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Water Management and Water Price Analysis in an Irrigation System Managed by a Water Users' Association

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Introduction

Irrigation in Tunisia is a very old practice but it mostly developed after the independency of the country. So, since the '60s, the State fostered irrigated agriculture and set up numerous projects for the development and use of water in agriculture. All over the country, irrigated schemes have been implemented.

At the dawn of the 21st century, the Government was mainly involved in seeking sustainable balance between water supply and demand. Demand management is, in practice, manly aimed at water saving, hand-over of responsibilities of operation and management to farmers' association and of the establishment of a water price policy allowing a better demand control though ensuring an efficient production system.

The first part of this paper refers to the analysis of the hydraulic operation and water management in an irrigated scheme managed by a water users' association (WUA) in Tunisia.

In the second part, an analysis is made of the water price adopted in the scheme, with the existing hydraulic system, and of its impact on farms. Based on field surveys, a comparison was made between the cost of water as one item of the expenditures paid by the water users' associations and its price of sale, as well as the water charges in the expenditures of the farmer, according to the speculation.

The case study refers to the WUA of "bir Ben Kemla", situated in the area of Sahel in Tunisia. It covers an area of 124 hectares suitable for tree

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and vegetable crops and includes 76 farmers. The scheme was set up in 1970 and was managed by the government up to 1994, when responsibilities were handed over water users' association.

1- Performance and constraints of the hydraulic management

The water of the irrigated scheme is withdrawn from a well situated in the same scheme and discharging 501 l/s. Water analyses show a TDS value higher than 3 g/l. Due to bad leaching and to soil salinity hazard, the available irrigation water requires some cautions in use and monitoring of possible detrimental effects.

1.1.The hydraulic network

Water is pumped from a well and conveyed to a divider situated upstream of the scheme that divides the discharge into two sectors, so as to ensure a pressure of at least 3 m at the upstream end of the field. Farms are being fully equipped with concrete storage basins of a capacity of 40 to 100 m^3. The network was evaluated on the basis of several criteria:

- The water losses it originates
- The adequacy of its pipes to the operation requirements of the network
- Meeting water demand at each hydrant, in terms of pressure and discharge for some farms still lacking storage basins, and in terms of volume for most of the farms equipped with basins.

The financial balance sheet of the association reports the pumped water volumes (measured through a water meter at the outlet of the pumping station) and the water volumes sold. Since hydrants supply water to the basins in most of the farms, the volumes sold by the association coincide quite well with the amounts of water supplied to all the hydrants. So, the inflow and outflow of the network as well as global losses also corresponding to a loss of profit for the association are known.

Table.1. Global water losses in the network

Year	**1998**	**1999**	**2000**
Pumped volume	280732	249659	316956
Sold volume	273633	244470	311969
Global losses or loss of profit	2.53%	2.08%	1.57%

The assessment of global water losses shows that efficiency is good. Nevertheless, a more precise evaluation of losses would have been possible if partial losses of the different reaches of the network had been measured. This would have allowed to have better knowledge on the conditions of each reach and to separate between possible losses of profit and real losses in the amount of water.

1. Water management by the water users' association

The irrigation network operates on rotational delivery and an irrigation interval is imposed at each hydrant depending on the served area. However, at present, and following on the construction of individual basins at the inlet of the farms, several advantages are possible and allow to improve hydraulic management:

- Flexibility in rotational delivery: basins are filled one after the other but farmers are handle their volumes, as they like best. The water management mode has moved from the availability of a service (discharge, pressure, time) to a service of volume.
- Water volumes used are known quite precisely, differently from a rotational basis delivery. Better control in water volume inevitably resulted in notable water saving.
- By knowing volumes, it is easier to settle the conflicts that usually occur between the farmers and the irrigation agency. The responsibility of a failing service is precisely detected and localised. The water volume withdrawn from the well and the volume required to fill the basin are known. It is then possible for the farmer to know how much he pays for the volume available in the basin, at the inlet of his farm and how much this is billed, according to the water losses between the well and his individual basin. This is cost accounting of the water service, from its source to the user. The farmer knows how much is his contribution to the total invoice that association fixes according to the effective supplies of water at the farmer field and the losses in the distribution.
- The management of water volumes through individual basins exerts a strong psychological impact in terms of re-appropriation of water by farmers.
- Similarly, the hydraulic system at the field level has improved, by adopting localised irrigation, though attending to the sustainability of the system (follow-up and monitoring of soil salinization). These techniques are mainly aimed at better water saving and alleviation of work, through automation of irrigation and fertilization practices.

3. Cropping systems

The following table reports the areas grown for each crop and the cropping changes over the last 4 campaigns (until early 2001):

Table 2. Dry farming crops

Campaign	Tree crops (Ha)	Dry field crops (Ha)	Dry oat (Ha)
1997/1998	24	18	21.5
1998/1999	24	22	22
1999/2000	24	30	22.25
2000/2001	24	0	0

Table 3. Irrigated crops

Campaign	Winter fodder (Ha)	Summer fodder (Ha)	Winter vegetables (Ha)	Vegetables (Ha)
1997/1998	5.5.	1.25	55.4	13
1998/1999	4.5	3	54	16
1999/2000	5.5	4.5	71.1	38.25
2000/2001	12.75	3.25	56.42	46.25

Dry farming crops (tree crops and field crops) are stable. The total average surface is about 67 hectares. These are not the privileged crops but they respond to a long tradition in the region, especially for olive growing. As for cereals, their importance is due to the need of having rotation and a dry crop on part of the land, because of salinity of the irrigation water and its effects. The drop in the cereal grown surface during the campaign 2000-2001 is due to severe drought that interrupted plant development.

However, under normal conditions, winter crops are more developed than summer crops. The preference of winter vegetables is justified in that the cultivated area includes late season crops, early crops under greenhouse and winter crops. This behaviour expresses a way to benefit from autumn and winter rainfall, thus reducing the use of irrigation water. Moreover, off-season crops are economically attractive in that they are better marketed and at a higher price because they are placed on the market global supply is low.

4. Indicators of the evolution of the irrigated scheme

4.1. *Cultivated land ratio*: it is the ratio of the cultivated area (dry and irrigated) to the total surface. It translates the development stage of the scheme and the dynamic behaviour of farmers. Table 4 shows that the land use ratio reaches 100% in 1998/99, i.e. the scheme has reached its full development. The drop recorded in 2000/2001 is due to a standstill in the vegetable grown areas and to the decline in field crops in dry year.

4.2. *Irrigation ratio*: it corresponds to the ratio of the surface grown with irrigated crops to the total surface. This rate indicates the portion of the scheme that is actually grown with irrigated crops. At the time of the study, the use ratio is expected to be 100%. This value is still low since irrigation is practiced only on half the area supplied with irrigation facilities (see tab. 4). This rate highlights a strong structural constraint since it remains unchanged over time. The reason is to be found in the high salt content of irrigation water, that imposes to practice crop rotation, whereby the surface irrigated for one year is left without irrigation the year after to allow salt leaching by rainfall.

4.3. *Cropping intensity*: it considers all the irrigated crops, and expresses the response capacity of the farmers, of the cropping pattern and the irrigation scheduling, to market requirements. The cropping intensity has reached a value as high as 173% during the campaign 1999-2000.

Campaign	Cultivated land ratio	Irrigation ratio	Cropping intensity
1997/1998	97.2	45.9	131.8
1998/1999	100	45.9	135.9
1999/2000	100	50.7	172.9
2000/2001	89.5	56.5	136.4

5. Analysis of water price fixation

To make a real analysis of water price at the water users' association level, the activity balance sheet of the years 1998, 1999 and 2000 are available.

5.1. Present cost of water, by balancing expenditures and revenues: in order to balance its budget, the association calculates the present cost of water. This implies that the revenues resulting from the sale of water have to be equal to total expenditures to be paid by the manager of the association and, consequently, by the farmer. The analysis of the farmers' technical performance has shown some heterogeneity in the investigated sample and, by that, the global interest of the association doesn't necessarily coincide with the interests of individual farmers. The expenditures presently paid by the water users' association are grouped into 5 items. Their real values their weight in total expenditures are reported in Table 5:

Table 5. Expenditures per budget item (1 Dt = 0.7 US$)

Expenditures	**1998 Dt**	**% Total**	**1999 Dt**	**% Total**	**2000 Dt**	**% Total**
Energy	3777	22	672	21	3745	11.9
Maintenance	2170	13	4959	26	827	2.6
Labour	4998	30	5952	31	5960	18.9
Operation of the WUA	301	2	365	2	117	0.4
Unforeseen events	5633	33	3800	20	20828	66.2

From the balanced budget of expenditures and revenues resulting from the sale of water, the cost of 1 m^3 of water is drawn as shown in Table 6.

Table 6. Balanced budget (1 Dt = 0.7 US$)

Year	**1998**	**1999**	**2000**
Total expenditures (Dt)	16879	19147	31476
Volume of water sold	273633	244470	311969
Cost of 1 m^3 of water (10^{-3} Dt)	62	78	101

- The analysis of the balance sheets presented in tables 5 and 6 shows that:
- Except the year 2000, when the delivery pipe broke in the month of July and made the budget item “miscellaneous” to jump to 66% of total expenditures, it is observed that the heaviest item (30% of total expenditures) is the remuneration of labour employed by the association, i.e. the ditch-rider and night watchman. These expenditures are not related specifically to the operation of the network and are thus fixed.

- The energy for the pumping station represents about 20% of total expenditures, except for the year 2000 where water delivery was not continuous.
- Maintenance and repair expenditures for the whole set of equipment and pipes are variable and range from 12 to 25% of total expenditures. Apparently, they are not related to the operation of the network for the current year, since the volume sold that reflects the water demand in the network is less important in 1999 than in 1998, due to higher maintenance expenditures.
- Maintenance expenditures represent yearly regular expenditures, estimated for each piece of equipment (well, network), as a percentage of the price of the latter. On the contrary, repair expenditures due to wear and the break of equipment, which is not a frequent occurrence, but occur occasionally and at random, cause some variability between years. This remark applies to miscellaneous expenditures, that cover any accident at the farm level and that vary from 20% to 66% per cent of the total expenditures of the year.

However, these expenditures cover the operation of the hydraulic network and the operation of the water users' association, but not the expenses for the amortisation of equipment and the estimates for future works. These important expenditures are presently paid by the government, but making the farmers aware of their responsibility and disengaging the State should lead, in future, to full financial autonomy of the association.

5.2. Comparison between the cost of water and its price of sale

The analysis of the users' association budget shows a large difference between the cost of water, drawn from the balance between expenditures and revenues and the intentional price of sale applied by the association (see table 7) and recommended by the government:

Table 7. Comparison between the cost of water and its price of sale

Year	1998	1999	2000
Cost of 1 m^3 of water according to the expenditure/income balance 10^{-3} Dt	62	78	101
Price of sale of 1 m^3 of water (10^{-3} Dt)	104	125	125

The benefits gained by the water users' association through the sale of water, are included as funds for future works, although the government still pays for a part of them. The amortisation cost of investments represents most of the expenditures of large works. Because of that, the budget period recommended to the water users' association confirms the willingness of the government to provide a financial facility, in order to transfer the whole responsibilities of operation and management of the irrigation development system as soon as possible.

If we assume a near future scenario where all the expenditures will be paid by the water users' association, the price of sale of water allowing to balance expenditures and revenues is 0.121 Dt/m^3. The price of water the government recommends to the association (0.125 DT/m^3 in 2001) anticipates the price at which water should be sold to recover expenditures once the water users' association will be self-funded.

This is a judicious and clever strategy of the government, in the sense that it uses its authority to recommend this price of sale to the association. It thus gives the latter a sharp difference in water price once it will become autonomous and that would supposedly be unfavourably accepted though justified.

To be noticed that in the financial year 2001, the water charges in the farmer's expenditures are estimated, on average, to be equal to 7% of operational charges (varying from 3 to 5% for pepper and 20% for tomato).

Despite the increase in the price of water, there has been the parallel introduction of localised irrigation techniques, a better irrigation scheduling and higher water saving in the applied volumes. On the other hand, a preferential water price had been envisaged to boost water saving and to use winter waters, which is accomplished through market that favours early crops.

Meanwhile, the beneficiary water users' association uses its reserves to propose new services to its members, by helping them to modernise operation and equip themselves with localised irrigation networks (no-interest credits). This financial facility to the water users' association allows it to be flexible in terms of expenditure recovery and make the farmers to postpone the payment of their water use charges upon harvesting and at a later period when the sum of money will be available.

Conclusions

The progressive hand-over of operation and management of water and of the hydraulic network to water users' associations, is partly analysed through the hydraulic performance of irrigated schemes, the evolution indicators of the latter and the budget analysis of the association and of the cost of water. This case study and the surveys referred to the water users' association of Bir Ben Kemla (Mahdia) in Tunisia.

It seems that the transition to water volume management instead of discharge-based rotational delivery through installing individual basins at the upstream end of the farm, has improved the system management (settlement of conflicts, metering the volumes delivered) and has given the farmer more freedom in management and a feeling of re-appropriation of water. By that, the indicators of cultivated area ratio, irrigation ratio and cropping intensity have increased and indicate a better control of the irrigation development system.

The water price and budget analysis has shown that the cost of water that balances expenditures and revenues, without including amortisation and large maintenance works, is of the order of 0.101 Dt for the year of low sale of water and of 0.062 Dt for the years of high sale of water.

Supposing to estimate water requirements and the volumes that could be sold - and if amortization and frequent maintenance are considered - the cost of one cubic meter of water balances the revenues and expenditures and leaves no funds to the association, and that doesn't consider the huge repair works, is of the order of 0.121 Dt. Water is sold at present at 0.125 Dt per cubic meter. This advance of the price of water gives the water users' association a financial facility with the support of the government that contributes to huge repair works. It also allows, in the near future, to prevent a sharp difference in water price once the water users' association becomes fully self-funded.

Still, a more detailed analysis on the sustainability of the water users' association system is required, taking into account the components of amortisation and huge maintenance works, the impact of the latter on the operation of the association and on its budget and, by that, on the income of the farmer.

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