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***Research Article***

# DETERMINATION OF OPTIMUM CROPPING PATTERN BASED ON THE SUSTAINABILITY OF GROUNDWATER RESOURCES (BAAGH-MALEK PLAIN)

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## ABSTRACT
According to the recent drop in level of groundwater and high crisis of Bagh-Malek plain's water sources, the present study has been designed with the aim of developing a sustainable cropping pattern and supplying groundwater resources.

Required information for this study is collected by both questionnaire and by using statistical sources of Jahad-Keshavarzi site and Water Organization of Khuzestan province in 2013. The results show that water inputs are considered the most limiting production factor in region agricultural sector. Also use of irrigation methods can increase to be twice capacity of region agricultural products. The main propose of this study on considering patterns which are considered Intergenerational sustainability on scarcity inputs such as water.

## INTRODUCTION

One of the main Development planners considered the country Special attention to Agricultural sector to be able to help develop other economic sector and meet the nutritional needs of population. Accomplishing this goal requires efficient use of productive resources. One of the guidelines which can be useful to some extent in this field is to determine the cultivated areas according to the potential of each area. Evidences and investigations carried out indicate that the majority of manufacturers have not much considered economic intergenerational problems, and production process is carried out according to the manufacturers' feelings and this will lead to uncertain random results and proceeds of the various crops (Daneshvar, 2009).

Thus optimum cropping pattern as well as paying attention to the stable use of production inputs is inevitable, not only because of dealing with drought and water, but due to eliminate the limiting factors and optimal utilization of existing facilities (Amini *et al.*, 2008). According to the above analysis, the pattern of using inputs; especially water, and measuring their mutual influences with indicators of stability has a crucial importance. There is a great emphasis on stability of using water sources in researches studied by Amini *et al.*, (2010), Bakhshoodeh and Baghestani (2009), Montazer and Lotfi (2008), Kohansal and Firouz-Zaraa' (2008).

This can be considered specifically in Khuzestan province, which has agricultural importance.

By consecutive periods of drought in recent years, sustainability of water resources and residents' livelihood has faced serious challenges.

Hence, this study deals with the issue of determining cultivation pattern, which simultaneously guarantees the continuous potential growth of income and employment in the region as well as the economic and social aspects of a system, with an emphasis on sustainability. So, this research tries to determine the efficient pattern of cultivation upon stability of using groundwater sources by choosing an important plain of the region, called Bagh-Malaak Plain.

## MATERIALS AND METHODS

***Research Methodology***

This study is a theoretical-practical research and a causal-exploratory pattern in terms of research method. In this paper, library and field study were used to collect the data. A large amount of information is gathered in time series by Agricultural Jihad and regional water organizations.

Some parts of sectional information aligned with cultivation pattern were collected by regional farmers.

Eight rural districts have been identified in the region, and they have been divided into three categories based on the size and number of farmers. Finally, using proportionate assignment pattern for each rural district, about 420 questionnaires were collected in order to extract the information of mathematical programming in region. This study has used multi-period linear programming. Dynamic optimization in the real world can be expressed with a breakdown of time periods.

The model includes determining the availability of resources, choice of variables and planning of resource consumption during a specified period.

The preferences of time, initial and final conditions are the most important factors which should be considered to solve such problems.

It is assumed that the plan contains "k" period, which will continue to from time "t" to time "t + k". The general form of these patterns could be considered as follows:

$$Max \ \sum_t \sum_j (1+r)^{-t} C_{jt} X_{jt} + (1+r)^{-T} \sum_e \sum_j F_{je} I_{je}$$

$$sub:$$

$$\sum_e \sum_j A_{ije} X_{j,t-e} \leq b_{it}$$

$$X_{j,-e} = X^*_{j,-e}$$

$$-\sum_j X_{j,T-e} + I_{je} = 0$$

$$X_{jt} \geq 0$$

$$I_{je} \geq 0$$

Variables of such pattern are defined as follows:

*K* is the length of period, $b_{it}$ is the source amount of *i* in year *t*. $I_{je}$ is the amount of $j$ 's units which has been completed $F_{je}$ Value of activity *j* after *e* years of the lifetime investment (Doran, 2002).

$A_{ije}$ is the consuming amount of *j* activity from *i* source in *e* year, and finally $C_{jt}$ is the impure profit of *j* activity in *t* year that shows amount of activity in year. In overhead phrases, prime limitation indicates the limitation of consuming in various sources. Second limitation shows primary conditions or amount of initial activity. Third limitation indicates that the sum of activities at the end of each period should be equal to completed activity at the end of each period. It should be noted that values of the variables in explained models are forecasted using time-series techniques in the future (McCarl and Spree, 1997)

## RESULTS AND DISCUSSION

***Results***

As mentioned above, time series technique is used to determine future values of variables. As these values have been distinguished, linear periodical planning patterns have been designed to introduce the efficient cultivation pattern during next five years in Bagh-Malek Plain.

In this study, two objectives have been considered: maximization of the value of water resources in crop production as a benchmark for stable use of water resources and maximization of the present value of earnings as one of the main purposes of farmers in order to develop optimum model.

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Table 1 shows areas under cultivation of different crops in a five-year-plan regarding mentioned purposes.
In this model, Bank Interest Rate has been assumed 12% and irrigation efficiency has been assumed 40%, using the traditional method of irrigation.
This table suggests the results of a fixed combination of crops cultivated for the period under study from period 2014-2015 to 2017-2018 which is desired for both target patterns.
Fixed combination of five-year period includes products such as wheat, barley, potatoes, corn, paddy and alfalfa.
Pattern of maximizing the added value of water, potatoes and hay crops are introduced as an efficient pattern for self-use in all areas.
The fixed combination of crops on the five-year period shows, whenever the purpose of a model is based on the sustainability of water resources, not only much water-requiring products, or just at the level of consumables (potatoes and alfalfa) would enter the pattern, but also the area under cultivation may be severely reduced, such as grain.
Products entered in the model study shows that fluctuations in the 700 hectares of cultivated wheat and barley acreage of 170 hectares in the two models are compared.
The total period of oscillation of 400 hectares of wheat is in the pattern of profit maximization model and 200 hectares to maximize the added value of barley in the pattern. The difference for acres pattern is defined as 4 hectares for profit maximization and 30 hectares for maximization of the value added. It is noted
Here that the patterns extracted in the years 2013-2014 are similar to patterns extracted on 2014-2015. On the other hand, patterns extracted on 2015-2016, 2016-2017, and 2017-2018 are the same. The main reason for this phenomenon is the proximity of water harvesting in these years. This means that water is one of the factors that determines the amount of acreage crops in the area.

**Table 1: Optimazation of cultivation pattern (intrest rate 12% -irrigation efficiancy 40%)**

| | **2012-2013** | | **201302014** | | **2014-2015** | | **2015-2016** | | **2017-2018** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** |
| wheat | 1500 | 820 | 1500 | 820 | 1700 | 1020 | 1500 | 820 | 1700 | 1020 |
| barley | 200 | 34 | 200 | 34 | 230 | 38 | 200 | 34 | 230 | 38 |
| potatoes | 20 | 70 | 20 | 70 | 60 | 120 | 20 | 70 | 60 | 120 |
| corn | 230 | 80 | 230 | 80 | 134 | 95 | 230 | 80 | 134 | 95 |
| paddy | 800 | 920 | 800 | 920 | 850 | 1040 | 800 | 920 | 850 | 1040 |
| alfalfa | 49 | 300 | 49 | 300 | 49 | 500 | 49 | 300 | 49 | 500 |

Total revenues returned to the water resources of the region based on the model to maximize the value added to water, is estimated about 1012 million dollars. Although this amount includes interest income from agricultural activities in the region; the shadow price of water will be calculated to understand the real value of water resources). The pattern of gross income in the period under review equals totally 2,098 million Rials. But the pattern of maximizing gross total income is returned to the water resources of 988 million Rials, which indicates 4% reduction, but the total revenues is calculated about 2308 million dollars, increasing ten percent compared to the maximization of the value of water.
Note the difference in interpretation of shadow prices depending on the objective function. In other words, the shadow price of production factors in the model to maximize revenue maximization model of gross value added to the water it really different. Shadow prices obtained by maximizing the added value of water resources in the changed pattern in the present value of revenues for water resources was due to an increase in a single at the source of that location. But what is discussed further in the literature of this study, under the shadow price of the model, is to maximize impure income, which shows a change in

impure income of one acre of crops per unit, increasing the supply. The average price per cubic meter of water in the shade pattern to maximize impure income has been about 1580- dollars, and 2350 dollars in the model of maximization of value added. It is obvious that the maximum value obtained for each cubic meter of water in the pattern of gross value added is the maximum water over the pattern. Comparing these prices with the price already paid by farmers shows a notable difference between paid value and the true value of water. This is the matter introduced by various experts as one of the major problems of water resources which agricultural sector encounters. Results of the model are designed in Table 2, assuming 75% efficiency.

As seen in the increased irrigation efficiency by 75 percent, the acreage of all crops has grown about 5-20 percent. It emphasizes on lack of water in the Bagh-Malek Plain. In other words, the present study indicates that the use of modern irrigation methods such as drip irrigation instead of gravity, and increasing water efficiency, has increased the availability of water and has developed under-cultivated level in studied areas.

**Table 2: Optimazation of cultivation pattern (intrest rate 12% -irrigation efficiancy 75%)**

| | **2012-2013** | | **201302014** | | **2014-2015** | | **2015-2016** | | **2017-2018** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** | **Value of water** | **Max of profit** |
| wheat | 1700 | 900 | 1700 | 900 | 1870 | 1320 | 1700 | 900 | 1870 | 1320 |
| barley | 233 | 43 | 233 | 43 | 340 | 55 | 233 | 43 | 340 | 55 |
| potatoes | 40 | 110 | 40 | 110 | 70 | 120 | 40 | 110 | 70 | 120 |
| corn | 270 | 94 | 270 | 94 | 310 | 100 | 270 | 94 | 310 | 100 |
| paddy | 880 | 1030 | 880 | 1030 | 950 | 1160 | 880 | 1030 | 950 | 1160 |
| alfalfa | 80 | 450 | 80 | 450 | 95 | 600 | 80 | 450 | 95 | 600 |

Total revenues returned to the water resources of the region based on the model to maximize the added value of water in the region are estimated to be about 1315 million dollars. The pattern of impure income equals 2,431 million Rials. But the pattern of gross income up Total revenue is returned to the water resources of 1050 million dollars, but total revenues decreased by 4 percent shows the area is about 3002 million dollars. As seen in all modes compared to the efficiency of 30%, water resources and impure income has been increased. In this case, the most important factor of water production is considered, similar to the 40%pattern of efficient irrigation. In other words, although modern methods of irrigation water could limit its current acreage, increased acreage restrictions on the use of this resource is produced each year. The average price of water in the shade of the resulting pattern has been obtained 1878 Rials and 2690 Rials for the pattern of maximizing the value added to gross profit. It is noted that in this model; like previous models, shadow price resulting in a value added pattern is more than maximizing profit patterns.

***Discussions and Suggestions***

As mentioned above, recent study has been designed due to the recent drought and water crisis in the country with special attention to this problem in agriculture and to design a pattern with regard to the stability of the optimal cultivation of groundwater resources. Because of the importance of Khuzestan Province in country's agricultural sector, Bagh Malek Plain in this province was elected as a sample region. As levels of rainfall in this region showed large fluctuations over a period of 20 years in the long-term average rainfall in this region, it shows a downward trend. It can be argued that the recent drought in the region has also been effective. One hypothesis was that the agricultural water is the most important limiting factor. As seen before, production capacity would double by irrigation method. In all models, the shadow prices for these inputs have been positive.

There are two reasons in which water is still known as the most limiting factor in agriculture, and any attempt to use it efficiently is a step towards increasing agricultural productivity and improving their income.

These issues are discussed in such studies done by Barim and Yazdani (2004), Hossein and Salaami (2004), Khalilian and Zare, (2004), Torkamani and Jafary (2000), Sayedan and Firouzabadi (2006), Bakhshoodeh and Baghestani (2009), Amini-Faskhordi and Noori(2010).

On the other hand, the results show that using modern methods of irrigation patterns with different objectives not only increases the present value of revenues back into water resources_ considered as an indicator of stability,_ but also, it enhances the value added to the farmers' gross income.

It has been approved in studies by researchers like Torkamani and Jafari (2000), Sayedan and Firouzabadi (2006). As can be seen, the shadow price of water is the best criterion for detecting low levels of such inputs on all models in the region which is greater than the price paid by farmers. In other words, the prices paid by farmers are only small fractions of actual value of inputs in the region. It is suggested to such planners to adopt policies to make prices paid by farmers closer to the true value of water. Obviously, regarding to rising cost of inputs and increasing its contribution in the cost of agricultural production, greater accuracy and efficiency of your request will be considered.

One of research hypotheses is difference in optimum cropping patterns with current pattern in the region that research results also confirmed it. Finally, it is suggested that Agriculture officials in region would consider optimum cropping patterns at supporting farmers, and they would set their Supportive policies are set A way that propel current cropping pattern propel to optimum cropping patterns.

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