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M. S. Bachta[1], A. Ben Mimoum[1], L. Zaibet[2], L. Albouchi[1]

[1] *Institut National Agronomique de Tunisie, Tunis, Tunisie.*
[2] *Ecole supérieure d'agriculture, Mograne, Tunisie.*

E-mail : bachta.medsalah@inat.agrinet.tn

Abstract - Water pricing has been a key concern in Tunisia for the last two decades. It is recognized that the average price of water remains very low as compared to the marginal value of water as well to the cost of mobilization of water. Alternatives to better allocation of water resources have been sought mainly with the increasing scarcity of this resource and the expanding irrigated lands. Failure to estimate a water price that reflects its real value would lead to sub-optimal allocation of water and in general to policy failure problems. Water markets have been a promising institutional arrangement for better allocation of water as demonstrated by diverse experiences of many countries. This paper attempts to examine the effects of the implementation of a market for water in Tunisia. Our hypothesis is that market allocation of water resources would improve the value of water (water price) and its distribution among farmers. Users will adjust their demand for water and then change production patterns, which lead to improved farm revenues (total farmers revenues). The paper compares the baseline (current) allocation to allocations based on alternative market structures extremes namely pure competition and monopoly.

Key words : water pricing, marginal value, Tunisia.

1 Introduction

Water pricing has been a key concern in Tunisia for the last two decades. It is recognized that the average price of water remains very low as compared to the marginal value of water as well to the cost of mobilization of water. Alternatives to better allocation of water resources have been sought mainly with the increasing scarcity of this resource and the expansion of irrigated lands. Failure to estimate a water price that reflects its real value would lead to sub-optimal allocation of water and in general to policy failure problems (Ahmad, 1998, 2001[1]).

Water markets have been a promising institutional arrangement for better allocation of water as demonstrated by diverse experiences of many countries. Among the most cited countries where such an experience has gained grounds we find Chile in Latin America where a system of water-use rights was re-established in 1981, and Jordan Valley in Palestine and Yemen in the Middle

East region. These institutional arrangements require well defined property rights over water. Unfortunately such a condition is lacking in Tunisia.

In Tunisia, past water management experiences have focused mainly on supply expansion solutions. These solutions deemed not sustainable given the increasing investment costs on one hand and the low cost recovery on the other hand. World wide, the expansion of agriculture has been accompanied by increased mobilization costs of traditional ground water sources due to physical and technical constraints. Between 1970 and 1990 such costs have doubled in some Asian and African countries (Rosegrant *et al.,* 2002[11] ; Rosegrant and Svendsen, 1993[10] ; Dinar and Subramanian, 1997[5] ; FAO, 1992[6]). This cost increase has resulted in a divergence between the economic value of water and the price paid by users although in many of these countries water mobilization costs are heavily subsidized.

Emphasis, instead, has shifted from supply expansion to demand management, mainly that associated with agricultural use since this sector alone consumes more than 80% of water available in most countries. To this end technologies of water conservation have been diffused, appropriate legal institutions were developed and pricing systems to managing individual demands as well as insuring full cost recovery were initiated. Water pricing to bring about the actual price to its economic value has been the most recommended instrument in order to increase the efficiency of water use. The economic literature, however, is rich of controversial effects of higher water pricing solutions on water demand. Caswell and Zilberman (1985[2]) and Caswell *et al.* (1990[3]) show positive effects of increasing water price on water conservation technology adoption. Whereas Varela-Ortega *et al.* (1998[14]) show that such effect is related to other factors namely the potential of diversification, water allocation and risk of water delivery. Other studies stipulate that an increase of water price may induce positive demand response only in the range of prices where the demand is elastic (Gomez-Limon and Riesgo, 2002[7] ; De Fraiture and Perry, 2002).

The method utilized to estimate water price may itself be problematic. Tsur and Dinar (1997[13]) studied different methods such as the volumetric pricing, the output-input pricing, the area pricing, the tiered and two part tariff pricing and the water markets pricing, and found that the effects are more manifest on the cropping mix rather than on water demand for each particular crop. To allow for better allocation and management of water resources, water would rather be expected to be exchanged among farmers on a market-based mechanism. There are a number of studies that have assessed the impacts of a water market on the usage of water. The examples of Chile and Mexico witness the potential of a market-solution to insure better availability and allocation of the resource (Thobani, 1998[12]). In Pakistan, the implementation of market exchange of water in two regions has resulted in the reallocation of water by 18% and 29% respectively. Impacts on farm revenues however remain as low as 2% and 5% respectively (Morardet *et al.,* 1994[9]).

Water distribution rules before the instauration of the market would influence the size of impact of such allocation system. *Ex ante* rules would lead to important effects on the adoption of market mechanism but may also decrease the chance of implementation of the market. On the other side, *ex post* rules would reduce the market impacts. In sum, the instauration of water markets has been an efficient way to improve the use of water through its reallocation among users. Compared to administrated prices, the market would insure efficient water rights exchange, lead to lower transaction costs and improve the efficiency of irrigation water.

This paper attempts to examine the effects of the implementation of a market for water in Tunisia. Our hypothesis is that market allocation of water resources would improve the value of water (water price) and its distribution among farmers. Users will adjust their demand for water and then change production patterns, which lead to improved farm revenues. The paper compares the baseline (current) allocation to alternative allocation systems based on different market structures namely pure competition and monopoly. On the basis of the results of this study it would be possible to conduct an *ex ante* evaluation of a water market. The paper is organized as follows. In the next section a brief overview of water policies in Tunisia is presented.

In section three we present the methodology used in the study to assess the effects of a potential water-market. Section four is reserved to the discussion of results, which will be followed by final recommendations and conclusions in the last section.

2 Overview of water policies in Tunisia

During the last four decades water management policy in Tunisia has gone through two major periods. During the first period efforts concentrated on the mobilization of water resources and the implementation of requisite infrastructure to the distribution of these resources all over the country. This has contributed to extend irrigated areas, intensify, diversify and regulate the agricultural systems. Along side to the mobilization efforts water has been subsided according to a pricing scheme which covers only part of the variable costs. With the increasing number of works (dams) the costs have been to the increase as well (table 1).

A combined pricing scheme based on a quota system and a price support is then applied leading to different water values as depicted in the analytical framework in figure 1.

TAB. 1 – The cost of selected dams and the corresponding water marginal cost.

Dams	Volume of water regularized (1000 m^3)	Cost of investment per volume of water regularized (DT/m^3)	Marginal cost estimated (DT/m^3)
Sidi Barrak	190 000	0,800	0,071
Sidi Aich	20 000	1,590	0,143
Barbra	80 000	2,260	0,204
El Houareb	27 000	2,620	0,236
Zaiatine	17 000	4,290	0,387
El Gamgoum	7 000	6,760	0,608
El Abid	2 500	8,40	0,756

Source : Ministère de l'agriculture (1999). (DT : Tunisian Dinar).

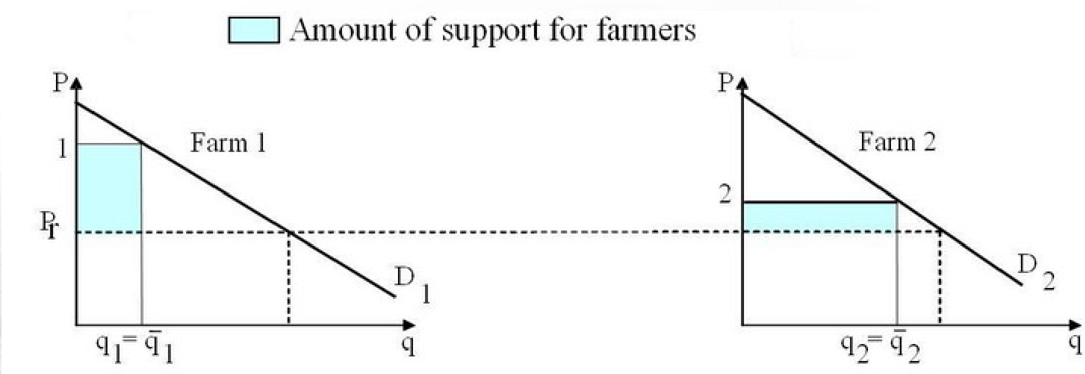

FIG. 1 – Price support and a quota system combined policy. (P_r : Price paid by farmers at present state, q_i : Water quota for the ith farm ; ρ_i : value of water (per cubic meter) at the ith farm)

The second period of water management has been marked by the development of the industrial and tourism sectors as competitors to the traditional water consuming sector ; i.e. agriculture in addition to increased demand for water in agriculture as a result of newly created areas and intensification efforts. The demand for water has increased substantially. Therefore, the new water policy has turned to the management and regulation of demand while continuing the effort of water mobilization. Further, following the economic adjustment policy adopted since late 1980s, subsidies were also revised to be gradually removed. Hence, a new pricing system were sought to find a compromise between the government seeking to cover investment costs, the service manager looking to adjust financial costs and the farmers whose objective remains to have water at lower costs. This deregulation policy was achieved by transferring water management from the state to the newly created farmers' associations in 1999, called locally "Groupements d'intérêt collectif" and referred to hereafter as GIC.

Both policies have maintained the same water access procedures notably the property right and water distribution criteria. Since 1975 the private governorship of water has changed to water use right instead. Moreover, water has been distributed according to land size regardless of crop choices. This has resulted in trials by farmers to improve water quantities either by exchange with neighbors or by surface water drilling. Such emerging water allocations reflected different water values among farmers exchanging water.

3 Implementation of a market for water : Methodology

3.1 Site selection and farm characterisation

To analyse the effects of a market for water an irrigated area called Melalasa in a central region of Tunisia (Kairouan) where a GIC has been active for few years was selected. This choice was also indicated by the existence of different water values as found from previous investigations as well as observed informal exchange of water among farmers. The area under study was developed in 1992. The GIC was established in 1994 according to the latest water management legislation. These farms are not similar in terms of endowments in primary factors (such as labor and water) as well as in cropping systems (irrigated vs rainfall) (table 2). Cropping system consists basically of cereals, vegetables and fruit trees mainly olive trees. Irrigated crops represent 48,6% % for farms type 4 and 77,1% for farms type 5 with an average of 60%.

Data were gathered through questionnaires administered to a selected sample of farmers belonging to the local GIC. Then, the sample was sorted into groups according to structural variables such as the farm size and production factors. This sorting process has resulted into five farm models or types.

Tab. 2 – Characteristics of farm models.

Farm type	Number	Farming system (ha)			Labor (day/year)	Current Water Consumption (m^3) (Quotas)
		Dry (ha)	Irrigated (ha)	Total (ha)		
Type 1	17	1,52	1,69	3,21	140	4375,900
Type 2	14	4,43	5,51	9,94	430	10633,800
Type 3	12	4,67	7,40	12,07	540	13810,200
Type 4	5	4,25	4,02	8,27	590	17767,500
Type 5	6	3,21	10,86	14,07	815	20285,000
Total GIC	54	184,41	279,93	464,34	22720	599533

3.2 Market structure and gains from exchange

3.2.1 Case of a competitive market structure

In this case, we assume that each farm belonging to the pre-selected farm models could participate in the market either by demanding or supplying water (assuming factor mobility). Such exchange would result into gains according to the market structure under consideration.

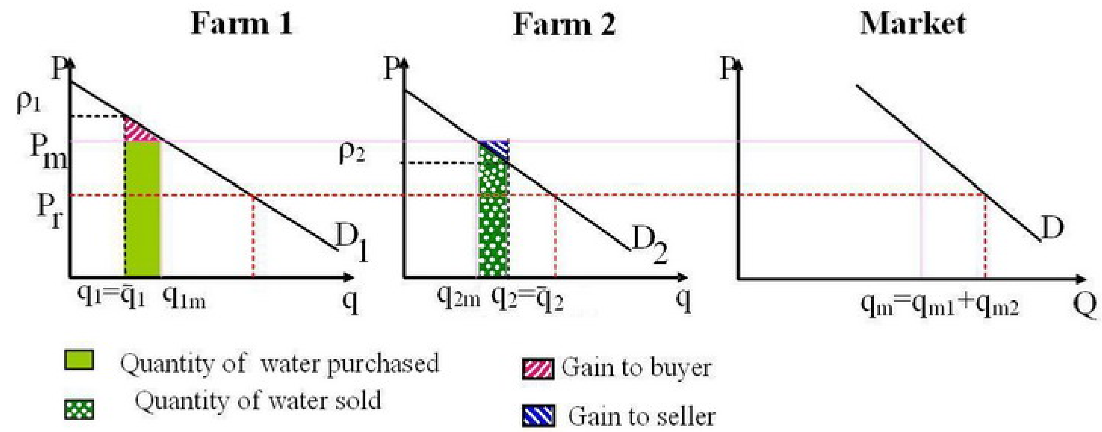

FIG. 2 – Exchange in competitive market.

Exchange in a market based on a pure competitive structure would result in gains as a result of the existence of a differential in the value of water (price) (figure 2). The value differential comes from either different initial endowments in productive factors (such as capital equipments) or different production techniques leading to higher productivity among farms. Distribution of gains (gain to buyer and gain to seller) are determined by the structure of demand curves D_1 and D_2 (demand elasticities) and the respective values of water ρ_1 and ρ_2.

3.2.2 Case of a monopolistic structure

In a monopolistic market structure (a situation where water is assumed to be fully detained by the GIC), producers would be worseoff as compared to the previous structure but water would have a higher value. In this case the quantity of water consumed (utilized) Qmo is derived from the GIC marginal cost of water (Cm) and it's marginal revenue (Rm) whereas the aggregate demand is derived from the first market structure[1]. This quantity is lower than that in the competitive market case.

These two market structures are used by establishing a baseline model which would be adjusted to reflect such structures.

3.3 Baseline model

To analyze these exchange possibilities taking into account the described market structures a mathematical programming approach was used. In a first stage a baseline

[1] The evaluation of the demand equation with respect to aggregate water endowments allow to derive different opportunity costs On the basis of these costs and quantities demanded it was possible to draw a global demand curve.

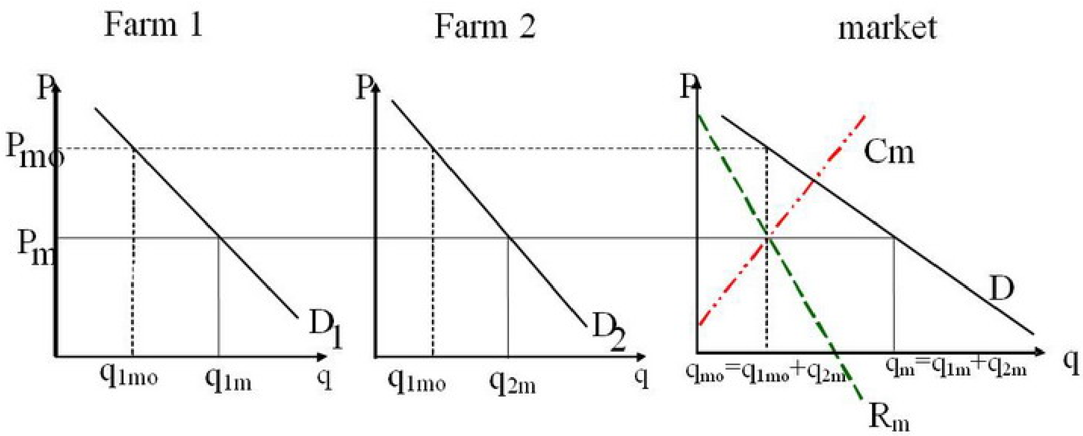

FIG. 3 – Exchange in monopolistic market.

model is specified to reflect the current functioning of the system. In a second stage we transformed the model to consider the two market structures.

The baseline situation was represented with a model which uses the positive mathematical programming (PMP) method with increasing production costs as suggested by Howitt (1995, 2000) and Gohin and Chantreuil (2000). The objective function assumes the maximization of total revenue which is evaluated as a weighted sum of the selected farm revenues :

$$MaxZ = \sum_{i}^{n} REV_i * nbr_i \tag{1}$$

Where :
- Z : total revenue ;
- REV_i : individual farm revenue ;
- i :1, ... n is the farm type (n=5) ;
- nbr_i : number of farms by group ;

The revenue of each farm i is defined by the gross margin :

$$REV_i = \sum_{i}^{m} X_{ij}\ rdt_{ij}\ P_j - \sum_{i}^{m} \alpha_j\ X_{ij} + \beta_j\ X_{ij}^2 \tag{2}$$

Where :
- j : 1, ..., m denote agricultural activities ;
- X_{ji} : the level of crop j at farm i ;
- rdt_{ji} : return of crop j at farm i ;
- P_j : price of crop j
- αj and βj : calibration parameters according to PMP method which are a nonlinear representation of the production costs. $\alpha_j\ X_{ji} + \beta_j\ X_{ji}^2$

The model constraints reflect the availability of productive factors. These constraints were presented in the model as follows :

$$\sum_{i}^{m} X_{ij} \leq Fland_i \tag{3}$$

$$\sum_{i}^{m} X_{ij}Clab_j \leq Flab_i \qquad (4)$$

$$\sum_{i}^{m} X_{ij}Cwater_j \leq Fwater_i \qquad (5)$$

$$\sum_{i}^{m} X_{ij}Cwater_j uswater_i \qquad (6)$$

Where :

- $Fland_i$: area of farm i ;
- $Flab_i$: quantity of family labo rat farm i ;
- $Fwater_i$: quantity of water available at farm i (water right or quota) ;
- $Clab_j$: stand for labour requirements ;
- $Cwater_j$: water requirements.

As such, equations 3 and 4 represent the land and labor constraints respectively, equation 5 is used to compute water consumption and equation 6 refers to the water availability (constraint). The area of olive trees is assumed to be fixed. This baseline structure will be used to analyse the two market structures namely the competitive market and the monopolistic markets.

4 Competitive market model

In this case it is assumed that exchange takes place among farm types in a perfectly competitive market.

In this market structure the constraint 6 is replaced by a constraint at the level of the GIC (zone under the GIC control) in which the demand is aggregated over all individual water demands. This is shown in the following equation :

$$\sum_{i}^{n} nbr_i * uswater_i \leq \sum_{i}^{n} nbr_i * Fwater_i \qquad (7)$$

The simulation of this situation is done following two procedures. The first procedure consists of transforming constraint 5-1 to reflect water balance for each farm as follows :

$$Uswater_i + Won_i = Fwater_i + Win_i \qquad (8)$$

$$\sum_{i}^{n} nbrE_i * uswater_i \leq \sum_{i}^{n} nbrE_i * Fwater_i \qquad (9)$$

With Won_i and Win_i refer to the sales and purchases of water at farm i respectively. The dual value of equation 9 is the equilibrium price of water.

The equilibrium price is the shadow price of equation 9. Quantities exchanged (Woni and Wini) are computed as the difference between water allocations in the base line and the new situation respectively.

4.1 Monopolistic market model

In the case of a monopolistic structure, the exchange of irrigation water is supposed to be administrated by the GIC as a single possessor of water. The monopolistic price is determined according to the equalization of marginal cost and marginal revenue. This case is in fact the full cost recovery scenario. This monopolist is facing the aggregate demand derived from the sum of all farm demands.

Compared to the base line model only the price Pwater has changed.

$$REV_i = \sum_j^m X_{ji} * rdt_{ji} * P_j - \sum_j^m \alpha_j * X_{ji} + \beta_j * X_j^2 \text{ - } uswater_i * P_{monopole} \tag{10}$$

The determination of water price elasticity was derived from the estimated demand function. To determine the quantities demanded (the dependent variable in the demand function) the model was run and simulated for different water endowments.

In the estimation we introduced a dummy variable to reflect the observed turning point of the demand curve at a quantity of 281781 m^3 .

$$Pi = a + bqi + \varepsilon_i \quad if \quad q_i \leq 281781 \quad m^3 \tag{11}$$

$$Pi = \alpha + \beta qi + \varepsilon i \quad if \quad q_i > 281781 \quad m^3 \tag{12}$$

Combining these models yields the following model to be estimated :

$$Pi = a + (\alpha - a)D_0 + bqi + (\beta - b)D_1 q_i + \varepsilon_i \tag{13}$$

where,

$$\begin{cases} D_0 = 0 \quad if \quad q_i \leq \quad 281781 \quad m^3 \\ D_0 = 1 \quad if \quad q_i > 281781 \quad m^3 \end{cases} \qquad \begin{cases} D_1 = 0 \quad if \quad q_i \leq 281781 \quad m^3 \\ D_1 = 1 \quad if \quad q_i > 281781 \quad m^3 \end{cases}$$

Results are presented in Table 3.

Tab. 3 – Estimation results of aggregate water demand curves.

Variables	Coefficient	t-test	Standard Error
Intercept	0,28	4,50	0,10
D_0	0,49	- 3,79	- 0,41 10^{-6}
$D_1 q$	- 0,15 10^{-5}	- 7,23	- 0,20 10-7
Q	- 0,15 10^{-6}	-21,16	- 0,13$10^{-1}$
R^2 adjusted	0,97		
Number of observations	12		

A quadratic cost function is also estimated for the period of time running from 1998 to 2003 using data avaiblable at the GIC level (table 4). We also used a dummy variable as follows :

$$CT_t = a + (\alpha - a)D_0 + bq_t + cq_t^2 \tag{14}$$

where,

$$\begin{cases} D_0 = 0 \;\; if \;\; q_t \leq 270396 \;\; m^3 \\ D_0 = 1 \;\; if \;\; q_t > 270396 \;\; m^3 \end{cases}$$

TAB. 4 – Estimation of the GIC cost function.

Variables	Coefficient	t-test	Standard Error
Intercept	- 69376	- 64,49	1076
D_0	30052	69,70	431,1
q	0,2096	41,17	0,5091 10^{-2}
q_2	- 0,7535 10^{-7}	- 10,96	0,6874 10^{-8}
R^2 adjusted	0,99		
Number of observations	12		

5 Empirical results

The following analysis concerns the two market structures as applied to the selected typical farms in the study zone. Effects of such models are analyzed in terms of changes in cropping systems as well the revenues. Changes in farmers' revenues are used as an efficiency indicator.

All changes are computed based on the baseline situation which should be regenerated by the model and consistent with the observed situation.

5.1 Baseline situation

The PMP method was crucial to obtain results as close as possible of the real observed situation (table 5).

Construction of demand curves Using these results as starting values the model was then used to investigate various changes as a result of an increase in water price. Individual and aggregate demand curves for irrigation water were derived by varying water price in the model.

The differences shown in Figure **??** are due to the heterogeneity of production systems and characteristics of farms. It is also shown that the aggregate demand is relatively price elastic, whereas at the individual level the demand is less elastic. In particular farm type 1 has a rather inelastic demand. Another important result is the fact that price elasticity depend on the range of price. This is particularly visible in the case of farm-type 4 demand and the aggregate demand curve. This finding was equally shown in other empirical studies (Gomez-Limon and Riesgo, 2002[7] ; De Fraiture and Perry, 2002).

5.2 The impact of market structure

Giving the baseline situation we intend in what follows to analyze the impacts of two hypothetical water-market structures.

TAB. 5 –

Activities	E1	E2	E3	E4	E5	Total GIC
Cropping system (ha)						
- Blé dur en sec	0,67	1,61	1,45	1,35	0,71	62
- Blé dur en irrigué	1,41	2,86	5,13	3,08	4,10	166
- Fève	0,21	0,27	0,31	0,77	0,00	15
- Pastèque et melon	0,21	0,27	0,31	0,77	0,50	18
- Olivier en sec	0,28	1,89	2,57	2,52	1,17	82
- Olivier en irrigué	0,45	0,54	0,68	0,78	4,41	54
Rainfall (ha)	0,94	3,50	4,02	3,87	1,87	144
Irrigated (ha)	2,27	3,94	6,43	5,39	9,01	252
Water consumption (m^3)*	4 376	10 634	13 810	17 768	20 285	599 533
Revenue before payment of water (DT**)	3 547	7 868	7 681	8 644	8 997	359 825
Water opportunity cost (DT/ m^3)	0,231	0,212	0,222	0,143	0,361	0,212

(*) : Water consumptions represent farms' endowments which could be exchanged.
(**) DT :Tunisian dinar.

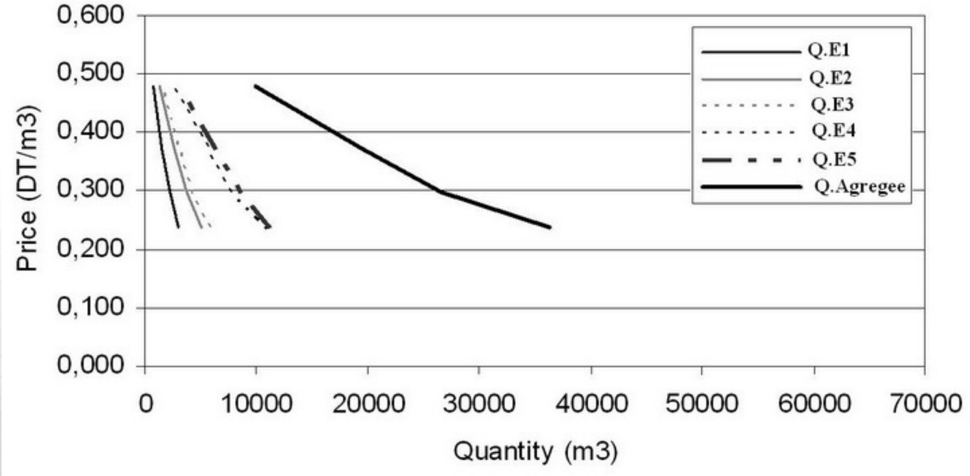

FIG. 4 – Water demand curves for the different farm types.

5.2.1 Case of monopoly

Using the results in table 3 and equating marginal revenue to marginal cost, the monopoly price corresponding to a demand elasticity of –1,12 is equal to 0,481 DT/m^3. Compared to the actual price this monopoly price is clearly higher, which is as expected. Simulations of the effects of a market allocation in the presence of a monopoly are shown in table 6. These effects are presented as variations with regards to the base situations of areas and crops cultivated.

TAB. 6 – Variation of land use and water consumption.

Activities	E1	E2	E3	E4	E5	Total (GIC)
Cropping system						
- Blé dur en sec	342	100	100	100	100	144
- Blé dur en irrigué	0	0	0	0	0	0
- Fève	9	81	0	0	0	23
- Pastèque et melon	92	90	94	88	77	89
- Olivier en sec	199	128	118	131	111	127
- Olivier en irrigué	39	0	31	0	97	58
Rainfall area	300	115	112	120	107	135
Irrigated area	17	12	8	13	52	20
Water consumption	33	20	13	15	61	27
Revenue before payment of water	58	64	52	55	1	49

Unit : base line situation equal 100.

Results show that variations occur at two levels ; the crops grown as well as farmer revenue. In general, the immediate impact of a higher water price is a shift in the cropping system towards non-irrigated crops, lower water demand and a negative effect on revenues (see farm 3, 4, and 5). Such a decline in the revenue could be interpreted as the social cost attributed to a monopolistic market structure. On the other hand, the GIC revenue from water sales has increased.

5.2.2 Case of a competitive market

As an alternative to the monopolistic structure, we have assumed a market where transfers of water take place between farmers in a competitive manner. Results of such a new situation are shown is table 7.

Compared to the base situation it appears that farmers, depending on the value of water which they could reach, adopt two strategies. In fact, farmers, with low values of water and belonging to type 2 have decreased irrigated area and water use whereas the others, with the highest values have had the opposite attitude. Results in table 6 confirm that the first category of farmers gave up part of their water (rights) to the second category. This transfer followed the simple rule that the opportunity cost of water for type 2 farmers is lower to the equilibrium price set up at the established market. This finding confirms also that the market is a medium to transfer water from less productive farms to the more productive ones.

The overall result is an increase of the revenue at the GIC level by 14%. On the contrary, the distribution of total revenues taking into account sales of water has improved with the establishment of the water market. This overall improvement results from the fact that the higher valorization of water is now being shared among a higher number of farmers. Compared to the case of monopoly, the competitive market structure has induced a higher utilization of water and therefore higher revenues for farmers.

Tab. 7 – Variation in land use and water consumption- case of a competitive market unit : base line situation equal 10

Activities	E1	E2	E3	E4	E5	Total GIC
Cropping system						
- Blé dur en sec	0	100	98	100	9	75
- Blé dur en irrigué	147	60	132	0	191	113
- Fève	100	100	102	54	0	89
- Pastèque et melon	100	100	100	98	120	103
- Olivier en sec	92	100	99	108	86	99
- Olivier en irrigué	105	100	103	74	104	101
Rainfall cropping acreage	27	100	99	105	57	89
Irrigated cropping acreage	130	71	126	32	144	109
Water consumption	124	73	124	31	136	100
Revenue before payment of water	107	92	110	79	128	103

6 Decomposition of water market effects

Referreing to figures 1 and 2 above the effect of exchange is decomposed into three effects ; revenue effect, support effect and a cost recovery effect. These effects are presented below with the different scenarios (no exchange, exchange in a competitive market and exchange in a monopolistic market) (table 8 and 9).

Tab. 8 – Revenue effects.

	Water price	Net revenue (water charges are not considered)						Aggregate Revenue (GIC) in TD
		Formula	E1	E2	E3	E4	E5	
No exchange	P_r	$R(E) - P_r * Q_{water-quota}$	3240	7124	6714	7400	7577	317858
With exchange	P_r	$R'(E) - (P_r\ Q_{water-quota})$ $+P_m\ (Q_{water-quota} - Q_{market})$	3260	7125	6746	8197	8527	328270
	P_m	$R'(E) - P_m\ Q_{market}$	2638	5615	4785	5674	5646	243137
Monopoly	P_{mon}	$R"(E)$	2073	4999	3981	4742	129	177490

P_r : current price in TD/m^3
P_m : competitive market price in TD/m^3
P_{mon} : monopoly price in TD/m^3
$R(E)$: initial revenue before payment of water for farm E
$R'(E)$: farm revenue before payment of water in the case of exchange
$R"(E)$: farm revenue in the case of monopoly

Finally, the improvement in cost recovery is depicted as follows :

CR_1 : cost recovery without market :

$$= (\text{quantity of water sold * current price / cost}) = (Q_{quota}\ P_r)/cost)$$

CR_2 : cost recovery in a market situation :

$$= (\text{quantity of water sold * market price / cost}) = (Q_{quota}\ P_m)/cost)$$

Given the same quantity of water being sold in both cases so the costs are identical. The

TAB. 9 – Public Support effects.

	Price of water	Public support via water pricing (in TD)						
		Formula	E1	E2	E3	E4	E5	GIC
No market	P_r	$Q_{quota(E)} * (P_{dual(E)} - P_r)$	705	1510	2099	1297	5903	100209
With a competitive market	P_r	$Q_{quota(E)} * (P_m - P_r)$	621	1510	1961	2523	2880	85134
	P_m	$Q_{quota(E)} * (P_m - P_m)$	0	0	0	0	0	0
monopoly	P_{mon}	$Q_{monopoly(E)} * (P_m - P_{mon})$	- 386	- 569	- 487	- 726	- 3333	- 43992

Note : $Dual(E)$: refers to shaddow price which represents the real value of water.
It also indicates the willingness to pay for water.

improvement in cost recovery is then given by $(P_m - P_r)/P_r * 100$ which yields a rate of 203% as compared to the baseline situation. In the case of the monopoly the quantitites of water are different and so are the costs. In such a case it is difficult to determine the rate of cost recovery.

7 Conclusions

Despite the rapid evolution of hydraulic policies over the last two decades, water distribution rules at public irrigated areas (almost 43% of total irrigated area) have remained independent of actual uses and ignored potential interactions that could take place among farmers. Given this situation, differential valorization potential are being noticed and have resulted in some water exchange initiatives though poorly organized among farmers.

The paper attempts to simulate the observed market arrangements into a formal water rights market. To this end two structures have been considered ; the first is one of a competitive market. Farmers are free to exchange water according to their initial potential water values. Trade will result in improvement of the productive efficiency of water and therefore higher overall revenue of farmers.

The second structure is one where the GIC plays the role of a monopolist. It is suggested that the GIC would possess all water resources. The market mechanism is this case has led to decreasing water consumption by increasing productive efficiency. Farmers' revenues however have decreased as compared to the initial allocation as well as to the competitive market case.

These simulation assumes that such a market is feasible ; i.e. that exchange is possible and that farmers could organize without higher transactions costs. Farmers with lower performance (value of water) are supposed to sell their water rights to those with higher performance. Such exchange is not always possible and could be induced if an appropriate system whereby an optimum water revenue tax was established to encourage optimal use of water.

Assuming the GIC as a monopolist raises two difficulties. The first has to do with the current status of the GIC which is conceived as a farmers' association having no monopolistic behavior. The second more fundamental problem is the free access to surface water and the possibility to have water by drilling wells. Such a possibility would exclude the potential for a monopolistic structure. The appropriate market structure to describe such a situation becomes one of stackelberg type. In this case small farmers would compete with a bigger water producer such as a newly created organism to manage water from drills and dams. Finally, in this paper water needs by crops were assumed constant. We can consider variations of these needs and examine yield changes to different water quantities using a bio-physical model.

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