

PARTICIPATIVE SUSTAINABLE MANAGEMENT OF RENEWABLE GROUNDWATER RESOURCES BASED ON THE CONCEPT OF WELL PURCHASING

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Abstract

This paper presents a participative management model with built in incentives for economically efficient and sustainable aquifer use. The new management model is based on the concept of “well purchasing”

The creation of water user associations or enterprises requires addressing the issues of capital formation, its management structure, the adopted water allocation policy, and corrective measures to mitigate potential negative impacts.

Among the three sources of capital in the hands of the aquifer users, their land, their wells and associated equipment used to abstract water, and their right to access the water, it is the last two that could provide the capital base for the formation of their association. For a variety of reasons it is better to leave the land in the hands of the landowners. The major capital of the association would be the wells and water rights of its users who would surrender them in exchange for title to a share in the enterprise. The surrendered water rights should be subject to the requirement that for sustainable aquifer use the sum of all rights to access the aquifer must not exceed its long-term sustainable yield. The shareholders would then be entitled to a water allocation derived from the exploitation of the wells, which would now be subject to the collective management of the enterprise.

For a successful transition from a situation of unmanaged, freely pumping wells to a system of well regulated collective exploitation of the resource the system of collective management must have adequate user participation and representation, and provide the users with tangible benefits. The board of the association must include representatives elected by the share holders, professionals recruited by the association approved by the shareholders and possibly, non-executive representatives of the Water Authority and other wider bodies that the association sees fit to offer representation to. The Water Authority would set every year the maximum total water allocation that the association can abstract, while it will be left to the association to decide the distribution of this abstraction to individual users. The association would be obliged to anticipate and prepare for the eventuality that the least efficient users would be forced partially or totally out of production and to cater for all the negative socio-economic impacts by providing suitable mitigation measures.

Because of the importance of sustainable management of economically important aquifers, the State can play a decisive role in the implementation of this management model by opening the way for reasoned State investment, providing capital grant incentives and the appropriate capital and banking infrastructure for the enterprises to get established. Consideration is given to a possible application of this concept in Tunisia.

1 INTRODUCTION

Issues of water resources allocation under conditions of water scarcity, as they pertain to sustainable groundwater management, have been addressed extensively in the literature. Examples of relevant discussions can be found in Bromley (1991), Gisser (1983), Matoussi and Slama (2000), McCarl (1999), and Sadan, et al (1987).

Recognizing that neither centralized management by the state, nor a “laissez faire” market-driven system guarantees the sustainable use of renewable ground water resources, we present a participative management model with built in incentives for economically efficient and sustainable aquifer use. To introduce the context of the situations where this model is applicable we consider the case of a Water Authority, confronted by a seriously over-exploited aquifer at risk of being irreversibly damaged, and which is searching a management approach that can avert the problem.

In this case the Water Authority knows, from its own past experience and that of other water authorities in the world facing the same problems that the solution cannot be found simply by imposing a direct management of water abstractions. In fact, today it is more or less universally accepted that attempts to manage naturally replenished groundwater resources through centralised systems for granting abstraction rights lead to inefficient resource allocation and more importantly does not abate the overexploitation of the aquifer and the degradation of the resource.

The Authority therefore opts for a policy of decentralised management for its aquifer based on the users playing an active role in the direct management of the resource whilst retaining for itself the public service functions it judges indispensable. These functions, which are more those of a regulator, are:

- Defining the limits of the aquifer use,
- Inventorying all users,
- Defining water use rights based on established water use,
- Undertaking a public information programme explaining the need for participatory management of the aquifer in the interests of all users, and
- Providing all the means necessary for promoting user associations.

Additionally, the Authority provides a network of observation instruments (observation wells and piezometers) and ensures that the technical means for managing the aquifer are in place (quantity and quality models, hydro-climatic data, water use and socio-economic data, etc) so that the best evaluations for reliable exploitation of the aquifer can be made before each period.

Once these basic functions are in place, the Authority needs to organise a wide consultation of all users with a view to creating a vibrant users association. To be viable the association must rely on a form and programme that is motivating and encourages the users to play a positive role in the development and prosperity of the organisation.

Any organisation of this type will need many components to be put in place. The four broad aspects that should be covered for such a participatory scheme are:

- the formation of capital
- the management structure

- the water allocation policy
- the corrective measures needed to correct the negative impacts due to the changed state.

The second section of this work addresses the issue of capital formation that will ensure the long-term success of the enterprise. The management structure and its functions form the content of the third section. The fourth section deals with the issue of water resource allocation and more importantly the question of re-allocation within the parameters of safe yield and long-term sustainability of the water resource. The fifth section provides an outline for the corrective measures that will almost certainly be needed to redress negative impacts of implementation.

Finally, in the last section of this work we give some thought to the feasibility of implementing this new approach, which we call “well purchasing”, to ground water resource management in Tunisia.

2 CAPITAL FORMATION FOR THE ASSOCIATION

A capital base is an essential prerequisite for any enterprise, ensuring its survival through the business cycle. It is normally desirable that the necessary capital investment is put in place by its backers, who then have the necessary incentive to protect and nurture their investment.

In our case, the sources of capital in the hands of the users of the aquifer that could be used to form the capital base are:

- Their land,
- Their wells and the associated equipment used to abstract water, and
- Their access to the water, adopting the principle that the sum of all the rights to access the water stored in the aquifer must not exceed its long-term yield (its long term capacity ensuring its stability as a resource).

Due to historical, cultural, legal and particularly emotional reasons, land is best left in the hands of landowners and we propose not to associate the transfer of land deed and title as part of the mix for capital formation. We see this as an important principle as the spectre of land nationalisation and collective farming would, in our view, lead to a categorical refusal of the individuals who rely on the groundwater resource to participate in this new approach.

The two sources therefore that can be used to constitute a relatively capital base upon which we could secure the viability of the association are:

- The water resource as volume assessed to be a safe yield for the aquifer offered, each year, to the users by nature as a “good”, and
- The water supply (the well and its related equipment), which is the productive capital brought about by the investments made by all the individual well users.

On the basis that the Water Authority would be in a position to define water use rights and distribute these pro rata on the basis of the established or authorised abstractions, each well user would, in principle, have the following capital to put forward:

- A water use right q_i^h , which is nothing more than a proportional share s_i^h of the declared safe yield of the aquifer Q^h , as follows:

$$s_i^h = \frac{q_i^h}{Q^h} \text{ where } i = 1, \dots, n, \text{ and } n \text{ is the total number of users.}$$

- A productive capital part in the total aquifer water supply, which we identify as k_i .

The association can therefore issue shares in its equity to the users pro rata to their capital contribution ($q_i^h + k_i$).

The capital base of the association, C , will therefore be the sum total of these contributions:

$$C = Q^h + K \text{ where } Q^h = \sum_{i=1}^n q_i^h \text{ and } K = \sum_{i=1}^n k_i .$$

Clearly, for the association to function all wells will need to be equipped with flow meters.

The major tasks for the association will then be to:

- preserve the “good” offered by nature by conceiving and implementing an appropriate water conservation policy for the scarce resource in order to avoid an irreversible degradation of the aquifer. This will be done by charging a water tariff, managing water abstractions and collecting payments, and
- ensure the productivity of the water supply. The association needs to implement programmes for adopting appropriate technology and management practices aimed at substantially boosting the production from the members’ water supplies.

In principle, the association will distribute the profits from its annual business in line with the share its ownership by the users.

3 RESOURCE MANAGEMENT

The board of the association will be made up of representatives elected by the share holders, professionals recruited by the association approved by the shareholders and possibly, non-executive representatives of the Water Authority and other wider bodies that the association sees fit to offer representation to.

The Water Authority within which the association will be called upon to declare its policy, procedures and practices for managing the groundwater resource will decide a regulatory regime for the association. Whilst the association’s policies and rules need to satisfy the Water Authority, wide latitude will be given to the association in choosing its preferred management approach.

The fundamentals for Water Authority regulation will be as follows :-

1. At the start of the growing season the Water Authority will fix -
 - The maximum draft for abstraction Q^a ; the individual water use rights will then be adjusted accordingly to -

$$q_i^a = s_i^h Q^a .$$
 where Q^a , the maximum volume to be abstracted can be the same, more, or less than Q^h , the “safe yield” volume used to decide water use rights depending on the updated data on the parameters used to judge the condition of the aquifer.

When the association exceeds Q^a in the given period, it will be made to pay a fine (which will be sufficient to be dissuasive) in proportion to the amount of the excess volume abstracted. This sum will be set aside to help fund resource management projects (for recharge improvement, pollution abatement, etc...)

- The water tariff p_i^h to be applied that will comprise two components, a water scarcity value and a fee due to the Water Authority. The association will keep the water scarcity component and will pay over the Water Authority component to the Authority. The fee will cover the cost of administration and the matching funds needed for the resource management projects.
2. The Water Authority will ensure that the association's management is compliant with the declared and accepted policies, procedures and practices.

4 WATER ALLOCATION

At the start of each growing season the association will allocate to each member the volume equivalent to the adjusted water use right q_i^a at the price p_i^h .

The mode of allocation, which will have been decided on by the association and approved by the shareholders in general session, could take the form of a "passive market".

Here the association fixes and allocates, at the beginning of each period to each member, the adjusted volume q_i^a , the use right, at a charged price of p_i^h . Each member then declares the volume really wanted, q_i for use during the period. The association then establishes the final accounts for its members on the following basis :

- If user i uses a volume q_i which is *greater* than the adjusted water use right q_i^a , he than pays to the association an amount t_i calculated as follows:

$$t_i = p_i^h q_i^a + p_i (q_i - q_i^a)$$

where p_i is the special price of water used in excess of each user's water right.

- If user i uses a volume q_i which is *less* than the adjusted water use right q_i^a , he than pays to the association an amount t_i calculated as follows :

$$t_i = p_i^h q_i^a - p_i (q_i^a - q_i).$$

The great advantage of the "passive market" is that the "buyers" and "sellers" of water don't actually have to seek each other out. There is no need to put a real market in place and the "virtual" market is capable of satisfying the users needs. The market system inevitably leads a more efficient resource allocation as well as it encourages resource conservation.

5 MITIGATING NEGATIVE IMPACTS

Despite the major benefits of the "passive market" of efficient resource allocation and resource conservation it is important to deal with the potential downside social consequences. In extreme circumstances this approach could lead to the least efficient users (the weakest members) being forced out of production with all its negative social implications.

To combat this tendency the question to pose is: *What ways and means can be found to encourage the less efficient farmers to improve their productivity so that they remain effective water users ?*

The association would be obliged to anticipate and prepare for the eventuality that the least efficient users would be forced partially, or totally, out of production, and to cater for all the negative socio-economic impacts by providing suitable mitigation measures.

6 IMPLEMENTATION

It appears to us that there are two decisive aspects to a feasible approach for groundwater management along the lines we have presented above.

Firstly, a powerful incentive needs to be given to individual well water users to surrender their, often hitherto unregistered, water exploitation to a collective management where the abstractions are metered. Here, we should expect to encounter fiercely independent water users who would not be expected to happily surrender their freedom to extract water at will. After all, in order to establish their right to freely exploit the water resource, these users have normally invested in their wells, pumps and ancillary equipment to access the water and are paying the pumping costs to exploit the resource. They then often face further investment and exploitation costs in order to pursue a falling water table. These users, whilst recognising the inevitable degradation of their resource, cannot easily put their trust in a collective management.

Secondly, the State needs to support the collective management system by progressively introducing a robust regime of authorisations and dissuasive taxes for groundwater users who are unwilling to join the collective management.

The proposal is to transfer the title to the well as a “point of access” to the aquifer, from the individual user to the collective enterprise (or association). In exchange, the well user will be given title to a share in the enterprise. The shareholder will then be entitled to a water use right for exploiting the well, which will be subject to the collective management of the enterprise. The abstractions from the well will be metered.

The keys that unlock the way for transferring the groundwater use from a situation of unmanaged wells freely pumping the water to a system of well regulated collective exploitation of the resource are “trust in the management” and “well-being of the individual”.

Trust in a system of collective management comes from adequate participation and representation. Owning a capital stake in the common enterprise needs to be “decisively” understood by well users as a satisfactory position for them providing them with adequate access to all the decision-making. This paramount state of stakeholder access to management should never be subordinated to the more “technical” interests of aquifer management. Put simply, everybody involved (users, managers and government) need to understand *that the success of the commonly owned enterprise* is the purpose of this vehicle for sustainable water use and everybody must trust that the success of the enterprise will be the means to ensure the preservation of the aquifer.

For the water users, the sensation of “well being” surely comes from being better off having made the decision to participate. The well purchase mechanism needs to provide the user with tangible benefits. Clearly, the important benefit of participating in a system that assures sustainable resource management should not be understated. However, it is very unlikely that this on its own will provide the incentive needed. More immediate benefits to the user need to be promoted. Firstly, a capitalisation of the value of the well could be offered, at least partially, literally as capital. Secondly, the enterprise (association) should offer a range of meaningful benefits for the users to boost their ‘market’ performance. Technical support that aids users to

get better value from their 'managed' water supply should be at the heart of the programmes offered.

The State should play a decisive role in the implementation. The preservation of an economically important aquifer can be worth an enormous amount to a regional economy and to the nation in the long term. Therefore, opening the way for reasoned State investment, providing capital grant incentives and the appropriate capital and banking infrastructure for the enterprises to get established, is justified.

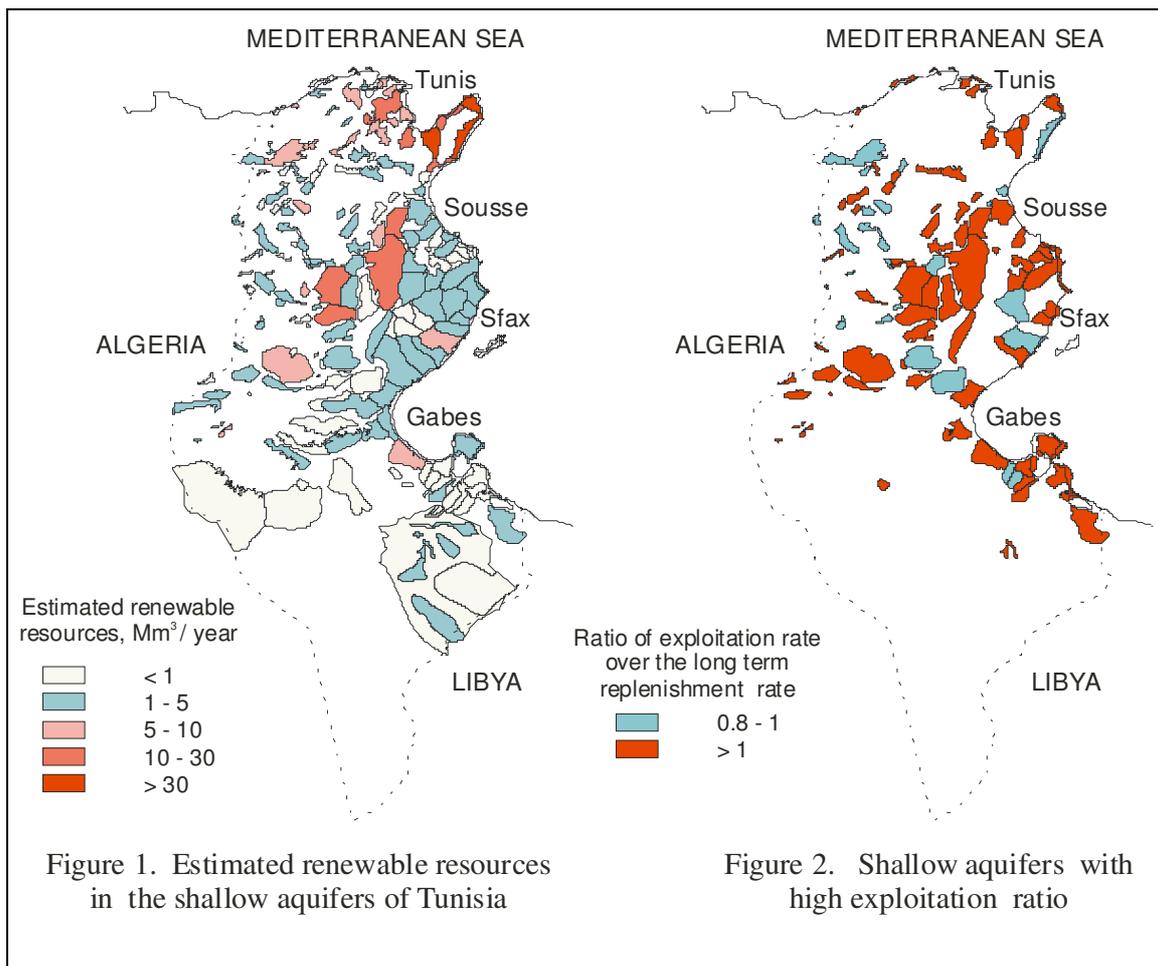
The successful implementation of collective groundwater management ought to render the authorising and taxing of groundwater abstractions by users who prefer to remain outside officially recognised participatory management a practical proposition. Only a small number of wells will need to be policed. The taxes for abstractions should progressively rise, eventually becoming prohibitive. In the fullness of time this will be the greatest incentive for aquifer users to seek the 'safe haven' of organised management.

With the successful outcome of the approach it will seem odd to future groundwater users that the proposition of letting 'free riders' pump their precious resource with such gay abandon was ever a notion supported by the majority of well owners in the first place.

7 THE POSSIBLE APPLICATION OF WELL PURCHASING IN TUNISIA

Groundwater is an important resource in Tunisia, accounting for about 30 percent of all water resources in the North, 82 percent in the Centre and 96 percent in the South. The Tunisian Water Code defines two types of aquifers for management purposes, the shallow aquifers (*nappes phréatiques*) and the deep aquifers (*nappes profondes*), a distinction based only on the depth below ground surface. According to the Water Code all groundwater at depth less than 50 m below the ground surface is defined as shallow, and the rest is considered as part of the deep aquifers.

Strict regulations and controls are imposed on the use of the deep aquifers, most of which represent non-renewable resources while, with very few exceptions, there are no restrictions on the exploitation of the shallow aquifers. Figure 1 shows the distribution of the estimated renewable water resources in the shallow aquifers. The Water Code, which is the only legal text regulating groundwater use in Tunisia, does not have sufficient provisions for the protection of the shallow aquifers, which has led to the overexploitation of shallow groundwater by individual users freely drilling wells and pumping as much water as they can get. In general there is no coordination among individual users within each shallow aquifer, and practically no control of ground water extraction by the administration. Many shallow aquifers are overexploited, experiencing a continuous decline of the water table, and in the coastal areas, water quality degradation by saline intrusion. Figure 2 shows the rate of exploitation of the shallow aquifers, based on 1995 data.



Recognizing these problems, the Tunisian Administration, with the support of the World Bank, took the initiative to develop a new groundwater management strategy and establish the proper legislative, institutional, economic and technical frameworks. The main elements of this strategy are described in the Water Sector Study (Ministère de l'Agriculture de la République Tunisienne, 1999). The conditions that will be created by the new groundwater management strategy would be favourable for the implementation of the concept of "well purchasing" as a management tool that would aid in achieving the goal of sustainable use of the renewable ground water resources of the country.

The proposed institutional structure for the management of the shallow aquifers consists of three different levels of entities: a) at the national level two departments of the Ministry of Agriculture, the *Direction Générale des Ressources en Eau* (DGRE) and the *Direction Générale du Génie Rural* (DGGR), b) at the regional level the *Commissariat Régional au Développement Agricole* (CRDA), and c) at the local level the water user organizations. There is already some experience in participatory water management in Tunisia, from the *Associations d'Intérêt Collectif* (AIC) organized to manage water from a single point of supply (surface water or a well pumping from a deep aquifer).

The new user organizations, the AIC for shallow groundwater management, are envisioned to employ participatory management to ensure the compliance of its members with their groundwater extraction allocations given in the aquifer management plan. The options that these organizations have at their disposal for managing limited groundwater extraction allocations include improvements in irrigation efficiency, water transfers among members, the cultivation of alternative crops demanding less water, and, if feasible, the import of water from

other areas. The CRDA will play the role of the water authority that every year sets the maximum draft for abstraction by the user associations and oversees their compliance, as explained earlier in the description of the “well purchasing” management model

The *technical elements* of the new groundwater management strategy include a more reliable assessment of the renewable groundwater resources, definition of the hydrogeological units that should be managed as separate units, improved aquifer monitoring to provide systematic and reliable estimates of groundwater use and assess changes in water quality. The proposed methods for estimating groundwater extraction include the use of meters and electricity records, where pump motors are electrified.

The ingredients for a decentralised participatory model as part of a new Tunisian shallow groundwater management strategy have already been proposed. Well purchasing is consistent with the spirit of this strategy and could be proposed to the users coupled with capital incentives tied to investments aimed at boosting agricultural output and conserving water use.

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