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Participation of Tree-crop Farmers in Spot Water Markets in Semiarid Areas: An Example from Iran

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Introduction

Water markets have been proposed as a tool for dealing with water scarcity and have been justified by emphasising their efficiency. Market-based allocation systems have the potential to ensure that scarce water will flow to the user who earns the highest marginal value from the water. Trading water in annual spot markets can reduce farmers' economic vulnerability caused by water supply variability across irrigation seasons (Calatrava and Garrido, 2005). Informal trade of water consists of farmers selling surplus ground or surface water for a period of time (crop season) to a neighbouring farm or town (Johansson, 2000). Governments and water authorities interested in establishing water markets as a tool to reallocate water away from inefficient uses and towards more valuable applications should learn more about the factors influencing irrigators' decisions to participate in water trading (Wheeler et al., 2009). As there are few transactions among water users (Young, 1986; Donohew, 2009), analysing available water markets and their participants would be particularly useful for policy makers who may need to alter existing institutions, so that the costs of water trade do not outweigh the potential gains from trade. The results of participatory studies are also of interest to farmers and municipal water providers which are actively engaged in developing water-leasing alternatives (Pritchett et al., 2008).

In Iran, the Law of Fair Distribution of Water (1983) shapes the institutions for water use. Under this law, people receive legal permission to use groundwater, which is a public good. However, these permissions are a form of property ownership and have very high shadow values, according to water charge levels of wells and water quality. There is a restriction in this law which can operate versus any water market expansion. Paragraph 28 of this law has forbidden any usages of the water which is different from the given permission. Moreover, the transmission of the permission should be done under the supervision of Ministry of Energy (MOE) with the transmission of the land to the new user by keeping the same permitted usages.

In this paper we study the factors affecting the decision of farmers to participate in water markets and buy groundwater for irrigation of pistachio gardens in the summer of 2008 in the Rafsanjan aquifer region in south eastern Iran. The logit model is used for the analysis and factors which affect the farmers' participation are statistically defined and analysed.

Material and Methods

The logit functional form from the GLM family was chosen for the further analysis. Field work was conducted for almost 3.5 months during November 2008- February 2009 in the Rafsanjan County in the south-eastern part of Iran. The main reason for selecting Rafsanjan was its unique agricultural production pattern (pistachio production) and its size. Data was gathered using two-stage random sampling. Considering the different water quality found within the study area, and the high cost of water quality studies, a readily available 4-year data set from the Rafsanjan

Water Authority (RWA) was used for the first-stage sample selection. The RWA randomly sampled 60 agricultural wells within the aquifer, and checks chemical and water parameters such as EC, pH, etc. seasonally in order to observe any quality changes that may occur. The survey comprised two different questionnaires; one concerning wells and the other concerning households. The questionnaire concerning wells was designed after consultations with irrigators, pumpers and well-representatives. This questionnaire contains questions regarding the well ownership, technical aspects, historical trends, well management, labour force, energy consumption, maintenance, water recharge and property value. The household questionnaire contains questions about garden management, garden structure, the value of harvested crops, household socioeconomic structure, inputs, garden operational costs, processing costs, water provision costs and water trade. Also included within the questionnaires were questions asking for agricultural expenditures over a one-year period, and crop yield levels and product sale prices for a two year period.

As the sample of wells was random it includes both large and small-scale farmers. The ownership pattern is very diverse. There were cases where 2-3 wells belonged to one landlord or where one well was owned by 200 people. Representatives of the 57 pumping units[1] were interviewed, along with more than 157 farmers whose land is dispersed around the aquifer. As a result of heterogeneous water-land ownership of the area, the spot water market is not recognised by all 57 pumping units. We found that water markets were operating among those pumping units with many owners, rather than those with few owners. Spot water market was available among 42 pumping units and 145 farmers in sample. 28 farmers in this group have participated in spot water market in summer 2008. Water trade covers a small share of water use per hectare among farmers in the sample and smallholders are more active participants within water markets.

In water market analysis, three different possible groups should be distinguished: water buyers, water sellers and those who both buy and sell. In well-established water markets, we can even consider non-trading water users as separate category. In this study we focus only on buyers and their characteristics, whom we compared with non-buyers in order to obtain a mutually exclusive sample. The water traded was based on hourly use. After arrangements with well representatives or technical observers, the number of hours supply is delivered to buyers from the well. It must be considered that the traded water is not a simple transportable commodity and most of the time trade is only possible for neighbouring farmers. The pattern of wells' water distribution can encourage or discourage spot water market expansion.

Results

There are several factors which affect the decision by farmers to buy groundwater. The relative importances of these factors are quantified using a logit regression with water buying as the binary variable. Table 1 shows the results of the logit regression. As the coefficients in the logit model do not reflect the marginal effects of the explanatory variables on the probability of participation, they have to be transferred to probability changes in interpretations

A farmer who transfers water from other wells to the target farm or transfers water from a target well to other farms (if such a possibility exists), is 27.5 percent more likely to buy water, which simply reflects farm water shortages. For every further piece of fragmented land, the farmer is 2.4 percent more likely to buy water. For one year increase in the average age of a garden, the probability of participation decreases by 0.7 percent. For each extra cubic meter of water quota granted per hectare, there is a decrease in the probability of participation by 0.001 percent; the significance of increasing water quotas becomes clear when one considers that volumes may be hundreds or thousands of cubic meters. A one meter increase in the depth of the water table increases the probability of participation by 0.31 percent. A yield increase of one kg dry pistachio per hectare encourages participation by 0.01 percent. A one percent increase in the share of

[1] Each pumping unit refers to the number of wells which irrigate a specific farm area. There could be one well or many. Usually, a pumping unit has one management pattern for all wells inside that pumping unit and it´s water is mixed for irrigation

labour costs, as a proportion of total annual variable costs, reduces the likelihood of water market participation by 0.5 percent. Labour costs were the most significant of all costs. An explanation about our quality variables is required. Single unit increase in EC of one µS/cm has a limited impact on water quality. EC was significant in the logit model, however it´s probability effect was very low. Therefore we have converted the variable to dS/m, or 1000 µS/cm. A one unit increase in dS/m decreases the probability of buying water by 1.9 percent, which we consider to be a low effect as 1000 µS/cm is such a large change that it occurs rarely. A similar consideration applies for pH, since pH is a logarithmic scale variable and therefore the difference between pH 7 and 8 is equivalent to changing river water quality to that of sea water, which is unlikely Therefore the 11 percent reduction in the probability of buying water associated with a one unit change in pH can be considered of minor importance, as actual changes in water quality are small.

Table 1 - Logistic regression coefficients of factors affecting the decision to buy groundwater

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	18.01	7.43	2.42	0.02
Using Other Wells (dummy)	1.94	0.79	2.45	0.01
Having other jobs (dummy)	1.26	0.57	2.19	0.03
No of fragmented lands)	0.29	0.11	2.63	0.01
Average age of trees in garden	-0.09	0.04	-2.45	0.01
Insurance cost (1000 Rial)	0.00	0.00	1.47	0.14
Pistachio production per ha	0.0013	0.00	3.10	0.00
Water quota per ha (cubic meter)	-0.0001	0.00	-2.03	0.04
Water level	0.04	0.01	3.38	0.00
Share of labor costs from all variable costs	-0.06	0.02	-2.48	0.01
PH	-2.39	0.94	-2.54	0.01
EC (dS/m)	-0.25	0.11	-2.29	0.02
Null deviance	142.301	df	144	.
Residual deviance	96.432	df	136	.
AIC	120.43	-	-	-
Model Test :	-	-	-	-
Difference of deviance	45.86893	-	-	-
Difference of df	11	-	-	-
Model P-value	0.00000	-	-	-
Wald statistic	39.7	-	-	-

Source: Study findings

Table 1 shows that quantitative water scarcity, technical aspects of farming and pumping and water quality are the major influential factors in the logit model. From the long list of farmer characteristics, the only significant variable in the model is the dummy variable which shows occupations of respondents in addition to farming. On average, having other occupations increases the participation likelihood by 12 percent. The only variable which can not be simply explained is the insurance costs for the previous year, which has a positive effect in the model. Although this variable is insignificant, it could not be eliminated by considering different model selection criteria. In contrast, insurance costs for the current year had no effect in the model. As farms have proximities to both groundwater (a hydro-geological variable) and neighbouring farms (a social variable), spatial autocorrelation could exist between these two variables. A farmer´s decision to participate in the water market could be influenced by the decisions of neighbouring farmers, or the error term in the logit model could be spatially correlated. Therefore, the Moran I test was used to test the spatial autocorrelation among the residuals. Inverse distance was used to establish a spatial weight matrix. As sample residuals are not appropriate criteria in GLM models, Pearson residuals and deviance residuals are checked with the Moran I test. No spatial autocorrelation was found in the model.

Discussion and Conclusion

In spite of a lack of regulation, we could identify a spot water market in the study area. The results show that this market is small and accounts for a limited share of water used for irrigation. Smallholders are the main participants in the market and water distribution patterns can affect the size of this market. Technical factors and profit-driven factors are more significant factors within this water market than farmer characteristics, household members, or social characteristics. The latter group of variables are not significant factors in the logit model. These results contrast with the findings of Wheeler et al. (2009) who regarded water markets as normal extensions of agricultural technology. The development of monoculture and the reality of market-oriented agriculture in Rafsanjan may explain the importance of profit and technical factors found. Interpretation of table 1 shows that water quantity factors affect the model more than water quality factors, which shows water scarcity is more important within the study area than quality. This suggests that groundwater depletion in areas with good water quality may result in an expansion of spot water markets. Furthermore technical innovations affecting productivity can encourage spot water market expansion. Regional labour market factors such as labour costs can affect the decision to participate in the water market. Increases in labour costs negatively affect water market participation rates. However, other variable costs do not affect the model. This difference could be largely due to the high labour intensity of pistachio production. It is therefore likely that labour efficiency improvements or technological adaptations which reduce labour costs might encourage water market participation.

Regulating the groundwater market may encourage water trade expansion among farmers, by relaxing current limitations on water use and land laws, as the area has already the potential for a more expanded water market. Future studies could analyse factors affecting the willingness to pay (WTP) in this fragmented market, in order to assist groundwater valuation research. Of regional interest might be an institutional study of groundwater regulation and laws to encourage the expansion of water markets.

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