Lessons learned from the Tunisian national water policy: the case of the rehabilitation of oases

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Lessons learned from the Tunisian national water policy: the case of the rehabilitation of oases

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Abstract. Tunisia, as a Mediterranean country, has an irregular climate. The country often suffers from local or general dry periods. To cope with this context of water shortage, Tunisia has adopted a rigorous water policy. This policy has lead to the development of the valuable hydraulic infrastructure in Tunisia today. The irrigated area evolved from 143,000 ha in 1976, to currently nearly 400,000 ha. To strengthen the performance of water policy across the country, three strategic water management plans (North, Centre and South) were instituted. Taking into consideration the diversity of water resources and the regional climatic and socio-economic conditions, complex irrigation schemes were built. In the south of the country, the rehabilitation of oases has been a major part of the national water policy. The strategic water management plan for the South (1979) was the prelude to successive projects. Challenging tasks to improve irrigation efficiency have been undertaken. Thanks to the development in techniques for drilling groundwater wells, the landscape of these irrigated areas has totally changed. In this paper, we discuss the relevant lessons learned from the Tunisian water policy. The case of the rehabilitation of oases in southern Tunisia is elaborated in more detail.

Keywords: Water – Policy – Irrigation – Oases – Efficiency.

Leçons tirées de la politique nationale de l'eau en Tunisie : le cas de la réhabilitation des oasis

Résumé - *Étant un pays méditerranéen, la Tunisie a un climat très varié. Le pays est souvent soumis à des périodes de sécheresse qui peuvent être locales ou générales. Pour faire face à ce contexte de pénurie d'eau, la Tunisie a adopté une politique rigoureuse concernant l'eau. A présent, cette politique a permis à la Tunisie de développer une imposante infrastructure hydraulique et d'accroître la superficie irriguée. Cette dernière est passée de 143 000 ha en 1976 à quelque 400 000 ha à présent. Afin de renforcer la performance de la politique de l'eau dans tout le pays, trois plans stratégiques de la gestion des eaux ont été établis pour le Nord, le Centre et le Sud du pays. Des schémas complexes des réseaux d'irrigation ont été mis au point, prenant en compte la diversité des ressources en eau et les conditions climatiques et socioéconomiques régionales. Dans le sud tunisien, la réhabilitation des oasis s'inscrit dans le cadre de la politique nationale de l'eau. Le plan stratégique de la gestion des eaux du sud (1979) a précédé de nombreux projets successifs, réalisés pour améliorer l'efficacité de l'irrigation. Grâce au développement des techniques de forage de puits pour le captage des eaux souterraines, le paysage de ces zones irriguées a totalement changé. Dans cet article, nous exposons les leçons tirées de la politique nationale de l'eau en Tunisie. Le cas de la réhabilitation des oasis du sud tunisien est plus détaillé.*

Mots clés: *Eau – Politique – Irrigation – Oasis – Efficience.*

I – Introduction

After half a century of water resources development, several lessons can be learned from the Tunisian national experience in managing water resources. For many decades, Tunisia has had a national water policy that defines the outline of water resources management. Despite the country's limited water resources, the accurate assessment of available water resources allowed Tunisia to satisfy the demand, without having to ration water even during periods of acute drought. This strategy was extended towards improved water demand management (Horchani, 2007). Indeed, the water saving plan aims to decrease the demand by 30% for all sectors. Major efforts are required in the irrigated sector.

Several reforms focused on the improvement of distribution efficiency. Moreover, significant financial incentives were directed at accelerating the introduction of water saving equipment (Hamdane, 2008). The many projects that concerned the irrigated areas, which were components of the water policy, induced a tremendous improvement of the development of the irrigated sector in oases in southern Tunisia.

This paper concerns the development of irrigation within the framework of the national water policy. The rehabilitation of oases in southern Tunisia is discussed as a case study. In the context of aridity and acute water shortage, the viability of agriculture in this region largely depends on the implemented strategies for rational management of groundwater resources.

II – Irrigation development : a key instrument of water policy

The irrigated sector in Tunisia has shown an accelerated development through the successive decades of water resources development. From nearly 143,000 ha in 1976, the irrigated area evolved to 380,000 ha in 2001. Furthermore, the hydraulic infrastructure target of 400,000 ha is expected to be achieved in 2010, when the planned surface water system will be fully operational (Hamdane, 2008).

More than 226,000 ha are irrigation systems under public management. The private systems, created around shallow wells, cover 175,000 ha. About 52% of the irrigated area is located in the northern part of the country, 31 % in the centre and 17% in the south (Fig.1). More than 40% of the irrigated area is used for fruit trees (40%), about 36% for vegetable (21% tomatoes and 15% potatoes) production. The cereal cultivation extends to over 14% of the irrigated area, while the feed crops cover 10%.

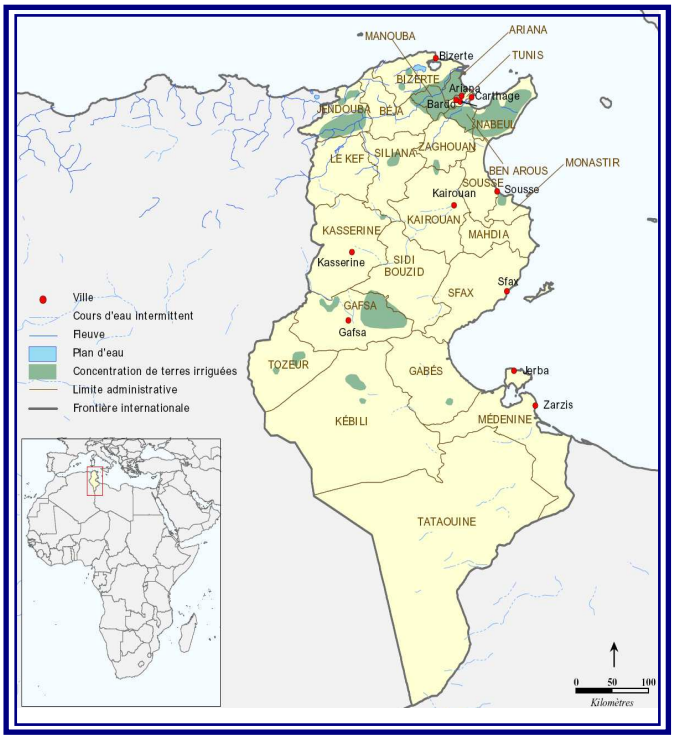

Figure 1: Location of the irrigated perimeters in Tunisia *(Aquastat, 2005).*

The contribution of the irrigated sector to the total value of agricultural production ranges between 30 and 35%. It contributes also 95% of vegetable production, 77.5% of fruit production, 30% of dairy products and 25% of national cereal yields. The irrigated sector also contributes 20% of the agricultural export value and employs about 26% of working forces (Al Atiri, 2007). Moreover, during the 11th national plan of social and economic development (2007-2011), the contribution of the irrigated sector is expected to reach 50% of the total agricultural production value.

The major Tunisian irrigation systems are collectives and have a regulated water service. They are managed by the public administration. About 62% of the irrigated area under public administration is supplied by water from dams, while 38% are irrigated from deep groundwater wells and treated waste water.

Listed by the nature of the water source, the irrigated perimeters under public administration consist of 142,000 ha irrigated from dams, 47,000 ha (only intensive) from groundwater abstractions, 30,000 ha are oases irrigated by deep groundwater abstractions and 8,000 ha from treated waste water. The private perimeters are supplied from shallow wells made by farmers (Al Atiri, 2007).

The Tunisian experience in developing the irrigated sector began after establishing the strategic water management plan in 1979. The irrigated perimeters were organized in three regions and a respective strategic water management plan was developed for the North, the Centre and the South.

This approach targeted more equity and efficiency in water management. An important strategy that was implemented was the promotion of rational water use. The approach emphasized the need to further involve farmers in water management. The principle of participatory management was often included in the projects concerning irrigation infrastructure rehabilitation.

III – The water strategy for southern Tunisia

The development of the oases in southern Tunisia is an important component of the development of the irrigated sector in Tunisia. These particular ecosystems constitute an intensively cultivated area, with three layers of cultivation (palm trees, fruit trees and vegetables). Palm tree production remains the main use of the irrigated area; it has the highest added value in the export sector while the two lower layers of cultivation are progressively disappearing. Water management in the oases faces several constraints: technical as well as related to farmers' behaviour. The water policy in those areas has a vital interest: it aims to maintain the balance between the available water resources and the development needs. There are three main aquifers that are supplying the oases in southern Tunisia: (i) Continental intercalary (CI); (ii) Complex Terminal (CT); and (iii) the Jeffara aquifer (Fig.2).

Because of their important reserves, the CI and CT aquifers that form the SASS (Système d'Aquifères du Sahara Septentrional or in English: North-Western Sahara Aquifer System) are the key resources for the development of the irrigated sector in these regions. In Tunisia, these reservoirs extend to over 80,000 km2 and are being exploited by more than 1,200 drilled wells (OSS, 2009a). The depth of the CT aquifer ranges between 30 and 500 m while the dept of the CI varies from 60 to 2,800 m. The CI remains the most important water reserve. It is, however, a non-renewable water resource. This aquifer is characterized by relatively hot water (30–75°C) at depths reaching 2,800 m. These geothermal water resources are located in a 600,000 km2 large reservoir, which covers the regions of Kebili, Tozeur, Gabes and the extreme south, and extends to Algeria and Libya. The CI aquifer is one of the largest confined aquifers in the world, comparable in scale to the great artesian basin of Australia. The principal areas of recharge are in the South Atlas mountains of Algeria and Tunisia, and the Dahar mountains of Tunisia (Edmunds *et al*., 1995). The mean salinity of both aquifers, varies between 2,5 to 5 g/l (Prinz and Loeper,

2008). The shared intensive use of these water resources from Tunisia, Algeria and Libya is now closely supervised in order to decrease their overexploitation across the three Maghreb countries.

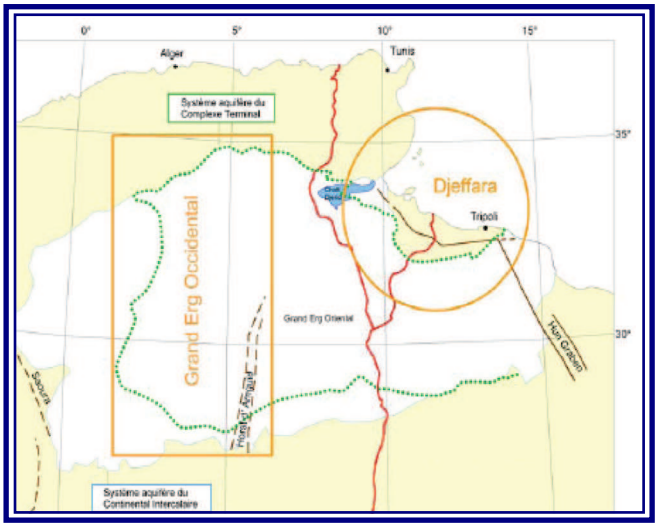

Figure 2: Location of the three main underground water resources in the Southern Tunisia *(Adapted from Schmidt et al., 2006).*

1. The rehabilitation of oases

Since 1972, Tunisia has undertaken an accurate assessment of the available underground water resources. To address the water needs of the expanding oases, the government instituted the strategic water management plan (1976) that defined criteria for natural resources exploitation. This plan aimed to address the growing social and economic needs. The main components are: (i) supplying drinking water, (ii) protecting the old oases that have survived in a context of acute water shortage (more than 129 oases on over 20,000 ha) and (iii) to satisfy the tourist sector, mainly in Gabes, Djerba and Jarjis (Seddik, 2009). The main interventions within the framework of the national water strategy were aimed at achieving agricultural development goals, following an integrated approach. The first step was water resources development. Across the whole southern country, considerable effort was made to rehabilitate hydraulic infrastructure. Deep abstractions were staged in order to increase the irrigated surface. Relevant irrigation and drainage networks were built. Furthermore, the implementation of storage reservoirs contributed to optimize water management, particularly during dry periods. The irrigated area extended through the creation of new oases in the regions of Djerid and Nefzaoua (3,500 ha).

The Tunisian government also promoted the development of irrigation in the oases by encouraging the intensification within farmer parcels. The common date palm varieties were progressively replaced by plantations with higher added value (e.g. *Deglet Nour* variety).

In order to optimize the water management in the southern oases, four specific water management plans were instituted in 1995 for the governorates of *Gabes*, *Gafsa*, *Kebili* and *Tozeur*. These plans aimed to reduce the water allocation shortage. In Kebili, 15 deep wells (up to 2,600 m) were drilled for the exploitation of warm water (72°C) from the CI aquifer. The CT aquifer was exploited by around 15 wells. Because of the increase in water availability, the irrigated area increased as well. More than 16,800 ha in the old oases were rehabilitated and, depending on the water availability, 700 ha of additional irrigated area was created.

In 1996, the project APIOS (***A***melioration of ***I***rrigated ***P***erimeters of ***S***outhern Tunisian ***O***ases) started. It focused on the rehabilitation of 153 oases. The intervention area covered 23,000 ha across the governorates of *Gabes, Gafsa, Kebili and Tozeur*. It was launched to tackle water mismanagement, mainly attributed to low efficiency of the irrigation and drainage networks. The prevailing situation demonstrated a high water loss ratio (40 to 60%) in major irrigated areas. The present situation shows a significant improvement in water management. As part of the rehabilitation works the old irrigation canals were replaced with watertight canals, the drainage networks were intensified. These efforts contributed to enhance water distribution efficiency with 25 to 30% and 7,500,000 m^3/ha/year were saved. Following the completion of the rehabilitation works in the concerned oases, the area productivity was enhanced by 38%, 19%; 23% and 39% respectively in *Gafsa, Tozeur, Kebili* and *Gabes* (Fig.3).

Furthermore, the cultivation intensity increased from 143% to 164%. The yield per unit of land has been improved respectively by 35%, 36% and 80% for dates, olives and fig trees as shown in figure 3 (SAPI, 2005).

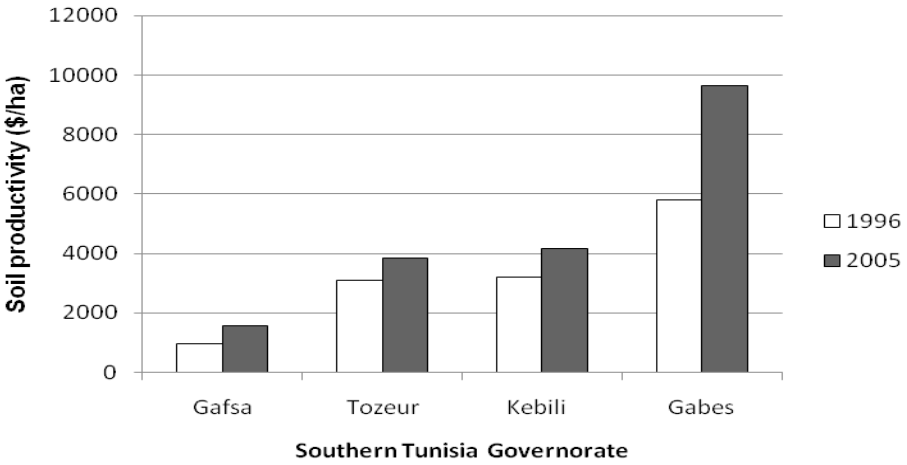

Figure 3: Impact of the rehabilitation works on the soil productivity in the oases in southern Tunisia *(Adapted from Sanyo, 2005*).

More than 90 oases were rehabilitated and a complementary phase of assessment was engaged. This assessment emphasized three highly important points: (1) water consumption on fields remains very high compared to the effective water requirements, (2) water pricing is still insufficient to fully recover real water costs and (3) introducing water saving practices will only be effective when the commitment of people to preserve their water resources is strengthened.

The southern oases have also benefited from the Project PISEAU (***P***roject of ***I***nvestment in the Water ***S***ector) that started in 2001. It focused on setting up pumping stations and building meshed irrigation networks. The introduction of reservoirs to better allocate the water supply, helped the common interest groups (GIC) manage their irrigation networks. After the final rehabilitation works undertaken within the framework of the project PISEAU I (2002-2007), the second phase started. This should be finalized after 2011. In southern Tunisia, the second phase will include not only the scarcity as well as the vulnerability of water resources to the risks of contaminations (salt, pollutants…). The recourse to non-conventional water resources should be strengthened by the installation of waste water treatment in the southern region. Public information campaigns will be increased and capacity building accelerated to further facilitate technology transfer

(water treatment units, water saving equipment, underground water resources level and quality monitoring). Table1 shows the chronological succession of main interventions undertaken to promote irrigation in oases in southern Tunisia.

Table 1: The main rehabilitation projects in southern Tunisian oases from 1976 to 2008.

Date	Intervention aim
1976	Tunisian Government launched a wide study evaluating water and soil resources in southern Tunesia.
1979	The strategic water management plan for southern Tunisia was instituted.
1980	Start of 3,200 ha rehabilitation and the creation of 2,100 ha new irrigated area within the framework of the strategic water management plan for the south.
1983	*Djerid* water management plan concerned the rehabilitation of 3,300 ha in Tozeur regions.
1984	*Nefzaoua* strategic water management plan rehabilitating 4,300 ha and creation of 500 ha new oases.
1985	Strategic water management plan of *Gabes* regions: new irrigated areas created of 200 ha and 5,000 ha rehabilitated.
1986	Strategic water management plan of *Gafsa* regions instituted to rehabilitate 3,300 ha of existing oases.
1995	The study of improvement of oases in southern Tunisia concerned 23,000 ha distributed between *Gafsa, Gabes, Kebili* and *Tozeur*.
1996	Beginning of the rehabilitation works (irrigation and drainage network modernization).
2001	Project PISEAU (Investment in Water Sector)
2005	Measures implemented in 90 out of 153 projects (58,82%).
2008	Evaluation of the rehabilitation works impacts and decision to undertake the second phase that will concern 7,427 ha until 2016.

2. The geothermic water use strategy

Within the national water resources development strategy, the geothermic sector is definitely a relevant development and employment vector. After the exploratory drilling campaigns in the beginning of the 1976, important underground geothermal water reserves were identified and widely exploited.

In 1986, the government started to use geothermic water for heating greenhouses in southern Tunesia. Several demonstration projects were implemented across the southern country and the experience was favourable. The assessment of these experimental projects demonstrated a promising development alternative for this region and has led to a continuous extension of the covered area (Fig.4).

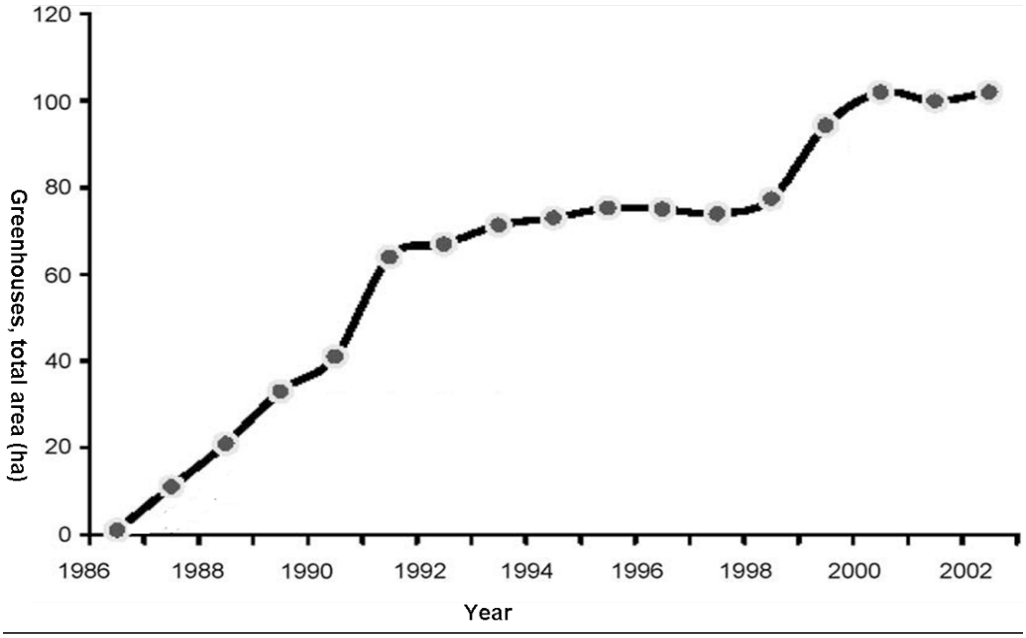

Fig. 4: Development of the geothermic greenhouses area in southern Tunisia *(Adapted from Ben Mohamed, 2003).*

The total volume of geothermic water currently used is nearby 3,417 l/s, with 1,682 l/s in *Gabes*, 1,100 l/s in *Kebili* and 635 l/s in *Tozeur*. The irrigated areas supplied by this resource is for these governorates respectively, 100 ha, 105 ha and 100 ha (Seddik, 2009).

The enormous reserve that the CI aquifer provides, has led to the lightning development of the geothermic sector in those region. It is used to heat greenhouses before being allocated to irrigation. Such double use of the water contributes to its promotion. This production method has attracted many investors in the southern country and has allowed the irrigated areas to produce high quality products for the local markets as well as for export (Fig.5).

Fig. 5: Geothermic greenhouse in the region of *Kebili*.

In 1993 an extensive work was commissioned to increase the geothermic agricultural areas across southern Tunisia. It allowed the development of further area of currently 215 ha, with respectively 88 ha in *Gabes*, 77 ha in *Kebili* and 50 ha in *Tozeur*. (Seddik, 2009)

To supply the required resources, about 77 deep groundwater wells were drilled to provide an amount of 2,360 l/s for both heating and irrigation purposes. The water quality of the used water ranges from 2,7 g/l and 3,3 g/l (Seddik; MAREH, 2009).

This salinity limits the yields but gives the vegetables a better taste, particularly the tomatoes and the melons. These products are in high demand in Europe and the Dubai Arab Emirates. The mean annual production from the southern part of the country approaches 8,000 ton/year, more than 45% of which is destined for export (MAREH, 1998).

In terms of employment, the geothermic sector supports the creation of 13 workplaces per hectare, while ordinary irrigated cultivation could not provide more than 3 workplaces per hectare. It provides 1,200 workdays per hectare while field cultivation could not provide more than 250 workdays per hectare. The expansion of this sector contributes also to reducing migration of the local population and has already become a pillar of the local development plan. (MAREH, 2009)

3. Water pricing policy

In 1991, a presidential decree outlined the water pricing policy related to the irrigated sector. It clarified the role of the stakeholders dealing with irrigation water management. The governmental development agencies as well as the farmers groups called GIC (groups of common interest) were called on to work closely together to establish water pricing and determine the mode of revenues collection, including the penalties rates in case defined rules are not respected. For this reason, three water pricing methods were recommended, as well as methods to collect the rates (Table 2): (i) the volume pricing method, based on actual water consumption, (ii) the global price method based on the irrigated area and (iii) the binomial pricing method that covers two proportions: a fixed part and a variable part dependent on actual use.

Table 2: The main water pricing and cost collect method followed in the public irrigated perimeters within the southern Tunisia *(Adapted from Sanyo, 2005).*

Water pricing method	Description	Water cost collection
Volume pricing method	This method is based on the actual water used. Reliable water meters in the irrigated area are required for this method..	The amount is paid directly after each irrigation turn.
Global price method	This method is applied in absence of reliable water meters in the irrigated areas. The water price is proportional to the irrigated area (fixed price/ha).	50% of the total cost is paid after planting, the rest is paid after harvesting.
Binomial method	This method includes a first fixed part based on the minimal annual consumption in the irrigated area. The second part is proportional to the surplus volume of water applied (m^3).	50% of the fixed amount is paid at the beginning of the agricultural campaign, the rest, including the price for the additional volume is paid after irrigation.

On the basis of these recommended water pricing methods, the governmental development agency and the farmers groups in close consultation define the suitable method to be followed according the circumstances in each irrigated area.

For the case of the oases in southern Tunisia, the water pricing volume method couldn't be applied in the same way as in the north of the country, where the irrigation networks are under pressure and the implementation of water meters is quite simple. Indeed, the water pricing in southern Tunisia is based on the total duration of irrigation (h/ha).

For this purpose, the assessment elaborated by SAPI (2005) showed that the volume method was chosen both in *Gafsa* and *Kebili*, while the binomial method was applied in *Gabes*. For the governorate of *Tozeur*, the three methods seemed to be applied; nevertheless the volume method was widely applied for the major oases.

Despite the strict commitment of the authorities to apply rigorous water pricing policy, there are many mismanagement practices that still represent a hindrance to a significant valorization of the resource.

Louhichi (1999) showed for the case of *Gabes* oasis, that reducing irrigation network losses by lining tertiary canals allows to economize 14,344 m3/year. The average total water cost reduction is 523 DT, which equals 0.036 DT/m^3. The unitary exploitation cost is 0.091 DT/m^3. The difference between both becomes more significant when the calculation takes into account several other exploitation costs (storage facilities, exploitation fees). Total exploitation costs amount to 0.416 DT/m^3, so 10 times the savings (0.036 DT/m^3). This demonstrates that it is more efficient to reduce water demand than to reduce the loss of .water in the system. However, the present method of water rate-making commonly used within the oasis is a fixed one and the amount to pay (DT/ha) takes only the irrigated surface as standard into account.

The current water pricing system doesn't take into account the investment costs the state provided to establish an imposing hydraulic infrastructure across the oases. Farmers pay only the exploitation costs (pumping fees, irrigation and drainage networks maintenance).

Sghaier (1995) claimed that such water rate marking doesn't valorise irrigation water. A water pricing policy recovering the full economic costs of water should be introduced. The water volume used by farmers each irrigation turn has to be the main standard of this water pricing policy. Moreover, the water price is now determined according to the budgets of farmers groups and shows an obvious stagnation. The development agency can hardly convince farmers to agree to increase the price of irrigation water, despite the growth of maintenance costs for irrigation networks.

4. Future challenges

At the national scale, it seems evident for the national policy to focus on water demand management as well as on improving the efficiency for both the drinking water sector and the irrigated agriculture (improving the distribution efficiency in irrigation networks from 66% to 80%). In absence of such improvements, the objective of 400,000 ha of total irrigated surface couldn't be met by 2010 (Treyer, 2000).

In the oases in southern Tunisia, the irrigated area is expected to increase from 46,000 ha in 1994 to 52,035 ha beyond 2030. For this purpose, the main objective of the long term national water strategy (EAU XXI) is to decrease the irrigation water demand. Indeed, this approach focuses on efficiency improvement and targets to reach the average of 365 million m^3 in 2030, while it was more than 506 million m^3 in 1996 (Sanyo, 2005).

Table 3: Water volume targets of southern Tunisia (*Adapted from EAU XXI, 1998; Sanyo, 2005).*

Year	1996	2010	2020	2030
Irrigated surface (ha)	46,000	49,000	50,490	52,035
Irrigation water consumption (m^3/ha/year)	11,000	9,500	8,167	7,022
Irrigation water demand (million m^3/year)	506	466	412	365

For irrigated agriculture in general, and in particular for the oases systems, the main challenge to meet is climate change. The impact of this phenomenon on water resources is expected to be very severe. Indeed, national studies predict a decrease of nearby 28% in non-renewable underground resources by 2030. The production in dry periods is expected to decrease with 50%, this equals 800,000 ha for rainfed agriculture. These impacts will be considerable also on livestock production which is predicted to decrease by 80%, both in the center and southern country (OSS, 2009b).

Facing these risks, Tunisia elaborated a national strategy to decrease the impact. The development of the mean climate indicators will be taken into account for the future natural resources management plan. The alert systems for both floods and droughts events are already established, with a network of climatic and hydrological stations across the country.

Water resources protection remains the focal point of such strategy, the enhancement of efficiency is supported by the implementation of several measures. In the drinking water sector, the hydraulic networks were subjected to an integral assessment that focused on the commitment of the population to water saving practices. In the irrigated sector, the intensification within farmers' parcels has to be enhanced in order to valorise the water resource. The cultivation of high added value crops should be intensified. Moreover, the contribution of the irrigated sector to the total agricultural production will be promoted. The objective is that this will reach nearly 50% on the long term.

For further economic efficiency, the government disengaged progressively from the management of water resources and required farmers groups to be more involved in protecting the hydraulic infrastructures as public facilities. The growing participation of the private investors, for example in the geothermic sector, calls for stronger promotion of water pricing and reduction of water wastage.

The national program of water saving was strengthened by the allocation of financial grants to introduce water saving equipment on farmer parcels. The percentage of costs covered by these grants are on average 40%, 50% and 60% to respectively extensive, middle and small farms (Hamdane, 2004).

It is evident that all these major efforts undertaken by the government would be sooner realized if farmers were committed to the same goals. Current practice of water use on parcels demonstrates that the applied water volume is more than the effective crop requirement. Traditional irrigation methods are still widely used within farmers parcels. The absence of any field levelling and the over application of water during irrigation, up to three times the actual crop requirements, cause relevant water losses (Mechergui and Van Vuren, 1998).

Ben Issa *et al.* (2006) showed the importance of salt inputs in case surplus water volume is applied. The problem of water wastage remains important in the oases in the southern part of the country. Another challenge that still is to be solved is the illegal extension of the irrigated area and

the increasing number of private wells (Fig.6) that occurs in downstream oases. In these fields, the excess water supplies a shallow water table that rises to a rather inacceptable level and creates water logging and in longer term chronic salinisation (Prinz *et al.*, 2005).

Fig. 6: Illegal well established in private parcel at downstream oases in the southern Tunisia oasis *(Region of Kebili).*

The first explorative studies conducted by OSS experts, predict a considerable decrease in artesian water in the extreme south of the country (Mamou, 2009). For the Nefzaoua region oases, Zammouri *et al.* (2007) three scenarios of pumping strategies from the CT aquifer were simulated. The main results demonstrate evident water quality deterioration across the whole *Nefzaoua*. In order to tackle these concrete changes, radical changes in the way the main stakeholders deal with water management in this country part should be considered. Furthermore, the regulations should be stricter in order to eradicate the phenomenon of illegal extension of oases.

IV – Conclusion

The rehabilitation of oases in southern Tunisia is a relevant component of the national water policy. In these arid regions (less than 100 mm in dry year), sustainable management of water resources is crucial to the accomplishment of the national development goals. Since the implementation of the strategic water management plan in 1979, the available water resources have been considerably exploited. The recent creation of oases with modern irrigation networks increased the production in irrigated areas. Furthermore, the rehabilitation of networks that sustained the old irrigated areas, notably within the framework of several projects (*PISEAU I, PISEAU II, APIOS*), improved the network distribution efficiency (25 to 30%).

The spectacular development of the geothermic sector is an important aspect of the national economy. The national efforts to develop irrigated agriculture in a severely arid climate, contributes widely to increase the productivity of the natural resources in these regions. It also provides job opportunities for the local population and enhances socio-economic variables. By achieving the water policy goals in the southern part of the country, the main stakeholders have capitalized a significant experience in managing water resources in a context of scarcity.

Despite the important success in the irrigated sector promotion in the south, the strategy of oases

rehabilitation is being adapted to meet the futures challenges. Indeed, as water resources will become scarcer and less reliable, the population in this part of the country will experience evident difficulties in efficiently managing the resource. A major assessment of water management practices within the oases revealed that improvement of irrigation efficiency could not be carried out without complementary work informing the users about water saving practices. The term rehabilitation should also refer to making people more aware of water as a precious resource.

More rational use of water resources will no doubt be increasingly required from all involved stakeholders, especially in irrigation. Futures challenges will demand considerably more investments. Recourse to the extensive use of expensive modern technology, such as water treatment, desalination, aquifer recharge, seems to be inevitable. Furthermore, more research needs to be focused on crop water requirements. The ongoing prospective studies that will define the strategic outline of the water policy in the coming decade underline the priority of higher irrigation efficiency.

The Tunisian experience showed that integrated water management is definitely the key element in maintaining a balance between resources and demand. More close dialogue should therefore be instituted between stakeholders involved in water management. Such dialogue should be a decisive tool to resolve water conflicts (the problem is even more acute for farmers in oasis).

Particularly in southern Tunisia, where irrigated areas suffer permanent desertification risks, a deeper understanding and a better assessment of the management of available water resources is required. The collection of accurate data regarding this aspect will provide new possibilities for future water policy. It will also facilitate effective decision making in order to meet the various societal needs and overcome risks of degradation of water resources.

Moreover, reforming water policy in the oases in southern Tunisia towards a comprehensive approach will allow all stakeholders to cooperate closely and to increase the transparency of their roles. Such a situation ensures both the competent authority and farmers to reach their respective objectives.

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