Akram, M., Azari, A., Nahvi, A., Bakhtiari, Z., &Safaee, H. D. (2013). Subsurface drainage in Khuzestan, Iran: environmentally revisited criteria. *Irrigation and Drainage*, *62*(3), 306-314.

[2]. Salazar, M. R., Hook, J. E., y Garcia, A. G., Paz, J. O., Chaves, B., &Hoogenboom, G. (2012). Estimating irrigation water use for maize in the Southeastern USA: A modeling approach. *Agricultural Water Management*, *107*, 104-111.

[3]. Wang, R., Li, Y., & Tan, Q. (2015). A review of inexact optimization modeling and its application to integrated water resources management. *Frontiers of earth science*, *9*(1), 51-64.

[4]. Daghighi, A. (2017). Harmful Algae Bloom Prediction Model for Western Lake Erie Using Stepwise Multiple Regression and Genetic Programming.

[5]. Daghighi, A., Nahvi, A., & Kim, U. (2017). Optimal Cultivation Pattern to Increase Revenue and Reduce Water Use: Application of Linear Programming to Arjan Plain in Fars Province. *Agriculture*, *7*(9), 73.

[6]. Yin, S., Wu, W., Liu, H., &Bao, Z. (2016). The impact of river infiltration on the chemistry of shallow groundwater in a reclaimed water irrigation area. *Journal of contaminant hydrology*, *193*, 1-9.

[7]. Alley WM (1993) Regional groundwater quality. Van NostrandReinhod, New York

[8]. Jin, L., Huang, G. H., Fan, Y. R., Wang, L., & Wu, T. (2015). A pseudo-optimal inexact stochastic interval T2 fuzzy sets approach for energy and environmental systems planning under uncertainty: A case study for Xiamen City of China. *Applied Energy*, *138*, 71-90.

[9]. Fan, Y., Huang, G., Huang, K., &Baetz, B. W. (2015). Planning water resources allocation under multiple uncertainties through a generalized fuzzy two-stage stochastic programming method. *IEEE Transactions on Fuzzy Systems*, *23*(5), 1488-1504.

[10]. Nahvi, A., Daghighi, A., &Nazif, S. (2017). The Environmental Impact Assessment of Drainage Systems: A Case Study of the Karun River Sugarcane Development Project. *Archives of Agronomy and Soil Science*, (just-accepted).

[11]. Shen, W., Ceylan, H., Gopalakrishnan, K., Kim, S., &Nahvi, A. (2017). *Sustainability Assessment of Alternative Snow-Removal Methods for Airport Apron Paved Surfaces* (No. DOT/FAA/TC-17/34).