Eco. Env. & Cons. 20 (1) : 2014; pp. (235-239)
Copyright@ EM International
ISSN 0971–765X

Application of corrected positive mathematical programming for determining culture optimum pattern (Case study: Mashhad plain subsurface water consumers, Iran)

Mahmoud Sabouhi[1], Fatemeh Rastegaripour*[2], Ahmad Ali Keykha[2], Saeid Reza Khoda Shenas[1] and Mahmoud Okati[2]

[1]Department of Agricultural Economics, Ferdowsi University of Mashhad, Mashhad, Iran
[2]Department of Agricultural Economics, University of Zabol, Zabol, Iran

(Received 13 January, 2014; accepted 2 February, 2014)

ABSTRACT

With due attention to demand increase of agriculture crops, efficient use from necessary rare resources is very important. So,evaluating culture optimum pattern in order to optimizing water resources consumption in agriculture part is necessary. In this study with due attention to water resources limitation in Mashhad plain was evaluated culture pattern determination in region using positive mathematical programming. Data were collected via complementing questionnaires by farmers consumed subsurface waterin Mashhad plain for the year of 2012-13. In this study we considered three types of irrigation such as surface irrigation, drip irrigation and subsurface irrigation for crops of wheat, barley, tomato, onion and sugar beet. Comparison of 3 groups shows that in large farms,drip irrigation acceptance is more. According to paper, in condition 1 scenario 1 the most planting surface has allocated to crops of wheat, barley and tomato. In scenario 2 with introducing new water resources and wastewater would decrease consumption of subsurface water.

Key words : *PMP, Culture optimum pattern, Subsurface water consumers, Mashhad plain*

INTRODUCTION

In recent decades, the scarcity of water resources and the inability of humans in producing the water, unlike other products, have increased the gap between supply and demand of the water, especially in regions of the world where there is a shortage of supply in water. In many regions of Iran there is not enough water in the required time for agricultural activities. In most areas water is the most important and most restrictive factor in production. According to available statistics and studies in Iran, water is one of the limiting factors in production of agricultural products and development of the agricultural sector is most directly in relationship with the quantity and quality of water resources and how to manage and use these resources (Khalilian and Mousavi, 2005).

Mashhad plain is located in Garah Ghoum basin. This basin is located in north of Razavi Khorasanprovince. Mashhad plain area is about 16500 km^2. These 16500 km^2 consist of about 5000 km^2 plain and 11500 km^2 mountains. This plain has variable soil and climate. In agriculture part of Mashhad plain there are 110823 ha watery garden

***Corresponding author's email:** Rastegaripour@yahoo.com (Fatemeh Rastegaripour)

and farm lands. The most important crops of this plain are wheat, barley, tomato, onion and sugar beet. Region climate is semi-arid. Annual precipitation average in high and low lands is 800 and 250 mm respectively. Maximum and minimum temperature of the region is 43 and –23 °C respectively (Regional Water Department of Mashhad, 2013).

There are three categories of mathematical programming models: normative mathematical programming (NMP) or optimization models, positive mathematical programming (PMP) and econometric mathematical programming (EMP) (Buysse, 2006).In normative mathematical programming (NMP) that are used for more than half a century in agricultural economics researches, an optimum solution should be selected from many possible answers. In these models, objective function variables and constraints are not calibrated based on historical data. The NMP models cannot guarantee that the answers are as in the base year and this is the major problem of these models (Fajardo, 1981).

Onate *et al.*, (2007) compared the effects of supportive mechanisms related to CAP on sample farms production in a region in Spain by using PMP method. The results showed a significant decrease in gross profit toward previous policies. Mohseni and Zibaee (2008) studied the outcomes of increasing cultivation of canola in the Namdan prairie of Fars province by PMP model. The results indicate a decrease in wheat and beans cultivation, but its impact on the water consumption in the fields is different.

Sabouhi *et al.*, (2007) examined the impact of changes in the water price and reducing the amount of available water on the private and social benefits in Khorasan province using PMP model. The results show that farmers respond to increasing the price of irrigation water through change in cropping patterns, so it does not lead to decrease the consumption of water. Hey *et al.* (2006) used PMP model to analyze alternative policies to improve the efficiency of the allocation of irrigation water in Egypt and Morocco. The results showed that tax on product can be a replacement policy for water pricing in both countries. Qarqany *et al*., (2009) has a study on the effect of reduction in available water for irrigation and increase in water prices on the cultivation pattern using the PMP method in Fars province of Iran. According to the findings of the research, reducing the available water and doubling the price of water has no effect on the amount of its consumption. Medellin Azuara *et al.,* (2009) made an economic assessment on irrigation water in three regions in California using the PMP model. The results showed that the value of water is at least 6.2 times more than the paid price by farmers.

Materials and methods

Nowadays mathematics programming models (PMP) were converted to an important manner and with vast application in agriculture politics analysis.

Standard PMP simulate behavior observed in basis year and can was used for a number of model parameters such as price of output and input, subsides, and available resources. Quadratic programming model can was written as following:

$$\max \quad z = \sum_j (r_j - Ac_j(x_j))x_j$$
$$s.t \qquad \sum_j a_{ij} x_j \le b_i \qquad .. (1)$$
$$x_j \ge 0$$

Where is, j: crop (output), z: target function value, x_j: j activity level, r: mean income per ha, a_{ij}:limitation coefficients metrics elements, and b_i: axis of available resources amount.

In this model, variableexpense functions for per unit activity $Ac_j(x_j)$ was defined as following:

$$Ac_j = \alpha_j + \frac{1}{2}\beta_j x_j \qquad .. (2)$$

In this equation, *â* and *á* are parameters that they must were calculated. Theses parameters were calculated as following:

$$\alpha_i = c_j \qquad , \beta_j = \frac{\mu_j}{x_j^0} \qquad .. (3)$$

C_j is expenses calculated j activity on the basis of basis year data.

μ_j is parameter of related to limitations of calibrating, that this limitation was stated as following:

$$x_j \le x_j^0(1+\varepsilon_0) \qquad [\mu_j] \qquad .. (4)$$

x_j^0 is activity levels of observed, **å** is one number of small positive.

Generally, calibration of a model by PMP method was done in three stages:

1. Estimation of crops final expense
2. Estimation of non linear expense function
3. Describing model calibrated and application it for politics analysis

Rohm and Dabbert (2003) introduced new model. They supposed that between similar crops verities, substitutive elasticity is higher than different crops. In this condition quadratic programming model can be as following:

$$\max z = \sum_j \sum_v (r_{j,v} - Ac_{j,v}(x_{j,v}))x_{j,v}$$
$$s.t \qquad \sum_j \sum_v a_{i,j,v} x_{j,v} \le b_i \qquad .. (5)$$
$$x_{j,v} \ge 0$$

And variable expense function of each activity unit is as following:

$$\alpha_{j,v} = c_{j,v} \qquad , \beta_{j,v} = \frac{\mu_{j,v}}{x^0_{j,v}} \qquad , \gamma_j = \frac{\mu_j}{\sum_v x^0_{j,v}} \qquad .. (6)$$

This method introduced one additional grade parameter, which this grade there isn't in above equations, so for all similar crops verities is equal.So there is a grade for each one of crops ($\gamma_{j,v}$) and verities of one crop (β).

Similar to standard method, set of expense function coefficients create final conditions. Parameters correction was entered in equation as following:

.. (7)

$c_{j,v}$ is expenses that were calculated on the basis of data of base year, and other parameters () on the basis of main question solution results with 2 sets of calibrated limitations of additional obtained following as(Cortignani and Severini, 2009):

$$\sum_v x_{j,v} \le \sum_v x^0_{j,v}(1+\varepsilon_1) \qquad [\mu_j]$$
$$x_{j,v} \le x^0_{j,v}(1+\varepsilon_2) \qquad [\mu_{j,v}] \qquad .(8)$$

$\mathring{a}_1$ and $\mathring{a}_2$ are small positive numbers, μ_j is dual value depend to crop, $\mu_{j,v}$isdual value depend to crop variety.

Use of one data and without considering external addition data led to one model can't be powerful. In the fact, when there isn't much information, estimations are unreliable and parameters obtain as imperfect.

Perhaps this problem was solved with use of early data, numerous data and methods of more powerful estimation such as entropy maximum. Although use of entropy maximum method without addition information and only with one data isn't one optimizing method in standard model. In the fact in standard method, μ (dual variable) is equal to zero, and grade coefficients interaction is equal to zero. Although in this method, dual variable for land is equal to land rent value, but dual variable value for final activities is more than zero, and this subject can calculate non zero grade coefficients for these activities.

Because of Rohm and Dabbert method can't show base duration activities, this method has solved this limitation. In comparison to above equations, calibrated limitation was determined as following (Cortignani and Severini, 2009):

$$Ac_{j,v}(x_{j,v}) = \alpha_{j,v} + \frac{1}{2}\beta_{j,v}x_{j,v} + \frac{1}{2}\gamma_j \sum_v x_{j,v}$$

$$\sum_v x_{j,v} \le \sum_v x^0_{j,v}(1+\varepsilon_1) + \varepsilon_3 \qquad [\mu_j]$$
$$x_{j,v} \le x^0_{j,v}(1+\varepsilon_2) + \varepsilon_3 \qquad [\mu_{j,v}] \qquad .. (9)$$

$\mathring{a}_3$ is one number of small positive ().For determining dual variable in this method, variable value function was defined as following(Cortignani and Severini, 2009):

$$Ac_{j,v}(x_{j,v}) = \alpha_{j,v} + \frac{1}{2}\beta_{j,v}x_{j,v} + \frac{1}{2}\gamma_j \sum_v x_{j,v} + \upsilon_{j,v} \qquad .. (10)$$

$$\alpha_{j,v} = c_{j,v} \qquad , \beta_{j,v} = \frac{\mu_{j,v}}{x^0_{j,v}} \qquad , \gamma_j = \frac{\mu_j}{\sum_v x^0_{j,v}} \qquad , \upsilon_{j,v} = \mu_{j,v}\left(1 - \frac{x^0_{j,v}}{\sum_v x^0_{j,v}}\right) \qquad .. (11)$$

are linear parameters that show relative value of *v* varieties of *j* crops.

In this equations j is crop (j= 1,…,5), v is irrigation method (v= 1,2,3) such as surface irrigation, drip irrigation and subsurface irrigation.is j crop income with v irrigation method, is j crop mean expense with v irrigation method, and is j crop planting surface with v irrigation method.

Results and Discussion

Results obtained from model calibration in groups studied have showed in Table 1. According to table, comparison of 3 groups shows thatin large farms,drip irrigation acceptance is more. Also drip irrigation acceptance in mediumfarms is more than small farms. This matter can be because of high expenses of drip irrigation system for petty landowner farmers. Also for cash crops, subsurface irrigation acceptance is more. This matter is because of high expenses of subsurface irrigation system.

Table 2 show medium farms culture pattern used from subsurface water. Aim of scenario 1 is condition that with due attention to harvest amount was determined culture pattern. In scenario 2 because of surface resources increase and available treated waste water, farmers use subsurface water hasn't enough water amounts, so were encouraged toward use of surface water and treated wastewater (Table 2). According to Table, in condition 1 scenario 1 the most planting surface has allocated to crops of wheat, barley and tomato. In scenario 2 with introducing new water resources and wastewater would decrease consumption of subsurface water. In condition 2 scenario 2 and with transfer of water and wastewater from other plains to Mashhad plain led to under planting surface increase to 5 ha, and in this condition main limitations is consumption water, and from total under planting surface of mediumfarms mean (15 ha) about 10 ha residue that must was irrigated with surface water of treated wastewater. Generally after adding new water resources and wastewater in scenario 2 relation to scenario 1, in condition 1 under planting surface of wheat 1, 2.28 times; under planting surface of wheat 2, 2.4 times; under planting surface of barley 1, 2.13 times; under planting surface of barley2, 2.75 times;under planting surface of onion 1, 2.75 times; under planting surface of onion 2, 3.0 times; under planting surface of onion 3, 2.0 times; under planting surface of sugar beet 1, 2.2 times; under planting surface of sugar beet 2, 1.5 times; under planting surface of tomato 1, 1.5 times; under planting surface of tomato 2, 3.0 times; and under planting surface of tomato 3, 2.0 times would increase.

In condition 1 under planting surface of wheat 1, 1.25 times; under planting surface of wheat 2, 2.66 times; under planting surface of barley 1, 1.25 times; under planting surface of barley 2, 3.0 times; under planting surface of onion 1, 2.0 times; under planting surface of onion 2, 3.0 times; under planting surface of onion 3, 1.0 times; under planting surface of sugar beet 1, 1.75 times; under planting surface of sugar beet 2, 2.0 times; under planting surface of tomato 1, 1.8 times; under planting surface of tomato 2, 1.0 times; and under planting surface of tomato 3, 2.0 times would decrease.

Table 1. Culture patterns using corrected positive mathematical programming

	small	medium	large
Wheat1	1.1	3.2	8.2
Wheat1	0.9	1.2	1.3
Wheat1			
Barley1	0.9	3.2	7.1
Barley2		1.1	0.3
Barley3			
Onion1	0.45	1.1	3.3
Onion2	0.1	0.3	0.6
Onion3		0.2	0.4
Sugarbeet1	0.25	1.1	1.6
Sugarbeet2		0.3	0.3
Sugarbeet3			0.2
Tomato1	0.7	1.2	2.2
Tomato2	0.2	0.3	1.2
Tomato3		0.2	0.3

Reference: research results

Conclusion

Developed PMP is used more than NMP models. Unlike NMP models, in PMP some of the parameters are able to reproduce the data from the base year. This method can reproduce the observed data called positive. The main purpose of this model is to explain the reaction of manufacturer to foreign changes that makes the PMP models interesting for policy makers.In this study with due attention to water resources limitation in Mashhad plain was evaluated culture pattern determination in region using positive mathematical programming.In this study considered three types of irrigation such as surface irrigation, drip irrigation and subsurface irrigation for crops of wheat, barley, tomato, onion and sugar beet. Comparison of 3 groups shows that in large farms, drip irrigation acceptance is more. According to paper, in condition 1 scenario 1 the most planting surface has allocated to crops of wheat, barley and tomato. In scenario 2 with intro-

Table 2. Medium farms culture pattern (subsurface water) in politics of under study

	New under planting in condition of scenario 1		Change of condition 1 relation to condition 2 in scenario 1	New under planting in condition of scenario 1		Change percentage relation to base condition	
	Condition 1	Condition 2		Condition 1	Condition 2		
Wheat 1	3.2	1.5	2.13	1.4	1.1	2.28	1.25
Wheat 1	1.2	0.8	1.5	0.5	0.3	2.4	2.66
Wheat 1							
Barley 1	3.2	1.5	2.13	1.5	1.2	2.13	1.25
Barley 2	1.1	0.6	1.83	0.4	0.2	2.75	3
Barley 3							
Onion 1	1.1	0.6	1.83	0.4	0.3	2.75	2
Onion 2	0.3	0.3	1	0.1	0.1	3	3
Onion 3	0.2	0.1	2	0.1	0.1	2	1
Sugarbeet 1	1.1	0.7	1.57	0.5	0.4	2.2	1.75
Sugarbeet 2	0.3	0.2	1.5	0.2	0.1	1.5	2
Sugarbeet 3							
Tomato 1	1.2	0.9	1.33	0.8	0.5	1.5	1.8
Tomato 2	0.3	0.1	3	0.1	0.1	3	1
Tomato 3	0.2	0.2	1	0.1	0.1	2	2
Sum	13.4	7.2		6.2	5		

Reference: research results

ducing new water resources and wastewater would decrease consumption of subsurface water.

References

Buysse, J. 2006. *Farm-level mathematical programming tools for agricultural policy support*. Ph.D. Dissertation, Univ. of Ghent, Belgium.

Cortignani, R. and Severini, S. 2009. Modeling farm-level adoption deficit irrigation using Positive Mathematical Programming. *Agricultural Water Management*, 96 : 1785-1791.

Dogliotti, S., Ittersum, M. K. and Rossing, W. AH. 2005. A method for exploring sustainable development options at farm scale: a case study for vegetable farms in south Uruguay. *Journal of Agricultural Systems,* 86: 29-51.

Hey, L., Tyner, W., Doukkali, R. and Siam, G. 2006. Strategic policy options toimprove irrigation water allocation efficiency: Analysis of Egypt andMorocco. Selected paper prepared for presenting at the American. *Agricultural Economics Association Annual Meeting.* July 24-27.

Khalilian, S. and Mousavi, H. 2005. Assessing risk effects of under pressure irrigations systems, a case study in ShahrKord city. Agricultural Economics magazine, 2005.

Medellin-Azuara, J., Howitt, R.E., Waller-Barrera, C., Mendoza-Espinosa, L.G., Lund, J. R. and Taylor, J. E. 2009. *Agrociencia.* 43(2): 83-96.

Onate, J.J., Tance I., Bardaj, I. and Llusia, D. 2007. Agricultural Systems. 94: 247–260.

Qarqany, F., Boustany, F. and Soltani, G. H. 2009. *Journal of Agricultural Economics.* 1(1).

Regional Water Department of Mashhad, 2013. Sabouhi, M., Soltani, Gh. and Zibaee, M. 2007. Effect of irrigation water price changes on private interests, and community by using positive programming. *Journal of Agricultural Science and Technology*.