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Optimization Cropping Patterns in Agriculture Wells with Monthly and yearly Water Volume Restrictions: Case Study

Samane Ehsani Kolikand, Bijan Nazari, Hadi Ramezani Etedali and Abbas Sotodehnia*

Department of Water Engineering, Imam Khomeini International University, Qazvin, Iran

***Corresponding author**: Abbas Sotodehnia, Professor, Department of Water Engineering, Faculty of Engineering and Technology, Imam Khomeini International University, Qazvin, Iran; E-mail: sotoodehnia@eng.ikiu.ac.ir

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Abstract

Volumetric water delivery is one of the main components of the groundwater balancing plan in IRAN. The optimal use water, in the volumetric water delivery condition, has requires its particular conditions. The purpose of this study was to determine optimum cropping patterns in agriculture wells under volumetric water delivery constraints and in accordance with water right licenses in Qazvin plain. The average productivity in the optimum crop pattern with monthly and yearly water allocation has increased by 83.3% and 100.4%, respectively, compared to the formal crop pattern. Also, the average net benefit in the optimum crop pattern with monthly constraints has declined by 1.9%, and the optimum crop pattern with yearly water allocation has increased by 72.7% compared to the formal crop pattern in water licenses. The average water use in the optimum cropping pattern with monthly and yearly water allocation has declined by 49.2% and 15.5%, respectively. The results showed that the approved crop pattern in the water licenses of agricultural wells requires a considerable revision and it does not conform to volumetric water delivery conditions. Also, by comparing the optimum crop pattern with monthly and yearly water allocation for conserving groundwater balance, annually water allocation can be recommended.

Keywords Optimum cropping pattern; Volumetric water delivery; Water productivity; Water licenses of agricultural wells; Qazvin plain

Introduction

The world has finite water resources, which are under increasing stress as the human population and water demand per capita both increase. These problems are not new but are now becoming more widespread and their impacts more devastating. This has provided additional impetus for the search for solutions to problems arising from the mismatch between demand and supply in terms of water quantity, quality and timing. Increasing water productivity has been identified as one of the global challenges that requires urgent attention [1].

Water is the key factors for sustainable agricultural in Iran. Increasing population, climate change and improper management of water resources reduced water table of groundwater. In order to find some solutions for prevention of reducing the water table of groundwater, in 1384, the Ministry of Energy started to write a law about improving the situation of groundwater resources. In 1394, the Ministry of Energy devised the groundwater balancing plan. Volumetric water delivery is one of the main components of the groundwater balancing plan. The climate change that effect on water resources such as reducing the flow of surface water and groundwater resources and the management plans such as water right and agricultural smart meters have caused to vulnerable and instable the livelihoods of family farmers. Increasing productivity, in addition to produce the demand of the community as a major goal, can increase the farmer's income. One of the solutions for increasing water productivity is modification of Cultivation model according to economic criteria and technical constraints and factors of production.

It suggested a linear model that optimized of cropping pattern in Egypt [2]. The linear optimization model is developed to maximize the net annual return from the three old region of Egypt. Data for 28 crops in five years are being analyzed. The results show that there is a significant reduction in the allocated areas for onion, garlic, barley, flax, fenugreek, chickpeas, lentil and lupine since they are considered as non-strategic crops. It developed an agricultural planning optimization-simulation model to optimize the cultivated area, crop pattern, and irrigation efficiency considering the climate change impact. The result shows the significance of using different tools and methods in assessing and allocating water resource in region with limited water resources.

This competition, especially poignant in the developing world where the poor are typically the most affected [3] has fostered the use of indicator to assist in allocating water optimally and to identify management and policy alternatives that would lead to more efficient and productive water use[4]. One of the best indicate is Net benefit per drop (NBPD). NBPD is definited an economic indicate.

Methods

Study area

Qazvin plain is located in north-west of Iran. The mean rainfall of the plain is 234 mm .This study considered 9 fields in Qazvin plain technicians.

Data collection

Parameter related to the simulation and optimization of 7 crops were collected through Regional Water Organization of Qazvin. Data related to formal crop pattern and volumetric water allocation constraints derived from licenses of agricultural wells. The complexity of crop responses of water deficits led to use of empirical production functions as the most practical option to assess crop yield response to water.

Among the empirical function approaches, FAO Irrigation and Drainage Paper n.33 represented an important source to determine the yield response to water of field, vegetable and tree crops, through the following equation:

Where Yx and Ya are the maximum and actual yield, ETx and ETa are the maximum and actual evapotranspiration, and ky is the proportionality factor between relative yield loss and relative reduction in evapotranspiration.

Deficits

The complexity of crop responses of water deficits led to use of empirical production functions as the most practical option to assess crop yield response to water. Among the empirical function approaches, FAO Irrigation and Drainage Paper n.33 represented an important source to determine the yield response to water of field, vegetable and tree crops, through the following equation:

Here Yx and Ya are the maximum and actual yield, ETx and ETa are the maximum and actual evapotranspiration, and ky is the proportionality factor between relative yield loss and relative reduction in evapotranspiration.

Deficit irrigation is an optimization strategy in which irrigation is applied during drought-sensetive growth stage of a crop. Outside these periods, irrigation is limited or even unnecessary if rainfall provides a minimum supply of water.

In this study, AquaCrop simulates 64, 64, 60, 60 and 60 deficit irrigation scenario of wheat, barley, tomato, corn and forage corn, respectively. Alfalfa and canola are considered as full irrigation.

Optimization

In this study, after simulating the effect of irrigation water amount on the level of crop yields, to determine optimum cropping patterns in agriculture wells under volumetric water allocation constraints in Qazvin plain, Lingo and Linear programming method was used. Model of Linear.

Discussion

Cropping pattern optimization in presents the optimized crop in monthly water restriction (OCPM) and yearly water restriction are patterns under different deficit irrigation conditions (Wheat, Barley, Corn, Forage Corn and Tomato) and full irrigation (all of crops).

As shown in optimized cropping pattern with monthly water restriction, no field consists of corn and forage corn. The results shows that Field of A1, A3 and A4 consist of deficit irrigation of Wheat treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the first decade of May) and barley treatment (20% deficit irrigation in the first decade of November and 50% deficit irrigation in the third decade of May) tomato treatment (40% deficit irrigation in the first decade of May and 40% deficit irrigation in the third decade of May), Field of A2 consists of two deficit irrigation of Wheat treatment (the first is 30% deficit irrigation in the first decade of November and 30% deficit irrigation in the third decade of May; and the second is 30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May) and barley treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May) tomato treatment (full irrigation); Field of B2 and C1 consist of deficit irrigation of Wheat treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May) and tomato treatment (full irrigation); Field of C2 consists of deficit irrigation of Wheat treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May), barley treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May) and tomato treatment (full irrigation) and Field of D1 consists of deficit irrigation of Wheat treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May) and tomato treatment (full irrigation).

It is in optimized cropping pattern, no field consists of barley, corn and forage corn. Field of B1, C1, C2 and D1 doesn't consist of fallow; it means that these fields don't have water constraints. The results shows that Field of A1, A2, A3 and A4 consist of deficit irrigation of Wheat treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the first decade of May) and tomato treatment (full irrigation) and Field of B1, C1, C2 and D1 consist of deficit irrigation of Wheat treatment (30% deficit irrigation in the first decade of November and 50% deficit irrigation in the second decade of May) and tomato treatment (full irrigation). As shown , generally, An optimal cropping pattern with yearly water restriction is 0.25% of tomatoes, 0.5% of alfalfa, 0.16 wheat and 49% of canola. The average of net benefit in the formal crop pattern and optimum crop pattern with monthly and yearly water allocation were estimated 51.6, 50.6 and 89.1 million Rials per hectare, respectively. The average net benefit in the OCPM has declined by 1.9% and the OCPY has increased by 72.7% compared to the formal crop pattern in water licenses, field of B1, C1, C2 and D1 in OCPY form has the same net benefit. They have no limited water. While the annual water use per hectare is 9426 cubic meters, the water rights of these fields were more than water use. So their farm is limited.

It shows water use in FCP, OCPM and OCPY in studied fields. The average of Water use in the formal crop pattern and optimum crop pattern with monthly and yearly water allocation were estimated 10476, 5326 and 8851 cubic meter per hectare, respectively. The average Water use in the optimum crop pattern with monthly and yearly water allocation has declined by 49.2 and 15.5% compared to the formal crop pattern in water licenses. Field of B1, C1, C2 and D1 has the same Water use. The average of NBPD in the formal crop pattern and optimum crop pattern with water allocation were estimated 5026.9, 9213.3 and 10076.1 Rials/m^3, respectively. The average NBPD in the optimum crop pattern with monthly and yearly water allocation has increased by 83.3% 100.4% compared to the formal crop pattern in water licenses.it shows field of B1, C1, C2 and D1 has the same NBPD. Although the average water productivity in the optimal cropping pattern with annual constraints is higher than optimal cropping pattern with monthly water constraints, some farms with optimal cropping pattern with monthly water constraints form are higher water productivity than same farms with optimal cropping pattern with yearly water constraints form.

Conclusion

The studied fields were consisted of 8 wells agriculture. Lingo and Linear programming method was used. The aim of model was to optimized cropping pattern based on NBPD and given constraints to 7 main crops. In this study, AquaCrop simulates 64, 64, 60, 60 and 60 deficit irrigation scenario of wheat, barley, tomato, corn and forage corn, respectively. Alfalfa and canola are considered as full irrigation. The average net benefit in the optimum crop pattern with monthly water allocation has declined by 1.9% and the optimum crop pattern with yearly water allocation has increased by 72.7% compared to the formal crop pattern in water licenses. The average NBPD the optimum crop pattern with monthly and yearly water allocation has increased by 83.3% and 100.4%, respectively. Also water use in the optimum crop pattern with monthly and yearly water allocation has declined by 49.2% and 15.5% respectively. The results showed that the formal cropping pattern in the water licenses of agricultural wells requires a considerable revision and it does not conform to volumetric water conditions. The results showed that the approved crop pattern in the water licenses of agricultural wells requires a considerable revision and it does not conform to volumetric water delivery (allocation) conditions. Also, by comparing the optimum crop pattern with monthly and yearly water allocation for increasing water productivity and farmer's income and for conserving groundwater balance, annually water allocation can be recommended.

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