

# **Towards an Efficient Management of Ein Sultan Spring in Jericho**

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## **1. Introduction**

Around 53,000 dunums<sup>1</sup> in the West Jordan valley WJV are under irrigation. They comprise almost 52% of irrigated areas in the West Bank (ARIJ 1998). Quite significant especially when off-season production, productivity and production costs are considered. The area under cultivation comprises only a fraction of the arable area. In Jericho Governorate, for example, only 4% of the total area is under cultivation, compared to 24% plus for the West Bank and 31-35% for Gaza Strip (PCBS 2004, P 28). Around 23% is under permanent crops and the rest (or 77%) under temporary crops (PCBS 2004, P 26). There is obvious decline in areas allocated to permanent crops compared with areas partially transferred to temporary crop cultivation (PCBS 2004, P 27). Reasons behind this failure to efficiently use available lands are mostly due to the military occupation and its political, security and military measures.

Agriculture consumes in the average 60-70% of water, especially in developing countries. Agricultural activities are, for several reasons, the least efficient in using this resource. This gives priority to be geared towards improving the water use efficiency, especially in agriculture and more precisely in developing countries, if conflicts at local, regional and global level are to be avoided.

This study intends to tackle the crucial issue of efficient allocation of irrigation water at farm (micro-) and spring (meso-) levels and on attempts to contribute to setting up a framework for a tangible and practical experimentation, research and study.

Resources (time and material) are neither available nor allocated to conduct an ambitious research and data gathering. Instead, a rapid research approach is used to investigate and test certain hypotheses in respect to irrigation water use efficiency in specific and allocation of Ein Sultans' irrigation water in general.

## **2. Methodology**

Land, in the form of territory, is a pre-requisite for a state's existence while freshwater is a pre-requisite for life (FAO 2004). So, water, not land, is now the limiting factor for improving agricultural production. Therefore, maximizing water productivity, not yield per unit area, is the strategy for water management.

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<sup>1</sup> Dunum (du) =0.1 ha or 1000 square meters.

The importance of this study lies in tackling the spring in a holistic approach as a unique socio-economic and technical system and hence better understanding of its components (elements or sub-systems) and a better foundation to working out sound solutions or decisions.

The study will indirectly contribute to the assessment of and setting objectives of water rights reforms based on the so-called "Dublin Principles". These are: 1. Freshwater is a finite and vulnerable resource; 2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels; 3. Women play a central part in the provision, management, and safeguarding of water; 4. Water has an economic value and should be recognized as an economic good (FAO 2004, P 43).

### **Data gathering**

A combination of quantitative and qualitative data was used to generate a blend of different types of policy-relevant information and ideas. Data used for the analysis came from secondary sources such as reports and previous studies; administrative records especially respect water discharges and water-rights and primary data through interviewing farmers and extension agents.

Although a few numbers of farms and extension agents were interviewed to study the Ein Sultan spring system, still these findings gave a hint about the situation and enabled extraction of useful suggestions and recommendation.

## **3. Results and Analysis**

### **3.1. Ein Sultan spring system**

#### **3.1.1. Springs' hydro-geological features**

West Jordan valley, particularly, the southern part (Jericho-Auja area) comprises an important outlet of underground water cached somewhere in the higher plateau, example is Auja, Nweimeh, Deyouk, Ein Sultan, Qilt, Ein Fashkha, Ein Gedi and others. These springs differ some times significantly in their hydrological, physical and chemical characteristics/indicators (see Arij, 1998; Zayed et. al., 2005, P201f), which simply mean that each should be considered separately as a unique water system with much in common and other features such as technical and socio-economics vary widely.

Ein Sultan spring is considered by ARIJ (1998, P 53) as a member of the Wadi el Qilt spring system. Its hydrological parameters used in vulnerability assessment (Table 1) shows quite a difference between Ein Sultan and other springs in the Valley or even in the neighborhood. The vulnerability index for Ein Sultan is low (see Zayed, O. et al. 2005).

Table (1): Hydrological Parameters for Vulnerability assessment of Ein Sultan

	Rating for DtW D	Rating for Recharge R	Rating for AM A	Rating of Soils S	Rating for Top. slope T	Rating for aquitar I	Rating for Karst C	Result
<b>Rate</b>	<b>3</b>	<b>10</b>	<b>10</b>	<b>6</b>	<b>7</b>	<b>6</b>	<b>10</b>	
<b>Weight</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>5</b>	<b>3</b>	
<b>Computed Vulnerability index = <math>\sum</math> Rate * Weight</b>								<b>164</b>

Key to Table (1) above

- Aquifer pumped **Lower**
  - (DtW) Depth to Water ...
  - (DtA) Depth to Aquifer ...
  - Rainfall over Recharge area (mm/yr) **700 mm/year**
  - (AM) Aquifer Media **Massive bided limestone**
  - Sig. area of Soil cover (>2m) within inferred flow path **Partly w irrigated and irrigable areas**
  - Topography/slope in direct recharge area **lower-moderate**
  - Protective aquitards in subsurface **yes**
  - Karst observed along flow path **Yes**
- Source: extracted from (Zayed, O. et. Al. 2005, Page 201f)

### 3.1.2. Water discharges

The spring has an average discharge of 650 cubic meters (cbm) per hour with significant monthly and annual fluctuations (Figure 1). The flow discharge of the spring has apparently a positive trend. Note that discharges are much higher in the summer months compared to winter months. Water demand for irrigation is the opposite, i.e. more water is required in winter for the off-season production.

Water discharges of the different springs in the vicinity of Ein Sultan (s) such as Nweimeh (n), Auja (a) and Duyouk (d) are somehow correlated with the exception of Duyouk spring which has a very low correlation (r) with Auja ( $r_{a,d}$ ) of only and even negative correlation with Nweimeh ( $r_{n,d}$ ) and Sultan ( $r_{s,d}$ ) of -0.31 and -0.17 respectively. other springs are either highly correlated such as  $r_{s,a}$  of 0.63\*\*,  $r_{s,n}$  of 0.84\*\*, moderately correlated as  $r_{a,n}$  of 0.42\* (where

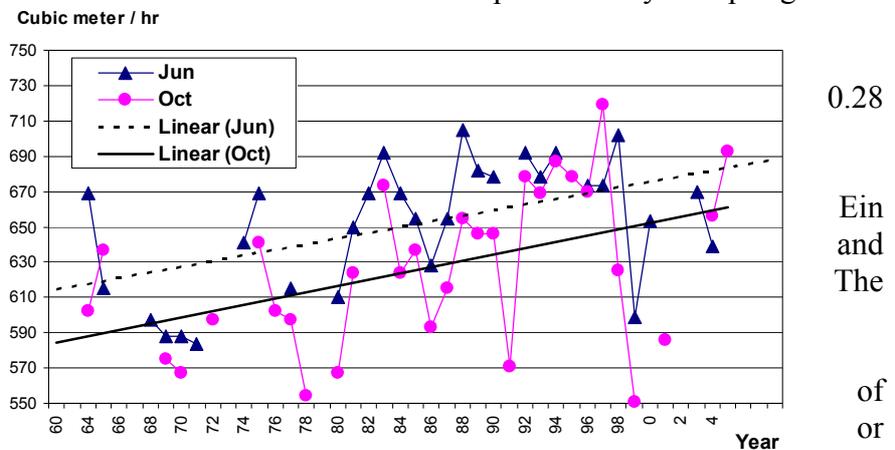


Figure (1): Monthly flow discharge of Ein Sultan spring and trend (1960-2008)

and \*\* mean significant statistics at  $\alpha \leq 0.05$  and  $\alpha \leq 0.01$  respectively).

All these seemingly adjacent natural springs have positive trend of the annual discharges except for Duyouk which has a diminishing trend. Discharge figures need further analysis and investigation since the hypothesis of diminishing flow discharges of the springs can not be proved true.

### 3.2. Water rights

According to Van Aken, M. et. Al. (2008), Islam recognizes two rights related to water:

- *Shefa*, the right of thirst, as universal right for human to quench all their thirst and that of their animals;
- *Shirb*, the right of irrigation, which gives all users the right to water their crops in case of need.

Ein sultan's irrigation water flows into 4 canals (A, B, C and D). Water rights are based on time-share and weekly basis. Ein Sultan spring's water is divided into 672 hours, i.e. 4 canals times 168 hours per week, while Ein Auja is divided into a 5 days rotation (120 hours (Sbeih 2005)).

Ein Sultan's water is divided into two (2) categories: The *Bustani* (Garden) and *Felha* (Agricultural) waters. The *Bustani* water is thought of as water for gardens and domestic use. It comprises one third of the springs water with 15 minutes per dunum<sup>2</sup> with time share identical with real time, i.e. 1 hour means 1 hour. The *felha* water is inherited and can be sold but not attached to land. The *Bustani* water is linked to the land. Here, the water time-share is sold or rented with the land but can not be exchanged from channel A to B ...etc. The *Felha* water comprise 2 thirds of the springs water. 1 hour of the *Felha* water comprise only 23 minutes of real time and can be sold or rented.

Many jurisdictions do not permit the trade in water rights separately to the land to which they have been issued indicating that such a right is not personal to him but incidental to his ownership (FAO, 2004, P 12). This is also the case in Ein Sultan's water, where time-share system is made flexible to meet local needs and future needs with less social conflict. Selling the water rights was strictly linked to land for Orchard's water (*Bustan*).

The water rights were changed in 2006 from time-share system to cubic meter after converting canal conveyance system into pressurized pipes. It is controlled by the Jericho Municipality (JM) officials. With the volumetric water rights, compared to time-share, farmers would become more secure from the water flow perspective which positively affects the utility and thus the value of any land tenure rights they hold (see FAO 2004, P 63).

### Water Rights and water use efficiency

Sharing water between farmers on time-share rights is, more or less, a zero-sum game in that the gain of one farmer (beneficiary) is the loss of another (see Fisher et. al. 2002) depending on the opportunity cost of water (productivity) at the different farms, which is

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<sup>2</sup> Indicating that when the time-share principle was introduced (around 1930s), agricultural production was the only thoughtful water use.

different depending on technique, production pattern, and many other administrative and farm-specific factors.

Efficient water allocation/water use efficiency suggests the transition from a concept of water allocation based on household heads towards a water allocation according to the crops in the fields. It requires allocation of water, or calculates water to be allocated, at farm level according to what is planted and not according to 'water rights'. Setting water rights as an upper limit (ceiling for water consumption at farm level) is another measure towards improving water use efficiency and decision making in that respect. Better if linked to water price discrimination, with favored prices for the water quote and normal price (water value) for the water consumption above the quote.

Around 734 farmers are dependent on the spring's water to irrigate their lands. The water-rights differ significantly. Rough estimates shows that around 180 farmers get only 1-12 minutes; 200 farmers get 13-30 minutes; and around 354 farmers get more than 30 minutes, of which only 6 farmers have water-rights of more than 40 hours each, or 1/3 the agricultural water. Farmers get now-a-days 75 cubic meters per hour compared to 100 cubic meters per hour earlier.

Area cultivated depends on the water-rights of availability of water as indicated in table (2) below. Crop density increases with increase in water-rights or cbm per dunum. It increased from 138% under shortage of water (13 cbm per dunum) up to 180 to 190% under better water security situation, i.e. 22 to 25 cbm per dunum. This relationship needs further investigation and in depth analysis.

Implications of water rights on inefficiency is expected to increase in light of the fact that Water-rights of the *bustan* water is inheritable as well as lands, which means fragmentation of water rights and land parcels and ultimately contributing to inefficiency in the allocation of spring's water unless arrangements were reached between new owners to consolidate their time-shares and land parcels.

Table (2): Land use and water-rights relation

	Area (%)	Crop Area (%)	Crop density	Quota cbm/du
Case 1	27.3	22.5	138	13
Case 2	2.3	2.6	190	15
Case 3	45.5	48.8	180	25
Case 4	25.0	26.0	175	22
<b>Total</b>	<b>100.0</b>	<b>99.9</b>	<b>171</b>	<b>20</b>

**3.3. Water uses**

The spring's water is privately owned. Jericho Municipality (JM) owns only 14-15 hours, which were bought some years ago. Water allocated for agriculture is potentially 3.5 MCM (or 400 cubic meter times 24 hrs a day times 365 days) but the actually received by farmers is around 2.6 MCM, i.e. only 74% of the farmers' aggregate water-rights.

Historically, the spring suffices irrigation of 4000 dunums (400 ha) of vegetables, citrus, banana and date palm...etc. The area under cultivation dropped to around 2,500 dunum (250 ha) due water shortage and domestic pressure put on the spring's water.

**Prevailing cropping pattern**

Out of the 2,600 dunum irrigated by Ein-Sultan, only 100 dunum are allocated to Banan, 500 du under citrus orchards and the rest, or 2,000 du are under temporary cultivation, either vegetables or cereals. A dramatic drop from previous years due to several reasons among which is the water shortage and inequitable distribution, in terms of needs and rights.

The prevailing cropping pattern (Table 3) shows the pivotal importance of September as the cropping in the Valley, confirmed by the work load and demand on irrigation water. Almost 73% of cultivated area is planted in September. The figures are identical with results of optimizing the cropping pattern in the East Jordan Valley (Musa, 1992) which shows that water available in September is the most active production constraint and has the highest shadow price (value). The whole area is put under cultivation in early winter (table 3) indicating the importance of off-season production in the Valley.

Certain crops are cultivated under plastic cover (shaded figures in table 3), particularly cucumber, pepper and tomato. Tomatoes, for example, can be cultivated under open farming conditions if planted earlier, others (cucumber and pepper) are not. A third category of crops like eggplant, squash, cabbage and cauliflower can be planted in the cold months (October-Dec.) without cover.

It seems that Jew's Mallows are the most important crop in summer months occupying 50% of the cropped areas (Table 3). It needs plastic covering if to be produced earlier, i.e. in February. Allocating most of the area to Jew's Mallow was not expected but indicates the willingness of farmers to use their water quote during summer months irrespective of expected economic returns. This phenomenon is widespread after diminishing of fruit trees plantation. This is another sign of water inefficiency. There is a need to make better use of water available in summer, which is more than water available in winter (Figure 1 above).

Figures in table (3) show that the land unit is used on the average 1.7 times, i.e. the cropped area = 1.7 times the agricultural area. Squash and Jew's Mallows are more frequently cultivated. Tomatoes are the most important single crop occupying 8% of the cultivated area and planted under plastic covering (shaded) and 37% of the total cropped area followed by squash.

Another important phenomenon is cultivation of Sweet Corn, occupying 2% of the cropped area but with a promising future if the food crisis continues and opportunity cost of available water is better utilized. Further investigation and research is needed in this respect.

Table (3): Land allocated to different crops, production techniques by planting date (%)

Crop	Aug.	E.Sept.	L.Sept	Oct.	Nov.	Dec.	Jan.	Feb.	E.April	L.April	May	June	Total
<b>Squash</b>	15	9			5	9							<b>37</b>
<b>Tomato</b>		25	1	8			4						<b>37</b>
<b>G. beans</b>		2											<b>2</b>
<b>Pepper</b>		3		2									<b>5</b>
<b>Cabbage</b>		2	1		5								<b>8</b>
<b>cauliflower</b>	2	2	1				2						<b>8</b>
<b>J. Mallows</b>								5	14	3	17	13	<b>50</b>

Sweet Corn		2											2
Egg plant		7		4	7								17
Cucumber				4									4
<b>Grand Total</b>	<b>17</b>	<b>53</b>	<b>4</b>	<b>17</b>	<b>16</b>	<b>9</b>	<b>6</b>	<b>5</b>	<b>14</b>	<b>3</b>	<b>17</b>	<b>13</b>	<b>171</b>
<b>Accumulated</b>	<b>17</b>	<b>70</b>	<b>73</b>	<b>90</b>	<b>106</b>	<b>115</b>	<b>121</b>	<b>126</b>	<b>139</b>	<b>142</b>	<b>159</b>	<b>171</b>	

### Recommended production plans (Extension agents)

The extension agents were of a different opinion. They suggested to allocate fruit trees to more areas (Table 4), particularly date palm (scored 18% of opinion) followed by open farming, particularly medicinal herbs (scored 9% of opinions) and only 2-4% of opinions were for cultivation under plastic covering. Extension agents took these allocation decisions based on the market (56%) followed by the comparative advantage of the valley (40%).

Table (4): Crops suggested extension agents

Fruit trees		Open Farming		Plasti-culture	
Crop	%	Crop	%	Crop	%
Date Palm	18	Squash	4	Cucumber	4
Citrus	9	Eggplant	9	G. Beans	2
Grapes	13	Tomatoes	4	Tomatoes	4
Banana	9	Melon	2	Pepper	2
		Med. Herbs	9		

The dispersion of agricultural engineers' opinions is either due to sampling errors or due to the uncertainty of extension agents with respect to optimal agricultural uses, particularly in cases whereby opinions change with time.

Extension agents are not always of the same opinion or suggestions. They do not seem determined in their extension messages. Being so is more acceptable than changing conditions or sampling errors. Reading the opinions of agricultural engineers show:

1. Asymmetry of available information to the different extension agents.
2. Inconsistency of information, ideas and extension messages.
3. Lack of clear and sound analytical capabilities to extract relevant suggestions and to support decision making at central, spring and farm levels,
4. Weak communication and outreach of extension services,

### Water uses and allocation efficiency

On the one hand, crops are very often ver irrigated; the amount of water should be decided according to the crop effective potential, which also depends on levels of other inputs, e.g. fertilizer...etc. There is no point in allocating the maximum water to a crop that is constrained by other inputs. World-wide used formulas for water requirement calculation are not applicable to all situations; they need adjustment to local production functions and factors.

On the other hand, farmers do not pay the actual cost of water (indicating inefficient water market). They use more water than needed, many areas were left without irrigation as there is not enough water and that the over all irrigation efficiency is less than 50% and the application efficiency is also less than 50% (Sbieh, 2005).

Some farmers may face water supply deficit (water insecurity), others may have a surplus of water supply (over-watered) either at certain time intervals or for a long lasting periods depending how efficient they were in adjusting their cropping pattern and crop requirements to their water time-shares. Recalling the zero-sum role shows that the water-

insecure farmer (low water quote per dunum) may lose some cropping opportunities and over-watered farmers (high water quote per dunum) may waste some water (see table 4 above). Both are subject to inefficient allocation of irrigation water and hence escalating the aggregate water allocation efficiency.

Ahmad, M. (1994) referred to the lack of demand-management practices in the irrigated farming and its contribution to low efficiency in water use and consequent waste. Matching the needs for water to water supply (water right) and optimizing the water demand of crops is complex. It requires a flexible, transparent and collective water management system. Irrespective of complexity, it is nevertheless crucial to work out and implement water management policies that consider compensating farmers for water surplus and supply others who face water shortages, a quasi-market for Ein-Sultan water (to be discussed later).

### **3.4. Water organizations and stakeholders**

Several organizations (at central and local levels) are involved in the spring's water management and have a role to play in that respect. These are: Palestinian Water Authority (PWA), Ministry of Agriculture (MOA), Local government or Jericho Municipality (JM), and Ein-Sultan Irrigation Cooperative (ESIC) representing the riparian farmers.

ESIC was established in 1999 to manage distribution of Ein Sultan irrigation water and represent ASF and to defend their water rights. It was established in response to donor preconditions (1996) to finance the conversion of the open canal conveyance system into pressurized pipes. The ESICs' general assembly includes 359 farmers out of the 734 beneficiaries.

There is no water mediator with a clear mandate or laws by which to solve the disputes around water. JM assumes this job in the meantime but negotiations are undergoing to transfer part of that authority to ESIC. Agreement is reached with JM to allocate 58% of the spring's water for agricultural uses<sup>3</sup>, which is neither respected by JM nor possible to monitor. It seems that JM is reluctant to implement already signed agreements, which adds to the already uncertain water availability to farmers (water security), which might have drastic and long term implications on the economic performance of the spring, particularly its overall socio-economic dividends.

These are perhaps some features of less efficient governing systems and institutional failures in allocating Ein Sultan's water. Institutional failures include markets, policies, political and administrative factors (FAO 2004, P40), while political failures occur through lack of government intervention, insufficient integration between agencies and departments; inadequate availability of information for policy-makers and poor communication between stakeholders at all levels (FAO 2004, P. 43).

It is imperative to empower local organizations, example ESIC, to improve their water-security situation, i.e. long-term access, availability, stability, utilization and safety of water by local communities and farmers (See Laban, P., 2005).

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<sup>3</sup> The municipality extracts 60-62% of springs' water not 48% as agreed upon.

### **3.5. Challenges ahead**

The future demand for the Ein Sultan spring's water is a function of the growth in population, agricultural production, productivity and water quality of other water sources (springs and wells), and future growth in other economic productive sectors.

- Domestic demand for water (drinking, industrial, eco-tourism...etc.) increases according to JM at 19% per annum, constituting a real challenge to agriculture production and hence livelihood and sustainable development of the whole region.
- Productivity and water quality of other water sources (springs and wells), which deteriorate due to over exploitation and deepening water table. Water sources are subject to intense pressure and yet, the pressure is likely to be aggravated in the coming years (Isaac, J., 1994).
- Future prospects and growth in agriculture activity, which is supposed to grow as a result of development initiatives. Important to emphasize here is that the value of marginal productivity of water is much higher in productive sectors other than agriculture (see Shetty 2006). This will no doubt be increasing pressure to allocate water away from agriculture to industrial and other productive uses as well as to increase irrigation efficiency in terms of more crop per drop.

### **3.6. Efficient allocation of irrigation water is possible with proper planning**

Efficiency and equity of the different water allocation systems can be judged according to certain criteria such as: Flexibility between uses; security of tenure for users; payment of real opportunity costs to internalize external effects; Predictability of outcomes; equity; political and public acceptability; efficacy in achieving policy goals; Administrative feasibility and sustainability (FAO 2004, P. 44). These principles need to be observed by the different actors and particularly by the policy makers at central level and decision makers at farm level.

Water allocation efficiency is not the responsibility of the farmers at farm level alone, but more crucial is actions and decisions prior to the inflow of water into the farm. (Mattiuzzi, V., 1994) expressed this well in saying '...its (waters') usefulness has to be implemented by a mix of different actions that have to start well before the mere irrigation activity.'

Imperative is to work out a balanced and sustainable water use plan based on the value of water over time and to increase water use efficiency, productivity and improve farmers' well-being. Three issues are of crucial importance, namely Governance, institutional reform and integrated irrigation water management strategy.

#### I. Governance conducive to sound, responsible and knowledge-based decisions:

Strategic water planning must be done in full recognition of the political and economic realities of the region, and must progress in concert with the implementation of well conceived plans for economic development, environmental protection, and, with the careful resolution of the political uncertainties (see McKee, 2005).

Agriculture water management must recognize the political sensitivities relating to water access, use and other competing allocation opportunities as well. Many factors need to be integrated to achieve efficient outcomes with respect to the spring's water management.

## II. Institutional reform:

Water institutions are not just Regulatory Agencies (see McKee, M., 2005). They have a dynamic and crucial role to play. Sustainable water management improvements require significant adjustment in institutional arrangements. Little has been done to restructure irrigation agencies or expand private sector participation ([www.worldbank.org/agsourcebook](http://www.worldbank.org/agsourcebook), 2006). Institutional reform involves redefining responsibilities and core activities of relevant organizations to create a clear and viable focus on important issues including pricing, distribution, capacity building, monitoring ...etc...

An integrated water management system is possible only with active involvement and participation of the spring's riparian, which indicates the pivotal importance of Building and empowering ESIC as Water Users Association WUA.

WUA (ESIC) needs to be recognized as a legal entity that can enter into contract and have power to enforce rules and regulations for the sake of its members, i.e. the time-share holders. WUA can assume the responsibility of water distribution, fee collection, maintenance, conflict resolution, and representing farmers.

Transfer of responsibility for the operation and maintenance of irrigation scheme from governmental agencies to farmer/irrigator operated "Water User Association", the so called "Irrigation Management Transfer" IMT (FAO 2004, P 66) can not be successful in the absence of secure rights both to water and land (see FAO 2004, P 70). But, a transfer of water rights management to WUA would be very helpful and effective, and may soon require an additional by-law in order to better define these transfers of responsibility (Van Aken, M. 2007, 147).

## III. Integrated Irrigation Water Management Strategy:

*A. Dispatching water use from water rights:* or depersonalizing the water distribution and keeping the water rights is possible and will certainly have significant impact on the water use efficiency at (micro-) farm level and more obviously on the aggregate spring system. One way of doing this is through creation of a special fund (*sundouk*) run by the ESIC to manage the financial part of the agreement. A sort of group agricultural insurance for the spring partners is a further improvement and guarantee for proper implementation.

*B. Deal with water as an economic good:* Market based proposed water management arrangements must seek to satisfy the two goals, i.e. water use efficiency and financial soundness. Recognizing water as an economic good requires a well-informed water pricing system and perhaps the establishment of a quasi-market for water. Economic theory argues that water is allocated efficiently if the true price is paid. Implementation of a quasi-market mechanism, such as permit trading, can establish a win-win situation wherein all parties (water insecure farmers and over-watered farmers) benefit economically more than they otherwise might from the allocation of a rigidly fixed quantity of resource. Important here is to distribute based on demand and not incinerating irrigation decisions based on water supply.

*C. Transparency and farmers' participation:* A more integrated approach to Water Resources Management requires enhancing stakeholder integration and involvement, improving access to and use of quality information and mainstreaming information and knowledge-based decision and policy making. This involves the active participation and interaction of farmers in decision making, monitoring and sanctioning.

#### **4. Conclusions**

Spring peculiarities are not well-considered in decision making, particularly in allocation of water among different uses and different crops, including springs discharges overtime, quality of water ...etc. The gathered data illustrates that extension messages are not farm specific. Imperative is to tackle the spring as a unique system with interrelated ecological (water), technical (distribution), and socio-economic dimensions.

Less efficient water uses prevailed that were carried out by individuals with no or very little planning. As a consequence, a series of socio-economic problems have risen and are subject to escalation. These can, and must, be solved to achieve sustainable and efficient water use of the spring system, particularly for irrigation purposes.

The study shows that the problem is not simply a technical one and associated with the spring or the water conveyance system but softer and linked to the socio-economic context and institutional arrangements which has much to do with the water rights, distribution and management of the spring system. Even at the farm level, there is much to be done with empowering the farmers and their collective work and strengthen their bargaining power.

The need for a strategic plan as a dynamic tool which identifies, defines, and describes the implementation process. It should be written to provide a vision, clear objectives, and clear activities to achieve these objectives and need to be worked out in full participation, involvement and backing of all stakeholders, particularly the farmers.

The water management and pricing policies must recognize these critical and crucial points such as to maintain the water rights of the beneficial farmers as a top priority of any induced water management strategy and policy; less drop per crop, i.e. efficient water use at farm level depending on crops technical water requirements, balanced agriculture inputs, and less water losses; water prices to promote adoption of water saving techniques and technologies and improved availability and stability of water supply (water safety); a proper pricing of water and security of tenure for users (water rights) is a challenge to be taken seriously if sustainability of the system is sought, not only the water per se.

Research and training is the key to form the knowledge-base and sharpen capacities to develop models, policies and programs to be implemented in irrigation management.

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