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EFFICIENCY GAINS FROM POTENTIAL WATER MARKET IN IRAN: SAVEH REGION CASE STUDY

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SUMMARY - Irrigation water in Iran is known as the most important and constraining factors of production in the agricultural sector. Historically, the overall of allocation of water has been managed by the government agencies based mostly on the socio–political criteria, instead of economic measure .This type of water management, however has resulted in an inappropriate water allocation in Iran. Water market, as an alternative mechanism for water allocation, can improve water use efficiency through the transfer of water to users who can obtain the highest marginal return from using it.This paper estimates the potential benefits of implementing water market among farmers in the irrigation area of 12500 ha in saveh region. At first, optimum crop pattern for 24 villages was estimated at absence of water market by using mathematical programming models. Then an aggregate model was used to estimate the effect of water market on farmers' profitability. Results show that exchanges among farmers can increase significantly water use efficiency, particularly during drought. Furthermore, water market as an economic institute, can increase proportionally labor demand or at least reduce negative impact of water scarcity on employment within agriculture sector. Also to broaden the water market the transaction cost had to be diclined.

Key words: water market, efficiency, mathematical programming model

INTODUCTION

Iranian irrigated agriculture uses about 90% of all the nation's available water resources. However, water use efficiency in this sector is low at about 30-35%. The need to increase the economic efficiency of water in the agricultural sector is perceived as the top priority of the country's national water policy. The absence of price signals in centralized allocation system has decreased irrigators' incentive to use water more efficiently (sadr,2003). Recently water market has been introduced as an alternative method for water resources management. Water market increases water use efficiently through transfer of water to uses with more value-added potential. Because of increased opportunity cost of water, even if farmers who do not participate directly in water market have enough incentive to use water more efficiently (Zekri, 2005). During the last two decades many authors have attempted to reveal the gains from water markets. Hearn and Easter (1996) assess the impacts of two real water markets in Chili. They show that the market transfer of water-use rights does produce substantial economics gains from trade in Elqui and Limari Valleys in north-central Chile. Dinar and Lettey (1990) and Weinberg *et al.* (1993), both in the Californian valley of San Joaquin and Garrido (2000) in Spain show that the implementation of the water market can increase allocation efficiency of this resource. Zekri and Easter (2005) conclude that water transfer among farmers and an urban water company can increases farmers' profitability by up to 7% in Tunisia. Also Gomez-Limon and Martinez (2006) Show that the simulated water market would increase economic efficiency and agricultural labor demand, particularly during drought in Spain.

This paper addresses the question of whether or not it is worth implementing water markets in Iran. In order to answer this question two irrigation water market will be simulated in Saveh region and their impacts on farmers' profitability (as a measurement of economic efficiency) will be estimated. Also changes for labor demand in agriculture sector will be investigated. Finally impacts of transaction costs and water availability on water market will be analyzed at different scenarios.

MATERIALS AND METHODS

It is assumed that farmers maximize their profit. Then they would allocate their water allowance to produce agricultural crops or to sale in the water market depending on marginal value of their water in their farms. Consequently water moves from lower to higher marginal productivity of water equals its market price.

In this study two mathematical programming models are proposed to investigate farmers' economic behavior. At the beginning it is necessary to notice two points. Firstly, in these models output and inputs ratio are fixed in different level of inputs usage. Whereas, due to diminishing marginal return rule, it may not be practically in this manner. This is an important issue in water market debate because transaction take place based on variations in VMPs of water among farmers whereas these models can not reveal these differences in the various level of input usage. Secondly, uncertainty in water availability, output price and transaction in addition to farmers' attitude towards risk influence trading pattern in the water market. However, the required information for risk analyses has not been available and water markets are simulated under certainty condition.

In the first model water exchanges is not possible (lake of water market). The main reason for using this model is to determine the optimum profit , which is later used an input into market model. The mathematical model for this case can be outlined as follow:

$$\Pi_0 = \sum_i GM_i(X_i^W) + \sum_j GM_j(X_j^S) \qquad (1)$$

SUBJCT TO :

$$\sum_i X_i^W + \sum_j X_j^S \le L \qquad (2)$$

$$\sum_i d_i^W X_i^W \le \alpha \, TW \qquad (3)$$

$$\sum_j d_j^S X_j^S \le \alpha \, TS \qquad (4)$$

$$X_i^W \ge 0 \quad , \quad X_j^S \ge 0 \qquad \forall i , j \qquad (5)$$

where:

$GM_i(X_i^W)$ and $GM_j(X_j^S)$: are gross margin for winter crop i and summer crop j respectively,

L: is the total available area for cropping activities(in ha),

X_i^W and X_j^S : are the area allocated to winter crop i and summer crop j respectively,

α: is scarcity coefficient

d_i^W and d_j^S :are water requirement of winter crop i and summer crop j respectively

TW and TS: are total endowment of water available in winter and summer respectively(m^3) .

The first equation is the objective function that maximize farmers' profit. Equation(2) represents the land constraint in cropping activities. Finally, equation (4) and (5) are winter and summer crops requirement restricted by water availability. Different scenarios are considered for water availability (αTW and αTS). For instance when α takes the value 1, the amount of available water is equivalent to experimented allotment in the 2000 year, whereas if coefficient α takes value 0.8 only 0.8 of this volume is available.

Now we assume that farmer were allowed to exchange water through spot market. The optimization model can be stated as follows:

MAX

$$\sum_k \Pi_k = \sum_k \sum_i GM_{ik}(X^w_{ik}) + \sum_k \sum_j GM_{jk}(X^s_{jk}) + \sum_k \left[(WP^w - \frac{tc_k}{2})WS^w_k \right] - \sum_k \left[(WP^w + \frac{tc_k}{2})WB^w_k \right]$$
$$+ \sum_k \left[(WP^s - \frac{tc_k}{2})WS^s_k \right] - \sum_k \left[(WP^s + \frac{tc_k}{2})WB^s_k \right] \qquad (6)$$

SUBJECT TO :

$$\sum_i X^w_{ik} + \sum_j X^s_{jk} \le L_k \qquad \forall k \qquad (7)$$

$$\sum_i \sum_k d^w_{ik} X^w_{ik} \le \alpha \sum_k TW_k \qquad (8)$$

$$\sum_j \sum_k d^s_{jk} X^s_{jk} \le \alpha \sum_k TS_k \qquad (9)$$

$$\sum_i d^w_{ik} X^w_{ik} + WS^w_k - WB^w_k \le \alpha\ TW_k \qquad \forall k \qquad (10)$$

$$\sum_j d^s_{jk} X^s_{jk} + WS^s_k - WB^s_k \le \alpha\ TS_k \qquad \forall k \qquad (11)$$

$$\Pi_k \ge \Pi_0 \qquad (12)$$

$$X^w_{ik} \ge 0 \ ,\ X^s_{jk} \ge 0 \ ,\ WP^w \ge 0 \ ,\ WP^s \ge 0 \ ,$$

$$WB^w_k \ge 0 \ ,\ WS^w_k \ge 0 \ ,\ WB^s_k \ge 0 \ ,\ WS^s_k \ge 0 \qquad \forall\ i,j,k \qquad (13)$$

Where:

WP^w and WP^s : are the market price of water (in rials/m^3) in winter and summer respectively

tc_k : denote the transaction cost of transferring water from the irrigator or representative k

WS^w_k and WB^w_k :are the amount of water sold and purchased by k (in m^3) in winter water market

WS^s_k and WB^s_k :are the amount of it which are sold and purchased by k (in m^3) in summer water market.

Irrigation water in saveh region is delivered to farmers during two period (November to next June and July to September) at two different prices (20 rials/m^3 in the first period and 30 rials/m^3 in the second period during 1999-2000). Hence two water markets are designed in this case study. Winter and summer water market seemingly separate but since winter crops and summer crops use the land competitively, both markets are implicitly interdependent. On the other hand winter water market influence winter plantation pattern and consequently summer plantation pattern and summer water market, vis versa. In the equilibrium point total gross margin from production, plus gains from both water markets are maximized. Whit respect to equation (6), farmers maximize their profit through Cropping and the exchange of water. It has been assumed that transaction costs are parameters and buyers and sellers pay them equally. Some authors have considered price in the water market as a parameter. Garrido(2000) assumed that market equilibrium price is equal to the buyers shadow price of water. Zekri and Easter (2005) argued that water market price is fixed exogenously and farmers selling water receive the lowest opportunity cost of water whereas farmers buying water pay price received by sellers, plus operating and management cost, plus transaction cost. According to Gomez - Limon and Martinez (2006) , in the above model water market prices (WP^w and WP^S) are fixed endogenously. On the other hand these variable allow equilibrium to be reached, while water supply equals water demand. The set of constraints (8) and (9) insure that volume of water used at region level are less than or equal to total available water in winter and summer. Equation(10)and (11) insure that in both water market volume of water used plus net volume of water traded by each irrigator or representative is less or equal to his allotment. Finally equation (12) guarantee that the profit reached by each farmer in the market should be superior or at least equal to his profit in the first case , when exchanges are not permitted. As Gomes–Limon(2006) commented , it should be paid attention that because of the set of constraints in equation (12) , the market eqilibria obtained via this model should be considered as “second best” optimal. On the other hand in the water market voluntary transfers are based on individual profit gains whereas implementation of a compensating mechanism, which transfers benefits from gainers to losers, can increase total profit more in the market equilibria.

RESULTS AND DISCUSSION

The Saveh region is situated in the north of markazi province in Iran. The average rainfall in the area is 180 mm/year and the average available water for irrigation is 300 million m^3 per year. The irrigated crops in this region are winter crops (i.e. wheat and barely), and summer crops namely cotton, cantaloupe and pomegranate.

The irrigated area considered in this study include 24 villages under Saveh irrigation network, which covers 12500 ha. The efficiency of water transfers from main cannel to farmers vary among 24 villages, ranged from 35% to 100%. Thus, it is expected that these differences can motivate farmers to participate in the water market. All information such as output and input prices, inputs used per crops and crop yields were obtained from the study of Mohamadinejad(2000).

Although attending “global optima” was not feasible, to credit “local optima” obtained I paid attention to the range that market price of water can fluctuate and limited the price to this range. According to the literature, price in the water market must be lower or equal to the highest opportunity cost of water (in without market scenario) and higher or equal to the lowest of them. Although the result obtained are local optima but they are confirmed with text and conformed to similar studies(Gomez-Limon and Martinez, 2006).

Water markets were simulated in alternative scenarios for different amounts of available water (by changing α)and two transaction cost(for tc=10,20 rials). The result of these scenarios were compared with those estimated in the first model (where water market is not implemented) and changes in aggregate gross margin and labor demand were calculated in the whole areas studied.For instance, *table1* presents the results obtained by simulating water markets using the 2000 data on water availability (for tc=20 rials). The volume of water exchanged is 85.2 million m^3 in both market(28% of total used water). The average improvement in farmers’ profitability is 5 %. Also total labor demand increase 6 % in the region.

Fig. 1 shows the impact of both markets on aggregate gross margin. When available water decreases (α diminishes), aggregated gross margin is reduced but this reduction is grater in “without market “ scenario than “with market “ scenario. This improvement in aggregate gross margin(as a measurement of economic efficiency)ranged from 1.6% to 26% for different values of α (tc=10 rials). It can be observed that transaction cost has negative impact on this improvement. For example if transaction cost increases from 10 to 20 rials (for α=1), then aggregate gross margin diminishes from 12% to 9% and water market losses its advantage about 3%. Fig. 2 show that implementing water market can mitigate negative impact of water scarcity on labor demand within agriculture sector. As accessible water drops, labor demand decline in both cases but this reduction is more moderate in the "with market scenario" than "without market scenario". This improvement in total labor demand ranges from 2% to 15.2 %. Increasing transaction cost, also, shrink this positive impact of water market. Although this impact looks to be negligible, but exist. Fig. 3 shows the volume of water exchanges in winter water market. When water scarcity increases (α diminishes), volume of exchanged water raise until point that scarcity coefficient equals 0.9. After this point volume of exchanged water decreases, due to decreasing the absolute available water. In summer water market, this issue occurs in experimented water availability, where scarcity coefficient equals to 1 (fig. 4)

Table1. results of simulating water markets(α=1, tc=20 rials)

	Winter water market		Summer water market		Profit without market	yearly	Increase labor
villages	Volume of water sold (million m^3)	Volume of water purchased (million m^3)	Volume of water sold (million m^3)	Volume of water purchased (million m^3)	(billion rials)	Improve ment on profit (%)	Use in days number (%)
Yal abad	0	0	0	8.8	6.4	1	0
Ghardin	10.7	0	0	6	5.7	2	10.4
Alusjerd	0	0	0	8.43	5.3	0	0
Herisan	0	11	13.6	0	3.2	15	0
Ojan	6.8	0	0	3.8	3.6	2	29
Khoram abad	0	2.7	4.3	0	2.5	1	0
Malkabad	4.6	0	0	2.5	2.4	2	29
Ostoj	2.6	0	0	3.1	2.3	1	0
Sorkhade	4	0	0	1.7	2.2	2	22
Sef abad	3.7	0	0	2.4	1.9	1	0
Holol	3.5	0	0	2.4	1.8	1	0
Lalaeen	3.36	0	0	2.7	1.7	1	0
Abasabad	0	0	0	0	1.6	0	0
Mahmod abad	0	0	0	0	1.5	0	0
Fansghan	0	6.5	4.9	0	.8	0	0
Mehr abad	0	5	4.6	0	.9	52	0
Asyabak	2.7	0	0	0.3	1.6	35	6
Tarkhoran	0	5.6	4.2	0	.7	1	0
Labar	0	3.6	4	0	.9	52	0
Jojen	0.7	0	0	0	1	22	0
Dalestan	0	3.9	3.5	0	.7	0	0
Hasan abad	0	0	0	0.25	1.3	35	6
Chal dagh	0	4.5	3.3	0	.6	1	0
Ali abad	0.14	0	0	0.02	.09	52	6
Total	42.8	42.8	42.4	42.4	50.69	5	6

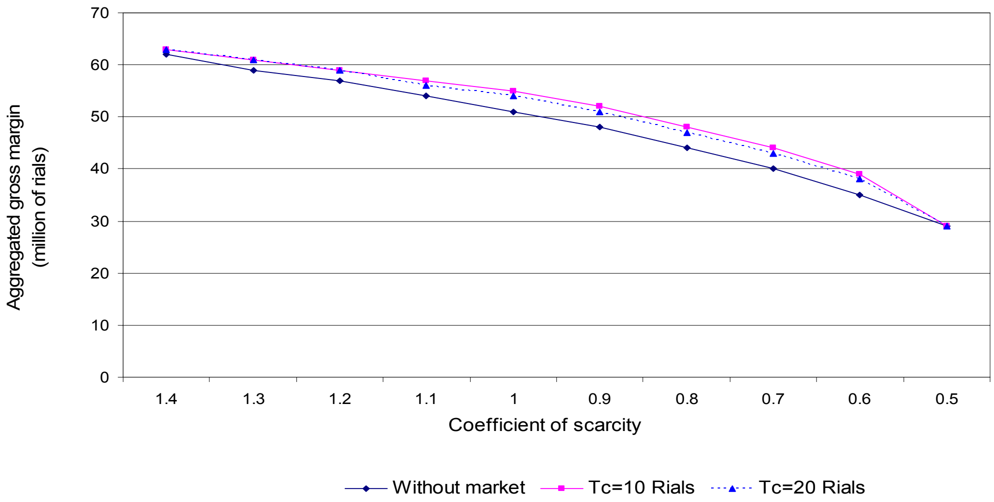

Fig. 1. Impact of markets on aggregated gross margin

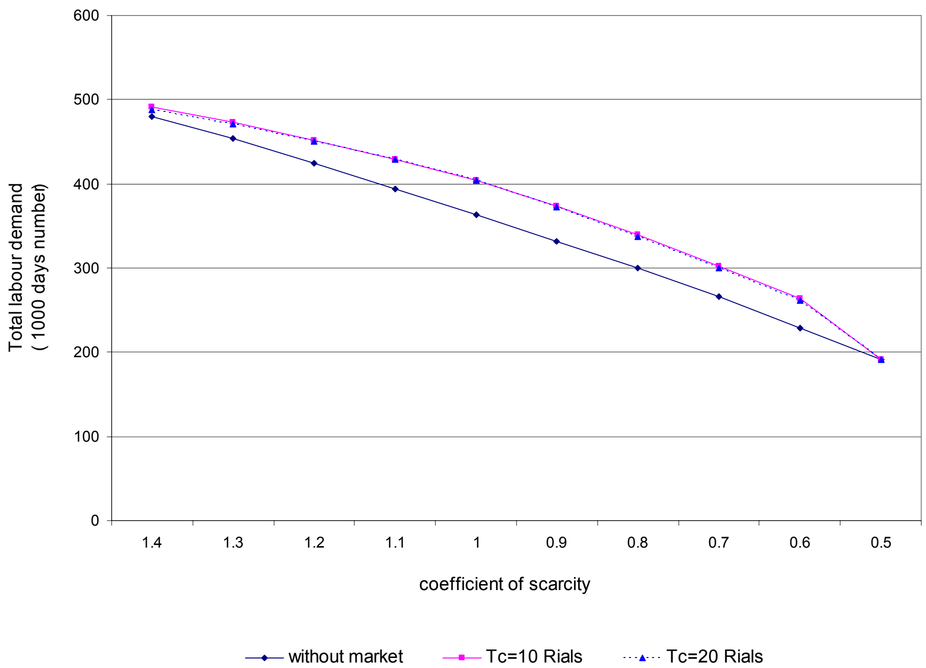

Fig. 2. Impact of water market on total labor demand

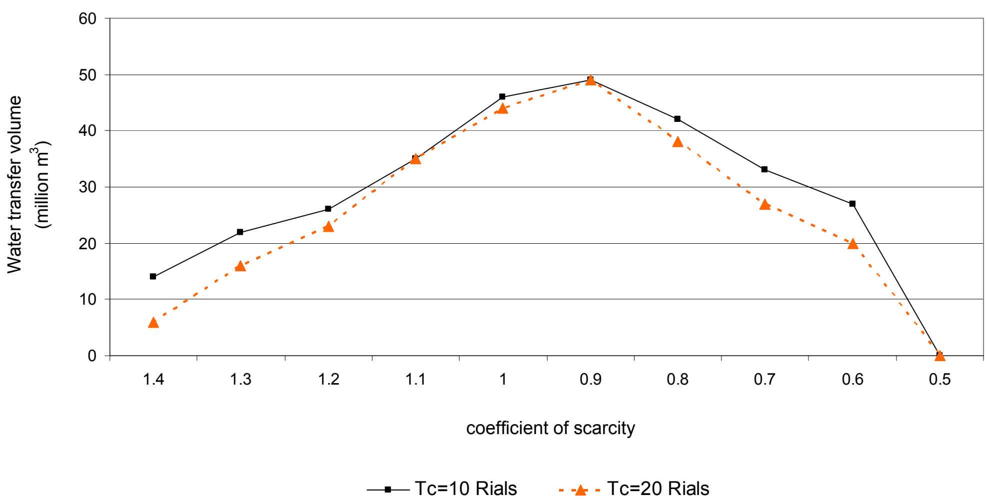

Fig. 3. water transferred in winter water market

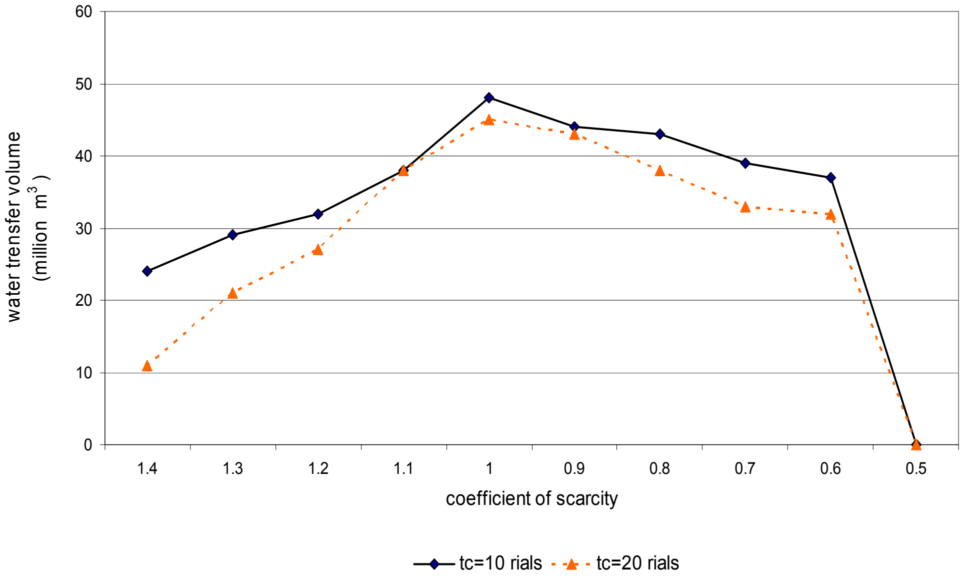

Fig. 4. water transferred in summer water market

CONCLUSIONS

This paper analyzes the potential efficiency gains of implementing water market within the agriculture sector in Iran. Results show that water exchanges among farmers can increase significantly water use efficiency, particularly during the drought. Thus it is very important to separate water right from land right and permits farmers to trade their water easily. Furthermore, since unemployment is a major concern in Iran, water market as an economic institute, can increase proportionally labor demand or at least reduce negative impact of water scarcity on employment within the agricultural sector. In addition to develop water market, it is necessary to lower transaction cost as much as possible.

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