SOCIAL AND ENVIRONMENTAL CONSTRAINTS TO THE IRRIGATION WATER CONSERVATION MEASURES IN EGYPT

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ABSTRACT

The present study takes a closer look at the irrigation water saving measures, which are being or can be applied in Egypt and represents them in the light of environmental and social perspectives. The irrigation water pricing and efficiency measures are the main focus of the study. The thesis investigates the relations between different variables involved in water conservation and how they interact with each other. As it will be shown, the controversial character of water saving measures does not always allow for the matching up of all interests embraced in water saving. A major objective of this study is to understand to what extent the water conservation measures can have the potential to level up the demand-supply imbalance and at the same time meet the social, environmental and economic interests of society. Can these measures be effective enough and acceptable in the country for achieving the multiple objectives of water conservation: agricultural production and social welfare without compromising one of them? This is discussed using the example of Fayoum governorate, representing the country's problems at a small scale. The scope of this paper is restricted to the environmental and social implications of the water saving actions leaving out the issues of the policy instruments and economic efficiency. A systems analysis approach was used for the identification and characterization of the relationships between social and environmental aspects of water scarcity and water conservation issues. The analysis is partly based on materials obtained during the fieldwork and includes interviews with officials of Egyptian government, NGOs and farmers in addition to the projects and reports of Ministry of Water Resources and Irrigation of Egypt.

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ABBREVIATIONS

CLD	Causal Loop Diagram
DRI	Drainage Research Institute
DWIP	Drainage Water Irrigation Project
FAO	Food and Agriculture Organization
FEDA	Friend of Environment and Development Association
GOGCWS	General Organization for Greater Cairo Water Supply
HDR	Human Development Report
IWRI	International Water Resources Institute
MWRI	Ministry of Water Resources and Irrigation of Egypt
NWPSWD	National Organization for Potable Water and Salinity Drainage
O&M	Operation and Maintenance
ORDEV	Organization for Reconstruction and Development of Egyptian Village
UNEP	United Nations Environmental Program
UNCCA	United Nation Common Country Assessment
WUA	Water User Association
IIP	Irrigation Improvement Plan

1 INTRODUCTION

Just a simple look at the world map provokes an illusion of an abundance of water resources. But the illusion vanishes as soon as our cognitive side escapes from deepness of blue marks representing the ocean and turns the look first to the green-blue valleys of the Amazon and to the very contrasting desert lands of Africa pointing to an extremely uneven distribution of the water resources on our planet[1]. Nearly 97 percent of water is salty seawater; another 2 percent is locked in ice caps and glaciers. Only 1 percent of it holds the hopes of over 6 billion people for the food that must be grown, the industry that must be run and the decent life with its needs of drinking water and the proper sanitation and other domestic uses. (UNEP)

One can fall into the same illusion of abundant water resources while passing by the water rich Nile and the lands alongside the river, which are sinking in green and often carry the traces of water on the soil after irrigation. This illusion does not last for long when the pictures of green fertile lands are changed by desert or crowded residential areas indicating the limited land resources and large population with its rapidly growing demand on water and food. A slight look at statistics provokes even more concerns. The figures point to the water stress with 950 cubic meters available water per capita. Statistics place Egypt among the countries where the water stress in the near future tend to drop under water scarcity thresholds decreasing to values of 670 cubic meter for 2017 (UN CCA, 2001).

The land once called by Herodote "the gift of the Nile" is experiencing a population boost, which threatens with enormous social, economic and environmental problems under conditions of declining per capita water resources.

The objective of this study is to understand to what extent the water conservation measures have the potential to level up the demand-supply imbalance and at the same time meet the social, environmental and economic interests of society. The controversial character of water saving measures does not always allow for the matching up of all interests embraced in water saving. The present study tries to take a closer look at the irrigation water saving measures such as efficiency, water pricing and reuse which are being or can be applied in Egypt. The aim of the study is to identify possible social and environmental constraints for the implementation of such measures and find out if they can meet sustainability objectives. Thesis investigates the relations between different variables involved in water conservation and how they interact with each other. It will be discussed using the example of Fayoum governorate representing the country's problems at a small scale. The scope of this paper is restricted to the environmental and social implications of the water saving actions leaving out the issues of the policy instruments and economic efficiency.

The study argues that imposing the charge for irrigation service without setting an institutional framework, clarifying the property rights would meet problems especially considering the farmer's current low trust in the system. Improving service, building drainage canals and delivering the information of the water reuse practices could ease the acceptability of charge for irrigation service.

The dilemma of the choice between present welfare and future generation rights is part of this complicated issue. As it will be shown throughout the discussion, the choice does not always represent only the concerns for future generation but is often linked to the present generation's welfare and retaining the political power as well.

The issue of implementability of irrigation water pricing policy in the developing country context provoked special interest to Egypt. Egypt has been managing its agricultural lands using irrigation methods since 5000 years. This country is known with its absolute dependence on irrigation

[1] Sandra Postel uses the notion "illusion of plenty" in her book Last Oasis (1997). I refer to the same notion based on my impression from the field trip, which conformed that this illusion does exist even in water short countries.

water, heavily subsidized water provisions and considerable strain from population growth. During the study many problems came up in context of pricing such as drainage water reuse and irrigation efficiency issues that have a direct connection to the water pricing measures and will be widely discussed throughout the study.

The thesis is presented in 7 chapters and was conducted in the following way. Chapter 2 gives the background information of the water scarcity and conservation measures discussed in the following chapters. It sets a theoretical framework for the study. The next chapter gives an overview of the methods, which were used for assessing and analyzing the information. Chapter 4 identifies the driving forces of water scarcity in Egypt and sets the background for analyzing the social and environmental limitations of water conservation measures. The issue of the constraints is reviewed in details in chapter 5 and finds further discussion in next division 6. In part 7 are given conclusions of the study.

2 THEORETICAL BACKGROUND

2.1. Water scarcity

> *"We are currently on the threshold of a serious water shortage" (Martinez, 1994)*
> *"Fresh water available for human consumption, for social, economic and cultural needs and for environmental requirements is rapidly becoming scarcer." (Abu-Zeid, 1998)*
> *"There are finite amounts of water that must be shared in common between various sectors, regions, and their users". (Johansson, et al., 2002)*
> *"Water shortages and needs are increasing, and the competition for water among urban, industrial, and agricultural sectors, as well as other resources users, is growing more intensive". (Hamdy, et al., 2003)*

Pictures drawn in most studies, concerning the water issues, are gloomy and alarming. Future estimations of per capita available water resources forecast water scarcity already in a near future. Especially dull look the projections for developing countries, the ones with high population growth and limited availability of fresh water resources. Areas at risk do include some regions of developed countries as well. (Martinez, 1994; Abu-Zeid, 1998; Hamdy, et al., 2003) Just 50 years ago absolute majority of a population had abundant fresh water resources per capita, except a few of the less fortunate countries. The situation since then has been changed dramatically and the list of countries suffering from water shortages expanded to 26 in total with population of 300 millions. (Abu-Zeid, 1998)

Countries are subjected to water scarcity conditions if the " population has suppressed the level that can be sustained comfortably by the available water" (Postel, 1997) If average total supplies per year are slightly higher than 1700 cubic meters[1] countries suffer from occasional or local water problems. If the water availability per person drops below this threshold, countries are considered as water stress regions (Postel, 1997). When per capita water use falls below 1000 cubic meters, countries undergo a chronic water scarcity with a "…significant and often severe restriction on material welfare at individual level and on development prospects at national level" (Myers & Kent, 1998). Less than 600 cubic meters of water would mean absolute water scarcity. Mohamed and

[1] The figure includes the water use for household, industrial purposes and for food production needed for one person.

Savenije (2000) characterize this level of per capita water availability as the water poverty limit. For 2025 about 3 billion people are expected to have less than 1700 m^3 of water per capita (Hamdy, et al., 2003).

The main users of water resources are agriculture, industry, and households. A major consumer of all fresh water withdrawals is agriculture sector; especially this is the case if the agriculture is irrigation-based. Therefore, serious disturbances in provision of adequate water supplies for food production puts at risk the basic needs of human livelihood. The food production takes up to 70 percent of all fresh water withdrawals per year (Abu-Zeid, 1998). As the agriculture is the basis on which the development of other sectors of the economy relies, the water stress and water scarcity conditions put whole economy at risk. First of all the water shortages will impose the major problems to the most vulnerable parts of the society restricting their ability of food production (Abu –Zeid, 1998). Water withdrawal for irrigation purposes is expected to increment only by 4 percent versus to the non-irrigation uses, which are predicted to increase by 62 percent due to population growth and rising per capita domestic water use. This will endanger the food security levels of countries heavily dependent on irrigation agriculture. (Rosegrant, et al., 2002) "Experience leads us to the fact that to feed 2 billion people water supplies used in agriculture will have to be augmented by an additional 15–20% over the next 25 years, even under favorable assumptions regarding improvements in irrigation efficiency and agronomic potential to meet food requirements. This will amount to an additional 0.6–0.7% of water supply per year"(Hamdy, et al., 2003).

The irrigation agriculture, which helped to increase food production rates, to stabilize and make the yields less vulnerable to the natural conditions might meet great constraints imposed by water shortages[1], especially for countries with high population growth rates. (Kijne, 2001; Hamdy, et al., 2003) Currently 18 percent of total arable land of our planet, which is under irrigation, produces 33 percent of the global food (Johansson, et al., 2002). Ongoing trends of water transfers from agriculture sector can further endanger the food production levels on irrigated lands pushing countries to increasing the food imports in order to meet the local food demands. (Kijne, 2001; Hamdy, et al., 2003)

A competition from other sectors reduces the availability of water for irrigation purposes. Agriculture is losing its existing supplies to domestic use and industry. Already observed trend of transferring the water resources to the domestic and industry sectors will remain the same as the agriculture accounts for the low added value user and becomes difficult to compete with other high value added users such as for example industry or service sectors. (Abu Zeid, 1998; Johansson, et al., 2002; Hamdy, et al., 2003)

The irrigation agriculture as the major user of water is recognized to be the main source for additional water. System efficiency improvements might meet one half of water demands by year 2025 (Johansson, et al., 2002). It would increase the water productivity, as the crop production per volume of water will rise. (Kijne, 2001)

[1] So for example in Egypt before building high Aswan dam (Which provides irrigation water year round)" river basin irrigation only allowed for one crop per year in large areas. Now perennial irrigation allows on average 2 harvests all over the Nile valley and Delta" (Holmen, 1991)

2.2. Subsidies

Despite the fact that availability of water resources is declining year by year and in some regions countries already are experiencing water stress, wasteful practices of irrigation are widely spread. As the practice shows the lack of proper incentives discourages the promotion of water saving technologies and changes in land management. Subsidies are responsible for “failure to value water at anything to its true worth” and underpricing assists in anchoring believes that water resources are plenty and abundant. (Postel, 1997) Heavy subsidies for irrigation are not only a luxury the developed countries’ farmers benefit from, but the practice of undercharging is widely spread in developing countries as well. The most challenging is the fact that the free of charge approach for irrigation service is used in countries, which have high risks of acute water shortages in the near future. (Postel, 1997; Myers & Kent, 1998)

The main reason behind the irrigation subsidies lay in social and economic objectives the governments are aiming at: to provide the water for farmers regardless of their disparate income levels. (Johansson, et al., 2002) It has been used to promote growth in agriculture and other sectors of economy as well (Rogers, et al, 2002). The subsidies in the irrigation sector have aimed at sustaining the agriculture economy, ensuring the self-sufficiency of farmers in developing countries. Almost free accessibility to the irrigation service boosted water demands and discouraged farmers from investing in efficient technologies and carrying out water saving practices. (Postel, 1997; Rogers, et al, 2002)

Another negative effect from irrigation subsidies pointed out in studies, are the low self-sufficiency of the irrigation sector. The cost recovery is not enough for operation and maintenance of the system, let alone the repayment of investment costs. Lack of funds in irrigation sector is compensated from the public funds diverting money from other projects and programs. Especially negative could be outcomes of such actions in countries with budget deficits. (Postel, 1997) Environmental consequences from the water overuse enhanced by irrigation subsidies lead to such problems as water logging, soil salinization and other forms of environmental degradation (Postel, 1997; Myers& Kent, 1998; Sur, et al, 2002) Therefore removal of subsidies is considered to be an effective mechanism for avoiding the water overuse and environmentally harmful practices connected with the over extraction of groundwater and depletion of aquifers. (Rogers, et al., 2002) The main argument against such measure is the equity consequences of subsidy removal because it is suggested that the poor will be deprived in secure access to the water needed for food production. On one hand it might generate the water conservation but at the expenses of certain groups of citizens who might be deprived in the basic needs. The water pricing mechanisms are not considered effective enough in redistributing the income. Authors of studies point out the need for adoption of different pricing mechanism in order to “account disparate income levels (Johansson, et al., 2002). Mohamed and Savenije (2000), recognizing the needs for efficiency improvements, emphasize also the fact that basic needs should not be sacrificed, since the main objective of efficiency increase is not restricted to the economic benefits only but it must ensure socio-economic net benefits to whole society.

Many authors emphasize the fact that poor already do spend a considerable part of their income on pumping the water from groundwater to compensate the unreliability of water supply. In these studies authors consider this as a good measure for farmer’s willingness to pay for the proper service (Myers & Kent, 1998; Rogers, et al., 2002; Ahmad, 2002).

There is another factor which makes the subsidy removal difficult task, as mentioned by Perry (2001) “In most developing countries, the agricultural sector is politically sensitive, sometimes even dominant. Changes that will reduce farm incomes are viewed with great caution by politicians.” This will be discussed later on.

2.3 Conservation measures

Limited supplies of fresh water create an urgent need for rationalizing the water use, but the ways aiming at the optimal use of water differ and are complex. Before reviewing different water saving measures let us take a look at the concept of water conservation itself. Defined by Bauman water conservation is any socially beneficial reduction in water use or water loss. (Tate, 1994) The main objectives of water conservation pointed out by Bau (1994) are as follow: "reducing the demand for water by fostering water conservation habits, stopping wasteful uses, decreasing peak consumption and charging for water at the appropriate rates. It also means taking advantage of technological developments and improved management techniques; coordinating water resource planning and management with land-use planning and economic and social planning; and establishing new or updated standards and regulations. In short, water conservation means optimal water use. It should be stressed that except in drought or other exceptional conditions, a water conservation policy is not intended to enforce arbitrary cuts in water consumption levels at the expense of the quality of life of the population. Its main purpose is different: the efficient use of a limited resource, which is essential to life". Water conservation can be implemented through effective water resources management, which involves both supply and demand side management measures. Supply side conservation measures would include the efficiency improvements in water extraction, transmission and conveyance, its reuse, whereas the demand side conservation measures seek for demand regulations through public education and effective water use practices. (Bau, 1994; Postel, 1997) The other measures, which would enhance demand side conservation, are economic instruments such as taxes, quotas and water pricing.

Water pricing has many constraints. First of all it is the cultural perception, believes sanctioned by religion and tradition, which perceive water not as commodity but one of the basic human needs. Thus the perception of water as a non-commodity resource persists to the increasing or introduction of charge for irrigation services (Abu Zeid, 1998; Perry, 2001; Rogers, et al., 2002) Water pricing is considered important strategy for water conservation purposes as it will be allocated for most valuable uses and avoided the waste of resources.

The objectives of water pricing simply can be shown with the following causal relationship:

Pricing ⟶ **efficient allocation** ⟶ **meet increasing water demand**

The main objective of the water pricing policy is maximizing efficient allocation of water resources, promote conservation but at the same time it should not compromise the social objectives such as affordability of water resources. (Rogers, et al., 2002) According to Rogers, the full price of water consists of operation & maintenance cost together with capital charges, adding economic and environmental externalities. However, nowhere is paid more than operation and maintenance cost. Different methods have been used for pricing, which can be placed in four major categories: volumetric pricing, non-volumetric pricing (based on land size or crop cultivated on land), quotas and water markets. (Johansson, et al., 2002) The current study is focusing on the first two pricing mechanisms leaving out the quota and market considerations.

Water pricing policy as an effective measure for water conservation provokes some doubts, as the practice does not confirm emergence of water saving habits among farmers if the prices fixed per hectare. In this situation the cost for maintenance and operation might be recovered but the main target of water saving is not achieved, as farmer does not have incentive for optimizing the water use. Only high prices would result in substantial water saving levels but last will compromise the social welfare of user groups. Suggested best pricing mechanism is volumetric pricing, according to delivered water quantities. (Perry, 2001; Ahmad, 2002; Yang, et al., 2003).

The present study tries to analyze the possible environmental and social constraints of irrigation water conservation measures stemming from the subsidy removal and introduction of cost recovery charge for the irrigation service in Egypt. The main core mechanism which should lead to the water saving is presented in figure 1. Step by step study will examine each link and see how the causal relationships are limited and what are these limiting factors in case of Egypt. Even though the main goal of the conservation measures is the water saving, it does not imply that other factors involved in water saving will be affected as positively as the water supply system. Therefore each of the variables must undergo the sustainability test to prove the overall positive effect for whole society which embodies not only need for economic development but environmental and social security as well.

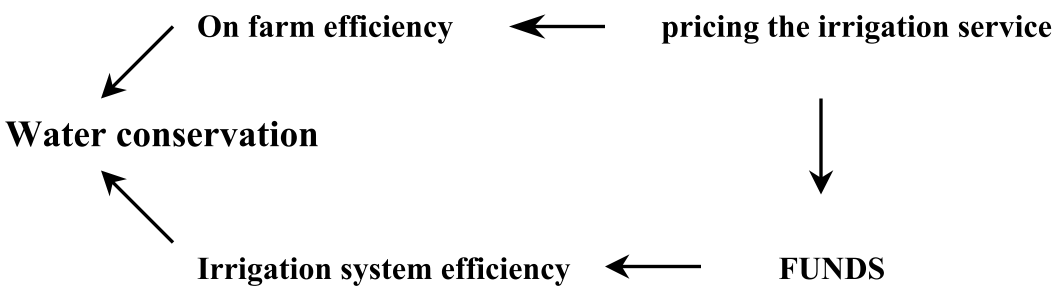

Figure 1: The causal relationship between pricing and water conservation (Pricing of irrigation service should encourage the investments in efficiency increase on farm, which would lead to rationale water use. At the same time the cost recovery would add capital to the funds and ensure the investments for improving the operation and maintenance. The last would increase the irrigation system efficiency in whole. This would result in achieving the main objective – water conservation)

2.4. Sustainability

To evaluate the effectiveness of conservation measures, present study takes an attempt to use sustainability criteria for evaluation of the current state of irrigation water availability in Egypt and situation, which might occur while implementing the water pricing policy.

Simple explanation of sustainability concept would refer to importance of living within the carrying capacity: "capacity of ecosystem in the size of population or community that can be supported indefinitely upon the available resources and services of that ecosystem... A community that is degrading or destroying the ecosystem on which it depends is using up its community capital[1] and is living unsustainably" (Encyclopedia of sustainable development) Human Being can be supported only if availability of crucial resources are ensured and protected from deterioration, but at the same time social welfare must be improved for billions of people who would enjoy better life generated by sound economic growth and fair distribution of the wealth. Sustainability of society is up to achieving multiple goals and not only one of them. Sustained welfare of human kind can be maintained and further develop only if sound conjunction of three main basic aspects of human society is in place: economic development, social welfare and environmental quality. (UN Division for Sustainable Development, 2003) The most difficult is to find the balanced approach, which would avert society

[1] Community capital includes: natural, human, social and building capital (Encyclopedia of sustainable development)

from trade-offs between the economic, social or environmental interests and interests of the future generation. (UN-CSD, 2003) This is especially important in case of developing countries. There is big challenge for societies to improve the social conditions of their population and ensure economic growth but not compromise the environmental interests. The sustainability concept requires an holistic approach including many aspects that drive society and long time perspective in decision-making. In discussion part it was taken an attempt to use the sustainability concept for evaluation of the conservation measures in Egypt, which are analyzed in chapter 4 and 5.

3 METHODOLOGY

The study was conducted in three steps: First, preparation for the field trip included collecting relevant literature addressing the issue of subsidies on irrigation water and possible environmental effects enhanced by water subsidies in Egypt. The issue of water subsidies promoting wasteful practices and planting water intensive crops, sounded challenging in Egyptian reality. There was a need to find a strong justification for governmental actions as well as supporting and opposing materials. As it is known, water saving can be enhanced through imposing a charge on irrigation water as discussed in many sources (Dinar & Subramanian, 1997; Bazza & Ahmad, 2003; Ahmad, 2000; Massarutto, 2003). The main initial question of the present study was effectiveness of this measure and its social acceptability. However, during the fieldwork the issue of specific environmental limitations of the water pricing and other conservation measures were given greater importance. The second step was the field trip to Egypt itself that was carried out in July 2003 in Cairo and Fayoum. On the last stage obtained data was analyzed and presented in current study.

Following sources of the data were used for the study: material from journals and books, interviews, projects and reports of the Ministry of Water Resources and Irrigation of Egypt. Literature review gave the background information and facilitated in building the analytical framework and theoretical background of the study. The empirical data obtained from the different sources during the field trip and literature review are used to understand how different dimensions of water saving measures interplay and to what extent. Figures and tables are used to illustrate the constraints that accompany implementation of each measure.

Data collected during the field trip and the material reviewed was broken down into the following processes: a) assessment of information about scarcity and water conservation of issues in Egypt; b) analyzing and comparing data; c) drawing the linkages and tracing the relations between the different factors involved in the study subject;

The materials were investigated using the systems analysis approach, mapping the mental models with the help of a Causal Loop Diagram (CLD). Systems analysis was considered most appropriate for analyzing and structuring driving forces underling the water scarcity problem. It was used for the identification and characterization of the relationships between social and environmental aspects of water scarcity and water pricing issues. Later it was applied for exploring the interactions between different variables involved in system as well.

Analysis of water conservation measures such as drainage water reuse was performed using the following data obtained from collected materials: a) the environmental parameters: water quality, soil salinity b) the social parameters: income, consumer behavior and cultural perception of water.

Data presented in the discussion and the conclusions drawn from it are mostly based on one source. It is understood that information, which is obtained from the official institutions, somehow supports the position of the ministry regarding the unacceptability of water pricing in Egypt and could be considered as a limitation of the study.

Procedure

On the first stage of reviewing the material regarding the irrigation water subsidies and collecting the data about environmental impacts from overirrigation was difficult because of lack of country specific data. The information I managed to find was poor. In order to understand the context of the irrigation water subsidies in Egypt and constraints of water pricing, it was necessary to take a closer look at the process in Egyptian reality. During the field trip I became more familiar with the situation in irrigation and interviews and discussions helped me to see more aspects involved in the picture of water saving that previously were invisible to me. For example the environmental aspects of my thesis that initially focused on salinity problems induced by overirrigation did not find confirmation in Egypt. Moreover, it was suggested to be a necessary measure for avoiding the soil salinization. This approach to the issue of soil salinity after the field trip was transformed into the issues of water quality and soil salinity caused by drainage water reuse and underirrigation. The subject of Egypt's low efficiency, which I intended to discuss in thesis, contradicted the data I was provided during the interviews and later in obtained materials. The controversial character of the figures made it necessary to analyze the approach taken for the calculations and discuss a problem of definition itself.

In order to have reflections of the water-pricing problem from different interest groups in the government of Egypt, interviews were carried out with officials from different ministries such as the Ministry of Water Resources and Irrigation (MWRI) and the Ministry of Social Affairs. I had discussions with representatives of Ministry of Environment and Institute of Drainage as well. Interviews were held also with an NGO dealing with environmental and sustainability issues and a professor of Cairo University from the department of irrigation engineering and my co-advisor Dr. Reda Haggag (Cairo University) as well. All interviews were organized with the help of my co-supervisor from Cairo University. Government and NGO representatives who were interviewed had direct or indirect involvement in the water saving issue.

Figure 2: Map of Egypt (source: online maps)

The interviews were semi structured focusing on three topics: water conservation measures that can be applied in Egypt, effectiveness of irrigation water pricing and its possible consequences for Egyptian society and constraints for implementation. The issue of subsidies was raised during interviews as well.

At the last stage of the field trip I faced unexpected difficulties. I intended to interview the farmers in Fayoum governorate. Fayoum is located 100 km southern from Cairo. International organizations were active in this region and data and materials are available. The region was chosen for study because it met the following criteria: salinity and drainage water reuse data was accessible, the region represents the water shortage problems that emerge due to over population, unequal distribution of water along canal and land expansion plans. All this embody country problems on smaller a scale but it includes additional factor that was interesting to look at – the existence of the

Water User Associations (WUA) with its effects on irrigation service performance and tackling the dilemma of unequal distribution of irrigation water.

The obstacle was the formal requirement that exists for foreigners and demands to apply for the approval of interview conduction. I and my interpreter, who helped me with the interviews in village Byahmo, were not informed about this condition before. Only after a few days it became obvious that without the permission from a few ministries interview with farmers could not be held. Since I did not have too much time left for my field trip and receiving the approval would take much time I decided to conduct the interview totally with the help of my interpreter for whom receiving approval from local government would take less time.

The study involved the interviews of six farmers and was conducted in the village Byahmo in Fayoum Governorate. The interview was carried out with a structured set of questions addressing the following issues: conditions which were acceptable for introducing charge for irrigation service, awareness of the problem of water shortage and its effects, their opinion about effectiveness of WUA. The respondents were differentiated by land size, location, and distance from the head of the canal, the land ownership and education. It was assumed that the answers and attitudes would be influenced by the above listed factors.

4 WATER SCARCITY IN EGYPT

Per capita fresh water availability in Egypt dropped from 1 893 cubic meters per person in 1959 to 900-950 cubic meters in 2000 and tends to decline further to the values of 670 cubic meter by 2017 and 536 by 2025 (UN CCA 2001; MWRI, 2002a; Abd-El-Hai, 2002). The main reason behind this rapid fall is the fixed water resources and the raising pressure from population growth. However, there are other factors more important in escalating the water issues in Egypt. They will be discussed in this chapter.

Here are presented the main driving forces of water scarcity. Some of the factors do not show direct linkages to the problem but have great contribution in establishing water stress conditions. So the driving forces are categorized in four different subgroups: social, economical, political forces and physical variables. First are presented social forces, next are physical variables, followed by economic and political forces.

4.1. Social forces

Egypt occupies slightly more than one million km^2, but only 6 percent of total land area is suitable for settlement, the rest of the area is desert. About 60 thousand km^2 of the land that covers the Nile Delta and Nile valley is home for 67 million people. The annual population growth rate is 2.1 percent. If the trend of population growth remains the same, the number of inhabitants of Egypt for 2025 will rise up to 95 million. (UN CCA, 2001) The country's fresh water supply has to deal with rapidly growing demand on the water for domestic use. Presently there are still 9-20 percent of people in different governorates to be provided with piped water and from 6 to 27 percent in need of proper sanitation (HDR, 2003). The water provision for agriculture sector has to catch up with increased needs for food as well, which place additional pressure on the water supply.

Due to the above mentioned population boost, available fresh water resources per capita was subjected to drastic changes during the last 50 years. It was reduced by half and the opportunities for future supply are not sufficient enough to support rapid population growth. Future projections are giving the figures far below of water scarcity thresholds. The population growth is escalating the water scarcity in Egypt but is not the single reason. It is a far more complicated issue involving many other aspects of social life and personal behavior.

The social forces can be viewed at four levels. Figure 3 presents the different layers of the social forces that contribute to escalating the water scarce conditions over time. Impacts of population growth and improved life quality will occur later, whereas poverty, unequal distribution, cropping patterns and consumer behavior contribute to emerging of water shortages already in present. Water stress influenced by those factors has discreet character in space even within boundaries of one village. Each of the factors is discussed in details in following sections.

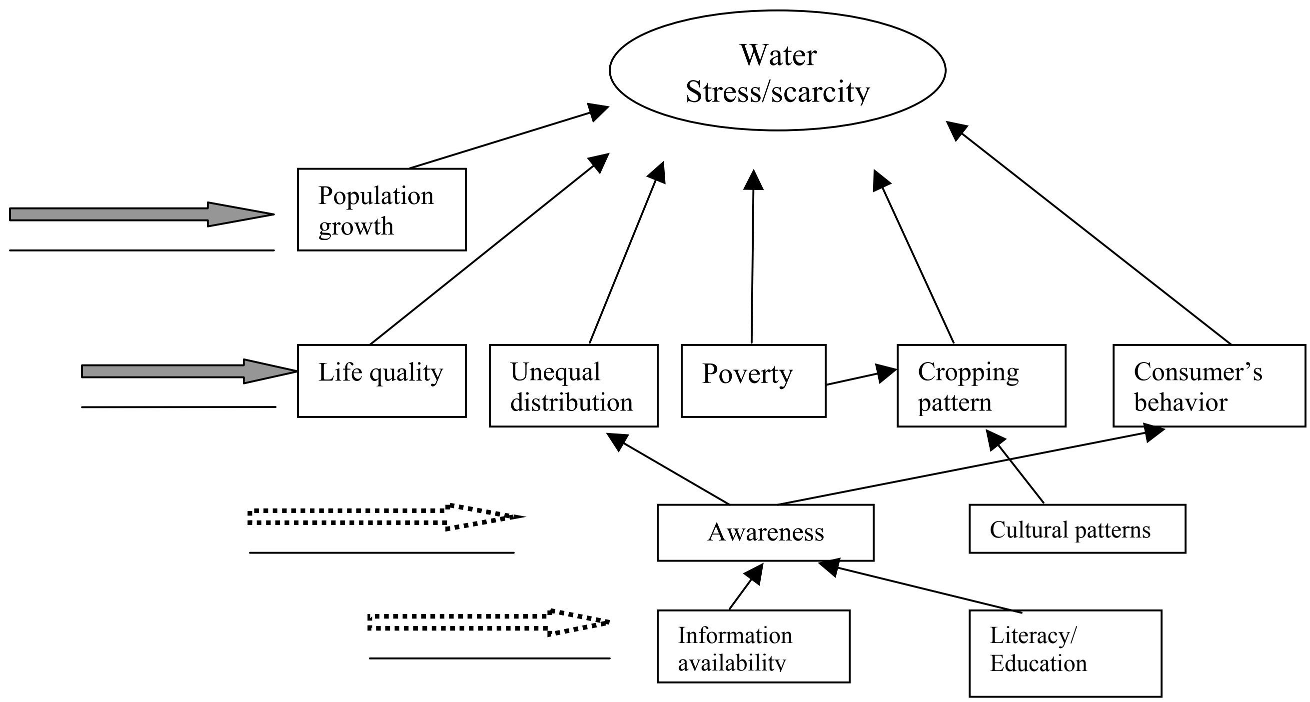

Figure 3: Different levels of social forces affecting enhancement of water scarcity conditions[1]

4.1.1. Quality of life

Accelerated economic growth in Egypt during the last decades is reflected in a better quality of life. The main indicators of living standard have improved remarkably over the last 30 years. Social and human development programs and health services have made advances in life expectancy, which has been increased from 55 years in 1976 to 67.1 years in 2001. Infant mortality was subjected to more

[1] Social forces were selected in relation to the water scarcity and can be viewed at two levels **according to their contribution in emergence of water stress conditions**. Major cause is population growth, which is followed by farm level conditions: life quality, poverty, unequal distribution, cropping pattern and consumer's behavior. These are influenced by factors such as awareness and cultural patterns. Next layer of interdependence is information availability and literacy/ education.

than three fold reduction during the same period. There has been observed increasing in the ration of population with access to the piped water to 91.3 percent in 2001 compared to 70.9 percent in 1976. Almost 100 percent of urban households have access to sanitation facilities against 78.2 percent in rural areas (HDR, 2003). The access to sanitation has been subjected to advancement during the last 20 years (UN CCA, 2001). However, the average figures hide behind great disparity between the regions in access to piped water and sanitation. For example in the Fayoum governorate 79.6 percent of population are supplied with piped and 18.6 percent do not have access to sanitation. These figures are among the lowest in the country leaving room for further improvements in life quality. Improvements can impose additional constraints to the water supply in Egypt spiraling upward the consumption levels.

Advancements in living standards together with population growth have already been reflected in expansion of water consumption levels for domestic use. Water use grew from 3.1 BCM in 1990 (Abu-Zeid, 1991) to 5.23 BCM in 2000 (FAO Aquastate). Further augmentation of the life quality and the population growth will push up water demands.

4.1.2. Poverty

Even though there has been observed changes in life quality, poverty is still problem in Egypt. According to the estimates of Human Development Report (2003) 20.4 percent of the total rural population of Egypt are poor and 6.1 – ultra poor[1]. The frequent poverty incidence in rural part of country points to the concentration of poverty in rural areas. Distribution of poor in country is quite uneven and shows significant differences between the regions. According to the same source, the Fayoum governorate, study is focusing on, has higher poverty rates that reach 35.4. The ultra poor account 10.9 percent of Fayoum population. In some governorates the proportion of poor is as high as 58.1 percent. Often low-income levels and poverty in rural areas trigger the increase of water use through shifting the cropping patterns towards the water thirsty crops (rice, sugarcane). Up to the end of 1970s agricultural sector was characterized by heavy government interventions in the production, trade and prices. The reform in the 1980s resulted in liberalization of prices and government control of the cropping was abolished. As a result of reforms there some changes in cropping patters occurred favoring production of high value added crops. Among them are rice and sugarcane with highest water requirements among the crops cultivated in Egypt. For example annual production of rice rose from 2.4 to 4.5 million tons (UN CCA, 2001) and fields of rice expanded almost by 50 percent (from 1 million feddan[2] to 1.5 million) (MWRI, 2002a). The cropping patterns that sometimes lead to water shortages serve the welfare interests of rural families. According to the UN CCA (2001), 57 percent of population lives in rural areas major part of which are engaged in the agricultural activities. As the whole agriculture is totally dependent on irrigation, it becomes the largest user of water resources. Its share in water use is as high as 83 percent (UN CCA. 2001). Agricultural activity is still a key source of income for majority of the rural population.

Expanded fields of rice require additional amounts of water for agriculture and therefore rice cultivation is limited by state. However, the fields of rice some times are out of control and there are observed violation of the quotas determined by government. Even though official reports explain increase in the cultivated rice areas by the increase in Nile flows during the 1990s (MWRI, 2002a), the

[1] The poverty line used in HDR 2003 for rural area is 3963 LE (Egyptian Pound). Poor is defined person whose expenditure is less than specified poverty line. Those who are bellow food poverty line (3752.6 LE) are considered as ultra poor.

[2] One feddan is 0.42 hectare

1998 national survey shows that the main reason of crop choice is the profitability of crops. The profit driven explanation seems more relevant in this case if we take into account the poverty levels in rural Egypt. The rice is a high value crop and is likely to be an important contributor in raising the income (Poverty Reduction in Egypt. 2002). So the fields of rice and sugarcane tend to expand and are driven by the welfare needs of farmers.[1]

4.1.3. Consumer's behavior

The water stress conditions are bound to such factor as conscious behavior of the consumer. The last derives from level of education, accessibility and availability of information and cultural patterns. For example in new lands regardless of presence of new irrigation systems, farmers still use flood irrigation (MWRI, 2002a; Bishay, 2003). They prefer the old methods they are used to and resist to the innovations. During one of the discussions in MWRI I was told about another interesting behavior pattern that hinders spread of water saving practices. The short duration variety of rice finds difficulties to expand in rice-cultivated fields in spite of lower water requirement. One of the reasons that was mentioned is the rice taste which Egyptian farmers do not like and refuse cultivation just for taste preference reasons. Another factor, which prevents wide spread of short duration rice, is the lack of information about availability of such varieties. Although the behavior is also provoked by accessibility of inexpensive, almost "free"[2] irrigation water. Here we have to take a look at another determinant of farmers' behavior that is awareness.

In 1998 a national survey of Egyptian farmers was carried out, aiming at identifying the farmer's awareness, attitudes and practices concerning the water resource management. The study shows that about 61 percent of male and 29 percent of female farmers know that available water resources in the country are fixed. Mentioned in introduction the illusion of abundance of resources is widely spread in the country, so only 21 percent of farmers consider scarcity problem that can emerge in future serious enough and 23.6 do not see the problem of scarcity at all. 57 percent of farmers hold the hopes that larger water quota is negotiable. The answers according to the education levels differ significantly showing higher awareness of the problem among higher-educated respondents. Low awareness can be explained with low, 53.1 percent literacy level in rural area (HDR, 2003) and poor accessibility to the information. The literacy levels of females are lower, which is reflected in considerably lower awareness levels. Awareness about water conservation measures is low as well. Farmers are poorly informed about possibilities how to decrease the water consumption. As survey indicates only 20 percent of male farmers and 4 percent of females had ideas about how to irrigate with less water, however about half or respondents are aware of advantages of night irrigation and almost all of farmers use land leveling. (El-Zanaty & Associates, 1998)

4.1.4. Unequal distribution

Unequal distribution of water is another factor that is involved in emerging water stress conditions. It is result of water overuse at the head of the canal bringing less water toward its ends. So the farmers at the tail of the canal and downstream suffer from water shortages and are forced to abandon cultivation

[1] Here one can argue that not only the low-income farmers stand behind the rice filed expansions but profit driven motivation of big farmers can lead to the same result as well. However, here must be noted subsistence character of the farms in Egypt with and average landholdings of 2.6 feddans and 40 percent of farmers hold less than one feddan (Moharam, 2003). Therefore it has been assumed that main contributor to augmentation of high water demanding crop fields is the low income levels, beside the "free water" factor which will be discussed later on in Political forces.

[2] The term "free" is relative and this issue will be discussed in next section.

of some part of their land in order to avoid yield losses, whereas at the head of the canal peasants enjoy the abundance of irrigation water. Interviews with farmers showed that some of them located far from the head of the canal were experiencing the losses of the yield due to underirrigation caused by unequal distribution of water. Unequal distribution of water can be linked to the behavior of farmers who cannot see far going consequences of their actions. So is the abuse and damage of irrigation infrastructure in order to get wider access to water (El-Khashab, 2003). The low cooperation levels and low communication facilities preventing spreading the feedback of downstream farmers to upwards is another aspect of complicated issue.

Farmers cannot always be blamed for their ignorance or low consciousness since the overirrigation practices that lead to water shortages downstream often are induced by unreliability of the water provision in canals. Uncertainty in water availability pushes them to overirrigate, as they are not sure in water delivery next time (Holmen, 1991).

As we see the water scarcity does not have certain time or space limits. Water shortage can occur in present even within the one-village boundaries, hiding behind the abundant fresh water availability at the head of canal. But water scarcity definitely will intensify over time and expand over larger space.

4.2. Physical variables

4.2.1. Water resources

More than 96 percent of Egypt' all fresh water resources is supplied by the river Nile (UN CCA, 2001) which originates from outside of the country boundaries and supplies nine countries among which Egypt, Sudan and Ethiopia are the main users. Fresh water sources from Nile are limited for Egypt by an international agreement between Sudan and Egypt from 1959. The agreement entitled Egypt to 55.5 billion cubic meters (BCM) of Nile water per year and assigned 18,5 BCM for Sudan. (Abu-Zeid, 1991)

A current water demand of Egypt is estimated at 67.47 BCM per year, from which the river Nile provides 55.5 BCM and therefore becomes an almost exclusive source of fresh water for country. The rest of the water requirements are met by a renewable groundwater with 4.8 BCM/year and a drainage water reuse, which is estimated as 4.5 BCM. Treated municipal and industrial wastewater water returns to the closed water system 0.7 and 6.5 BCM respectively. (UN CCA, 2001) From the 55.5 BCM about 3 billion BCM is lost to surface evaporation from the irrigation system (MWRI, 2002a).

For year 2017 water demand is expected to rise up to 87.9 BCM. The rapid growth of demand is planed to be partly supplied with additional water resources that can be obtained from non-renewable groundwater aquifers in the Sinai and the Eastern and Western deserts. (UN CCA, 2001)

Table 1: Present and projected water resources in BCM based on CCA materials

Source	**2001**	**2017**
The Nile	52.5*	55.5**
Renewable ground water	4.8	7.5
Agricultural drainage water	4.5	8.4
Treated domestic waste water	0.7	2.5
Treated industrial waste water	6.7	6.7
Desert aquifers	0.57	3.77
Rainfall and flush harvesting	-	1.5
Saving from management	-	1.5
Total	69.77	87.37

* 3 billion cubic meters of surface evaporation is subtracted

** Including the 2 BCM possibly yield from Jonglei project. Jonglei project in Sudan intended to increase availability from Nile water reducing the evaporation from Sudan's Sudd swamps. Project has not been completed due to conflict in region.

As we see from the table, the water balance for year 2017 can meet the demand if the Irrigation Improvement Plan, drainage water reuse, treated waste water reuse achieve the target figures. The objectives provoke some consideration regarding its implementability. This specially refers to the prolonged conflict around Jonglei project in Sudan leaving little hopes for its termination or drainage water reuse that already in 1990 amounted 4.7 BCM and according to the 1990 study of Adly Bishay had to reach 7.00 BCM in year 2000. Unfortunately as we see from the table1 the figure remains almost the same since that time.

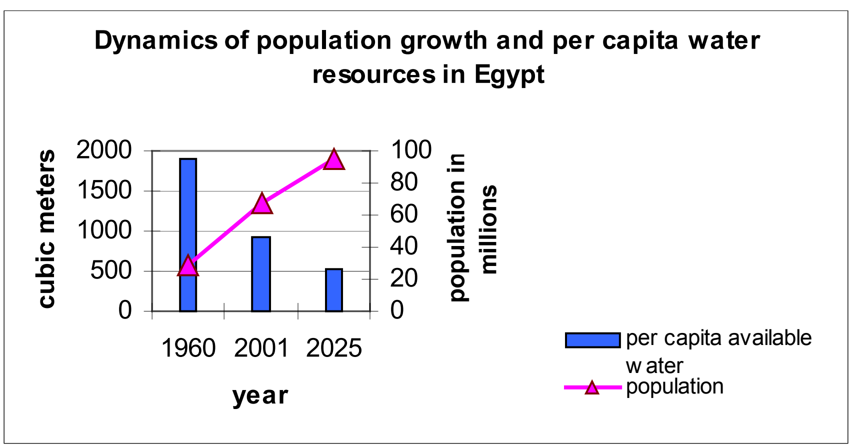

Figure 4: Dynamics of population growth and per capita available water resources in Egypt (Based on the data obtained from Abu-Zeid, 1991 and UN CCA, 2001)

4.2.2. Land expansion

Expected considerable increment in demand occurs in agricultural and industry sectors (Abu- Zeid, 1991) due to further development of manufacturing sector and land reclamation projects. Annual 2.1 percent population growth rate obliges agriculture sector to provide food for larger number of people and this under condition of continuously declining per capita crop area and per capita crop production (MWRI, 2002a). The difficulties in relation to limited land resources are not restricted to the problem of food security but it is linked to the employment issue as well. The rural area is accommodating 57 percent of the population, 50 percent of which is involved in the agricultural sector (HDR, 2003). The food and habitat requirements and increasing demand on job push the government to the horizontal land expansion plans. The last has been considered as a solution for the absorption of population growth and job generation. The Plans promise to add 3.4 million feddans of desert land to the cultivated land area (UN CCA, 2001). The land expansion projects indent to reclaim almost 44 percent of present cultivated land area by transferring the water to the desert lands. This means that at the present water use practices land expansion would place an enormous strain on water supply.

4.3. Economic forces

As supplies fail to catch up the growing demand, competition for water will intensify and not only from domestic water user side. The potential target that might lose its existing supplies is agriculture as the largest water user. The Table 2 illustrates the present water distribution among different economic sectors. Agriculture is the largest consumer of water resources worldwide and so it is in Egypt as well. The annual freshwater withdrawals for agriculture sector in 2001 amounted 83 percent[1] (UN CCA, 2001). In spite of its high water consumption levels its contribution to GDP accounts only for 16.5 percent versus to industrial and service sectors with 33.3 and 50.2 percent share in GDP respectively. As some analysis point out agriculture can be affected by increasing water scarcity due to growing demands from other sectors. It has to compete with high value users; this in the long run would lead to release of water from agriculture to the other sectors (Engelbert et al, 1984). The consideration about water reallocation becomes relevant taking into account Egyptian government's support to the development of industrial sector (MWRI, 2002a).

Table 2: Water allocation among the water users. (Based on the data obtained from Abu-Zeid, 1991. and UN CCA, 2001. Figures given by FAO Aquastate are indicated in red).

Water Users	**World wide** (In percent)	**Egypt** (In percent)		
	1999	**1990**	**2001**	
Agriculture	65	84	83	***78***
Industry	25	7.8	10	***14***
Domestic use	10	5.2	6	***8***
Total water use in BCM	-	59.2	67.47	***68.67***

[1] The accessed data referring the water use by sector creates big confusion by giving different estimates for agriculture raging from 78 percent (FAO Aquastat) to 80 (El-Quosy, 2003) and 86 (world development indicators 2000 in Abd-El- Hai, 2002). The figures indicated in UN CCA lie between those numbers and were chosen for further analysis assuming that truth must lie somewhere in-between.

The last 10 years increase of water requirements was observed in industry from 7.8 to 10 percent (to 14 percent according to the FAO Aquastate database), which was mainly compensated by declining the share of other users. The same applies to the domestic water use that increased from 5.2 to 6 percent (8 percent is given in FAO Aquastate database), whereas during the same time the water use in agriculture declined by one percent (by 6 percent according to FAO Aquastat). So the impacts of intensifying competition between sectors are already becoming evident.

It is important to emphasize the fact that economic reasons behind the water reallocation such as high productivity cost of water, can facilitate to emergence of the water scarcity conditions most probably in agriculture sector as the last is low value water user.

4.4. Political forces

4.4.1. Irrigation water subsidies

Water is a critical component of development in Egypt. However, limited water resources are not treated as a scarce commodity, in contrary it is heavily subsidized by Egyptian government, which unintentionally promotes wasteful practices and hinders the emergence of rational use of resources. (Ahmad, 2000) Issue of subsidy involves many factors and its removal would have wide spread effects on whole society. The interactions of subsidy-attached variables are shown in figure 5. Next follows the detailed discussion of each factors effected by subsidies and their contribution in water scarcity.

The domestic use of water shows inefficiency of water distribution system in 1991reached 50 percent (Abu-Zeid, 1991). It is much the same even after 10 years. In present the leakages in the system including illegal connections and other leakages is estimated at the same rate of 50 percent and in some cases it reaches even 70 percent (Nicola, 2003). Situation in distribution schemes are partly generated by lack of funds for improving the operation and maintenance of the whole system which itself derives from the low cost recovery. The real cost of drinking water in Cairo is 0.65 LE[1] per cubic meter and to the households it is sold for 0.12 LE. Commercial sector is subsidized as well - from the small workshops is recovered only ½ of the cost, big factories pay 0.50 LE per cubic meter of purred water. Collection efficiency is another issue we will mention that 25 percent of all factories in Cairo do not pay the cost for water delivery. (Hamoda, 2003)

[1] LE- Egyptian Pound. 1 LE equals approximately 0.16 USD (07.2003)

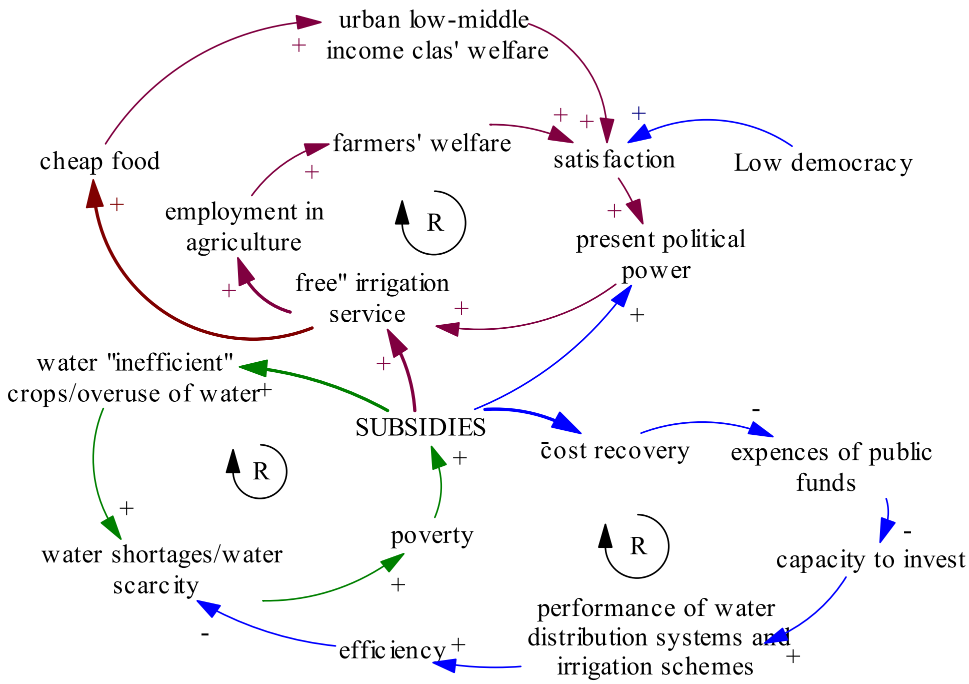

Figure 5: CLD: irrigation water subsidy and the water scarcity relations in Egypt.
The more irrigation is subsidized the longer can be water kept free of charge, which leads to increasing employment in agriculture and improving farmers' welfare. The higher is income the more are farmers satisfied which facilitates to retaining the present political power. However, low level of democracy has negative effect on farmers' satisfaction but as long as the social welfare is some how satisfying farmers needs, they bear present situation. From subsidy benefit the urban low- and middle-income classes as well, as the last are provided with cheap food. (The loop can be read in negative context. By the removal of subsidies there will be no free irrigation service, which will effect rural employment negatively, and welfare will drop down. The low levels of democracy will mountain dissatisfaction of society which will negatively effect the political power balance in country) On the other hand the higher are subsidies the lower is cost recovery and less is expenses of the public funds. Therefore the capacity to invest is lower. It negatively affects the performance of irrigation system and lowers the efficiency levels. Low efficiency has negative contribution in emerging water stress/scarcity conditions. The subsidies also promote water intensive crops, which aggravate the water scarcity problems even more. Scarcity leads to the lowering the incomes and poverty. The higher is the poverty the more is need for subsidies. The relations here are negatively reinforcing.

Irrigation is the major consumer of water in Egypt and is the major source of development of agricultural sector. Irrigation water is not the exception and is heavily subsidized as well. Different sources give diverse information about the price for irrigation water delivery. Postel (1997), Wickelns (1998), Ahmad (2000) point to the provision of water in irrigation canals free of charge, whereas the interview with representative of MWRI (2003) and report (MWRI, 2002a) indicate that farmers are charged for irrigation service through land tax. During the field trip I did not have access to the data indicating the share of water delivery costs in land tax, which makes it difficult to calculate to what extent is government subsidizing the water provision in the irrigation schemes. There was an attempt to draw the conclusions regarding the subsidy scale using incomplete data. The total yearly investment budget for operation and maintenance of the irrigation and drainage system (including mail canal system/distribution works) accounts 100 LE per feddan/year (MWRI, 2002b) whereas the land tax is 20 LE per feddan per year (MWRI, 2002a) with an exception of new lands which are not subjected to land tax (MWRI, 2002b). The figures give a general picture regarding the farmers' very low contribution in operating costs and can be assumed that irrigation service is almost totally subsidized.

Subsidies serve to the social objectives providing services for wider group of population, avoiding the excludability of the marginal groups who cannot afford the service. The main justification behind the subsidiary reasons pointed out during interviews with government officials or NGO representatives was the affordability. However, the affordability is not the single driving force for the government policy in Egypt. There are other social benefits of irrigation water subsidy that were mentioned during interviews. So from the perspective of food security, subsidies on irrigation hold absolute explicit importance since food production is completely dependant on irrigation. Produced food is cheep enough to benefit the urban poor and middle class. (El-Quosy, 2003)

4.4.2. Other aspects of subsidies

There are other positive social effects from irrigation subsidies that have influence on the generation of social benefits. These are employment and income increment. Through affordability of irrigation water, agriculture absorbs 50 percent of labor in rural Egypt (HDR, 2003) and prevents from pushing rural households out of agriculture into cities that cannot provide shelter, jobs and food for millions. Thus the subsidies on irrigation avert cities from increasing poverty, crime and social unrest that can lead to political instability. As Young (1992) notes, farmer serves as an instrument of public policy "the farmers and the public are in food producing and employment creating partnership and the government's (taxpayer's) part of the bargain is to provide the water." Here one can assume that the retaining the power is part of the bargain as well. There is very little determination for cost recovery (Young, 1992) and concerns regarding the farmers' welfare might be not the only reason behind the low political will. Removal of subsidies becomes politically infeasible for political elite as it might threaten with change in political power and stability (see relations in figure 5).

There are other aspects of subsidy that in the long run will result in harmful effects on environment, economy and society. "Water free" conditions contribute to the rising demand against the limited supply options and therefore are considered to be one of the driving forces of water scarcity. (Meyers & Kent, 1999. Rogers, et al., 2002) Discussed in social forces some wasteful practices and growing of high water demanding crops are deeply rooted not only in income levels or behavior as such but are fed by the subsidy. A "free" resource sends misleading signals and serves as an incentive to grow water inefficient crops and overuse the water imposing water scarce conditions to the future generations. Although it is not restricted to the resource scarcity only but gives the rise to the negative environmental effects such as drainage problems, water logging, declining groundwater tables, salinization (Sur, et al., 2002).

To some extent irrigation water subsidies have equity versus consequences and evoke some objections. Subsidies lack the ability to deliver its benefits equally, according to the farmers' needs. So the farmers situated at the head of the canal withdraw higher amounts of water and are likely to benefit more from free provision of irrigation water than the ones at the tail of the canal who suffer from water shortages and use a far less water (Sur, et al., 2002). Therefore, it is obvious that subsidies in this case contribute to inducing the water shortage or scarcity problems by favoring ones and dismissing others.

Increasing water pollution levels from industrial and domestic use also can contribute to emerging water scarcity earlier than has been projected. The contaminated wastewater is likely to reduce the available water for irrigation and other uses as well (Meyers & Kent, 1998). There are other negative consequences for agriculture caused by water reallocation between economic sectors. As it was mentioned above, water is subsidized not only for irrigation but for domestic and commercial uses as well. As commercial use of water is high value user, the competition between sectors might become harsh initiating water scarcity conditions for agriculture earlier.

There is need for investments in improving the maintenance of irrigation schemes. Because of very low cost recovery the main source for the operation and maintenance (O&M) is the public fund placing on it additional pressure and diverting the financial sources from other social or human development programs that might had higher priority if the sector would fully achieve the cost recovery. Tight public funds do not allow carrying out improvement plans, resulting in further deterioration of the system. This would lead to lowering efficiency rates and fostering the water shortages. The last has direct negative impact on the farmer's welfare. The relations are illustrated in the CLD (figure 5) and show the negative reinforcing character of subsidies on farmers' welfare in long run imposing the problems if not only to the present generation but to the future generation as well.

Water scarcity cannot longer be considered as a problem, which can emerge at a certain point over time and spread over the country just at once. Unequal distribution of water along the canal do not always provide users sufficient water even within the same village already now even though average per capita figures based on existing supplies, do not indicate water stress conditions. The same applies to the water allocation among the different water users. Increasing competition between different consumers, the water contamination from industry and poorly treated sewage further reduces the available water for irrigation uses.

The next chapter discusses irrigation water conservation measures and environmental and social consequences that accompany them. Water conservation measures are divided in two groups: supply side measures and demand side measures according to their impacts.

5 WATER CONSERVATION MEASURES

5.1. Supply side water conservation measures

From supply side measures study looks only at efficiency. The irrigation efficiency improvements are seen as an effective tool for increasing the water supply sources. It can be carried out through irrigation improvement plans and better land management. Focusing on the subject of discussion, a wider set of factors comes into play. Therefore the concept of efficiency can be only viewed in its broad meaning which entails the technical and environmental efficiency aspects and water reuse as well. The last is directly linked to the efficiency concept. Firstly the limitation of the applied efficiency definition in Egypt is discussed; later on the constraints that accompany implementation of this conservation measure will be identified with regard to environmental and social impacts.

5.1.1. Definition of Efficiency

The efficiency improvements of the irrigation system are important water saving measures as they results in reduction of water losses at each level of the irrigation system. The simple scheme of irrigation can be visualized in the following way: water withdrawn from the river Nile is kept in the reservoir. The water from storage flows into the main canals. The irrigation canals enrich their water flow with extracted water from aquifer and groundwater, drainage water and discharge from industrial and domestic users. From the main canal water is delivered to the farms passing the secondary canals and water distribution system which itself consists of tertiary canals and mesqa[1] (see figure 6). (Holmen, 1991; Tiwari & Dinar 2002) After transmission water is applied on the filed. Plants for crop production consume the part of it, another fraction ends up in the drainage network and the third is just lost to seepage. Thus taking into consideration the structure of water distribution scheme, efficiency can be discussed at different levels.

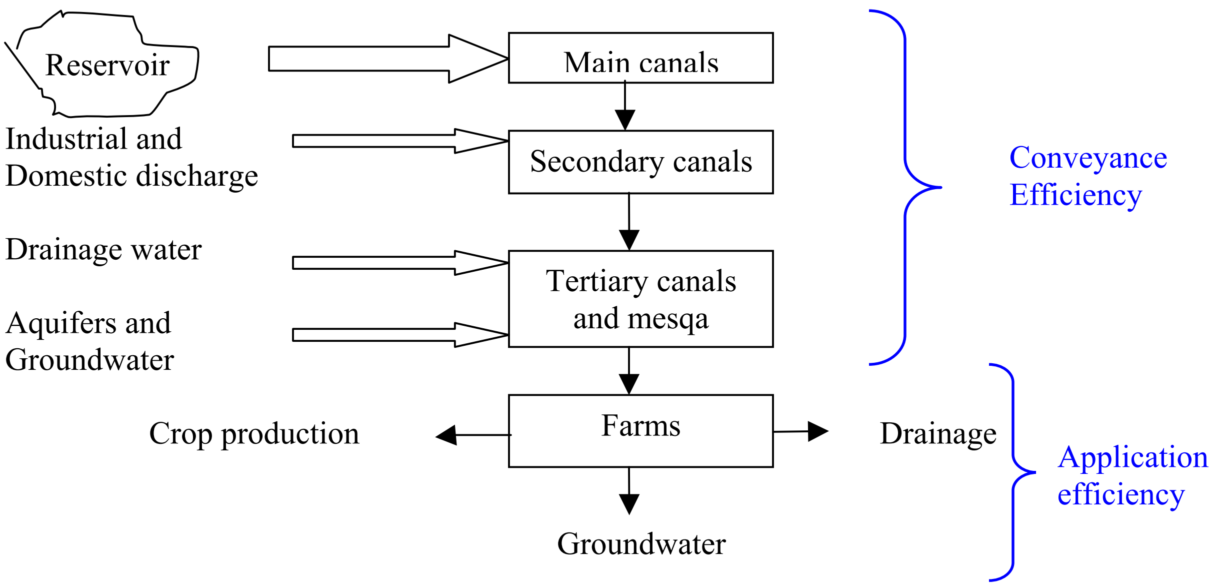

Figure 6: Irrigation water distribution scheme (based on Tiwari & Dinar, 2002)

The part of water carried by irrigation schemes is lost to seepage and percolation as a result of poor technical conditions of distribution system and topography. Some water evaporates during conveyance. So the water use efficiency can be splinted into conveyance, distribution and application efficiency. If the conveyance efficiency points to the ratio "between water storage facilities and delivery systems at farm level"(Martinez, 1994) the application efficiency refers to the water use at the farm level (Tiwari & Dinar, 2002).

The worldwide overall surface irrigation efficiency is estimated at 37-50 percent (Carruthers, et al.1997; Tiwari & Dinar, 2002). Conveyance efficiency is around 60 percent (Martinez, P. 1994), application efficiency while using the traditional methods of irrigation accounts 40 percent, whereas advanced systems show high performance with 60 to 70 percent efficiency (Martinez, 1994; Myers & Kent, 1997). In Egypt average leakage during conveyance from outlets to the fields is 11 percent and those between outlets and main canals 25 percent (Tiwari & Dinar, 2002). 10 billion cubic meters are lost in canals (Imam, 2003). The figures indicate poor performance of distribution systems in Egypt. This brings us to the suggestion that improvements in efficiency rates leave a significant scope for water conservation. However, the data obtained during the field trip shows the opposite.

Irrigation efficiency figures in Egypt seem surprisingly high taking into account the fact that the most common method used in farms is the flood irrigation. According to the information obtained from WMRI average efficiency rate of irrigation system is around 75 percent, which makes it highest in the world. Much the same applies to the conveyance and application efficiency. So the Conveyance efficiency on the old lands is 70 percent and on new lands it reaches 80 percent. Application efficiency

[1] Mesqa - name for irrigation ditches

rates are higher - 80 and 90 percent on the old and new lands respectively. Keller (1992) argues the same. He points out the facts that in Egypt efficiency rates are considerably high – 89 percent.

The high efficiency levels mentioned above create much confusion taking into account the worldwide irrigation efficiency rates. The significant divergence between the world average and country figures can be explained by the different methods applied for calculation of efficiency rates. The estimations used in case of low irrigation efficiency rates refer to the ration of the amount of water applied at the root zone (used by plant) and water delivered (Tiwari & Dinar, 2002).

The estimates in case of higher efficiency rates apply the methodology, which is considering the natural water-recycling factor in equations. Let us take a closer look at the approach, which is drawn from the so-called "IWRI paradigm"[1]. The point the IWRI paradigm is making is that water lost to seepage and percolation during conveyance and application cannot be considered as loss. Moreover, as Perry points out (Perry, 1999), losses and efficiency are "misused and …misleading for understanding water resource systems".

The main idea of the approach is as follows: water diverted from the reservoir and other sources partly evaporates. Some fraction of water is taken up by plants and used for evapotranspiration. The water, which is lost to seepage from canals and fields, percolates to the deep aquifers and groundwater. Here the water is recaptured and ground water and aquifers are recharged. The lost water is reused as additional source of supply later on, obtaining it from wells or aquifers. The drained water, which is collected in drains, is returned into the irrigation system as well. So the water can be returned to the system again and go through the same cycle until almost all of the water is consumed. (Keller, 1992; Perry, 1999) Therefore the efficiency rates still go upwards in spite of the great losses during the conveyance and field application.

The calculations of efficiency suggested by IWRI, which include the natural recycling factor, lead to very controversial conclusions. In fact it diminishes the importance of efficiency improvement measures. So the study of Keller concludes that due to high irrigation efficiency rates in Egypt, potential for improving the general overall basin wide system performance from physical water use efficiency standpoint is limited. So does Seckler in his article (1992) stating " The benefits of investing in on-farm efficiency in such systems are substantially reduced by system wide effects, perhaps even to zero".

The logic of the paradigm is convincing unless we do not pay any attention to the deterioration of water quality that accompanies each cycle of reuse. Going through the continuous recycling phase water picks up considerable amounts of salt from the soil, saline sinks, fertilizers, pesticides (Keller, 1992; Fernandez-Jauregui, 1994; Tiwari & DWIP, 1997; Dinar, 2002). The reused water quality becomes so deteriorated that it is questionable whether water can be used for irrigation or not (Martinez, P. 1994). The issue of water quality will be disused in the chapter later on. Here I just want to emphasize the fact that estimate offered by the "IWRI Paradigm" lives out such important factor as an environmental efficiency[2].

In a study done by Tiwari & Dinar (2002) environmental efficiency is defined as an "available water resources (that) must be managed in a way so as not reduce opportunity for potential use by future generations for various ecological reasons". High irrigation efficiency rates in Egypt, as suggested by some authors, might be subjected to a great cut down if considering the environmental

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[1] IWRI – an acronym for International Water Resources Institute. The Paradigm was based on studies of Keller. D and Willardson, L.S.

[2] The paradigm has some other objections as well (Tate, 1994): Brooks questions the assumption of natural recycling. He finds that the idea about effective natural recycling must be proven and cannot be just assumed. Another point is considerably inefficient use of capital, as the less efficient on-farm consumption needs larger supply and effluent facilities.

efficiency. Negative changes in water quality require higher amounts of water applications on fields to leach out salts and avoid salinization of soil. Thus water use can increase due to low environmental efficiency rates and bring the gains from natural recycling to zero (see figure 7). The negative environmental effects will be discussed later on again.

Another form of recycling, such as drainage water reuse, has the same affects on environmental efficiency. Drainage water used for irrigation must be drained quickly and applied in larger quantities in order to avoid salt accumulation and soil contamination from pesticides and polluted sewage water. The short stay of drainage water requires frequent irrigation operations (DWIP, 1997; Water management in Fayoum, 2000) and therefore increase in water use diminishes the high efficiency scored from natural recycling (see figure 7).

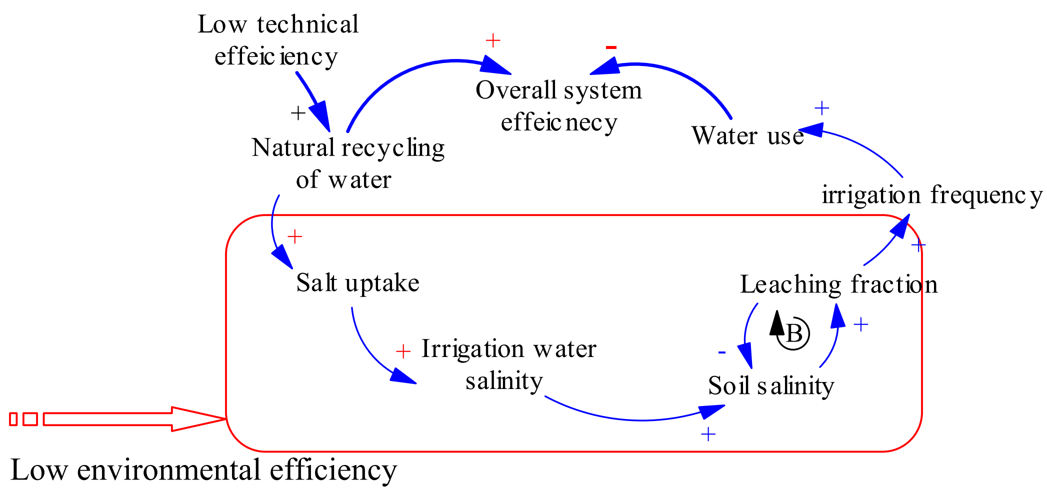

Figure 7: CLD for efficiency

More sufficient seems saving the water trough the increased technical efficiency of irrigation system so the high quality fresh irrigation water from river is not lost. It can be used down streams instead of naturally recycled saline water that would contribute to an increase of salt concentration in the soil. It turns out that even though the recycling compensates water losses, costs of same fraction of water mountain, as obtaining naturally recaptured water from the wells and aquifers is quite costly. Unfortunately it is impossible to carry out further studies in limited time and take a look at the possibilities for synergy of these two approaches. Technical and environmental efficiency must be considered together in order to draw picture closed to reality and consider all side effects.

In spite of the mentioned in interviews and in some publications, high efficiency levels of irrigation in Egypt, importance of the efficiency improvements is widely recognized and the Irrigation Improvement Plan (IIP) has been under way. For example though improvement of irrigation systems one billion cubic meter was expected to be saved for year 2000 (Abe-Zeid, 1991) however, the objective is still not reached as it was mentioned in interview with Jan Bron (2003) lack of funds became unbeatable constrain. MWRI (2002a) report points to the necessity of the irrigation improvements virtuously managing to avoid any discussion regarding the current efficiency estimates. The document does not contain any data referring to the efficiency in irrigation sector.

Thus, the suggested constrain for efficiency increase, such as limited possibilities for improvements due to the present maximum efficiency levels in Egypt, has some objections. However, there are other limitations for efficiency increase such as land fragmentation, low public funds and environmental constraints we are going to take closer look next (see figure 8).

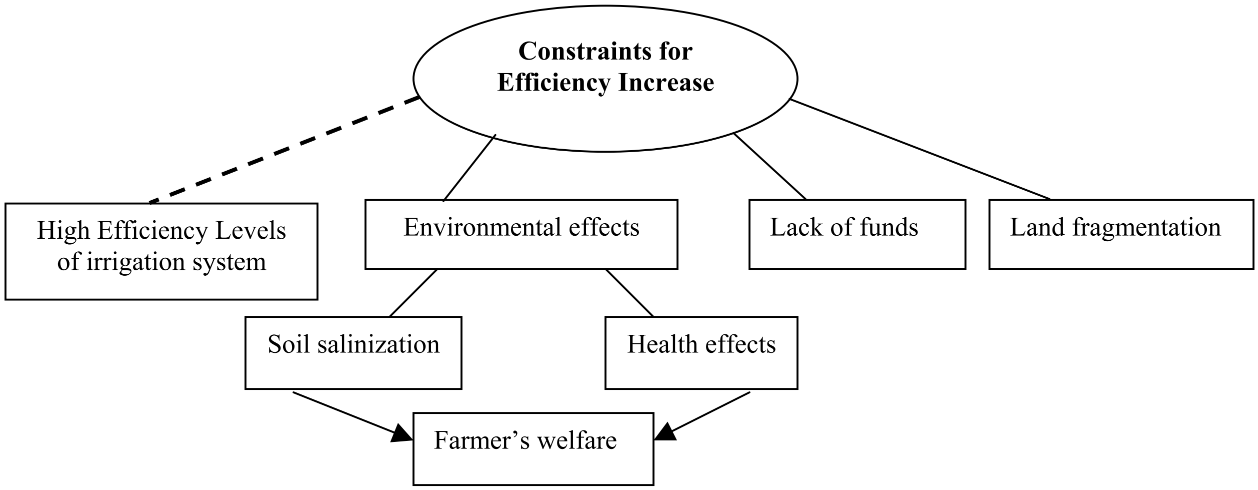

Figure 8: Diagram presenting the constraints for efficiency increase (The dash line indicates weak causal relationship)

5.1.2. Land fragmentation

Agrarian reforms of 1950s and 1960s undertook the land redistribution and setting the ceiling for individual land holdings giving the average of 2.1 feddan per landholder for the whole country. The land is continuously subjected to subdivision through inheritance. (Holmen, 1991) It should be noted also that cultural patterns facilitate to the further fragmentation of landholdings as well. The farmers prefer to buy the plot on the old lands where the size of land is already small neglecting the possibility to purchase the lands in reclaimed areas where the size of landholdings are considerably higher (Reda, 2003). Thus at present 7.8 million feddans are under cultivation of 10 million landholders with average less than one feddan per landholder (El-Quosy, 2003). Trends of land fragmentation is more severe on old lands where only 10 percent of landholdings exceed 3 feddans, from 3 to 5 feddans plots constitute to 7 percent of holdings. Others are less than 3 feddans. (DWIP, 1997) It is expected that due to population increase and limited land availability the size of the farms might further decline. This will negatively affect efficiency of irrigation system, as the part of water resources is lost during the water distribution to each small tiny plot (MWRI, 2002a).

5.1.3. Lack of public funds

The maintenance and operation of irrigation canals due to low cost recovery must be supplemented from central funds. Total land tax collections for year 2000 amounted 133 million at an average 20 LE/feddan/year while the expenditure of Ministry of Water Resources and Irrigation annually accounts for 750 to 800 million LE (MWRI, 2002b)[1]. Only part of the land tax is used as financial contribution to the O&M of irrigation system. Missing funds must be replenished from already hardly pressed

[1] The budget allocation for operation and maintenance of irrigation infrastructure is not adequate. So in the year 1993 it accounted for 70 percent of the adequate level of funding (Bazza & Amad, 2003) that indicates one more time that there is a need for cost recovery.

central budgets. So the lack of finances is reflected in lower service delivery and puts the Irrigation Improvement Project (IIP) in unfavorable conditions, slowing down the process (Bron, 2003).

5.1.4. Water reuse

The efficiency increase implies not only improvements in technical performance of the system but irrigation water reuse as well. The drainage water reuse is given great importance in Egypt (Interviews In MWRI, DRI, Cairo University) which is reflected in plans to increment the recycling levels from present 4.5 BCM to 8.4 BCM in 2017 (UN CCA, 2001). 1.5 million feddans are currently irrigated with drainage water (MWRI, 2002a) and reuse rate is about 2.5 (Imam, 2003). However, as the final report of Drainage Research Institute concludes “increased salinity level will limit full utilization of this amount” (DWIP, 1997). The main reason behind this is adverse effects on soil and farmer’s welfare.

Environmental impacts:

There are negative environmental effects, which might emerge with efficiency increase due to drainage water reuse. These negative effects include the extensive accumulation of salt in the soil and the degradation of underground water quality. The environmental implication of drainage water reuse will be discussed on the example of Fayoum governorate. Here were collected region-specific materials and conducted interviews with farmers. The study intends to introduce briefly the environmental aspects of soil salinity before the discussion of region-specific constraints.

Soil salinisation is the process that “results from the accumulation of free salts to such an extent that leads to the degradation of soils and vegetation”(Hillel, 2000). The problem of soil salinisation in arid conditions emerges with irrigation and agricultural practices. Soils naturally containing sizeable amounts of salt are enriched with salt from other sources such as the irrigation water and fertilizers. (Hillel, 2000; Umali, 1993) There are other factors that influence the salinity of soil as for example seawater intrusion, but we will focus only on salinity elements that can be linked to irrigation.

The irrigation water with its content of salt added to the soil can cause the increase in soil salinity levels if there is no sufficient leaching (see figure 7). At the root zone of plant salt concentration raises imposing unfavorable conditions to grow. As the osmotic pressure surrounding the root zone is high, extraction of water becomes more troublesome for plant and requires more metabolic energy. To prevent plants from damage, the soil must be sufficiently leached. Moreover, in saline soils soil flocculation can occur as a result of increased salt concentration. The clay particles clumped together and forming flocks hinders plants’ root to access the oxygen. (Hillel, 2000) The negative relation between saline soils and plant survival is reflected in declined crop yields. As the DWIP (1997) shows there is a strong negative correlation between the Electrical Conductivity (EC)[1] of soil and crop yield of rice and maize, moderate for cotton and low for wheat.

In Egypt the irrigation water shows large uptake of salt. For example the salinity of irrigation water at the Aswan dam accounts 0.4 dS/m while already in Cairo it raises up to 0.55 dS/m (Keller, 1992). The increment of water salinity partly is determined by salt contributions from domestic and industrial discharges but it is considerably low in comparison to the salt leached from drainage or groundwater. Reuse of water again and again mountains the concentration of salts in water. So in Fayoum fresh water salinity averages 0.5-0.7 dS/M (Mission report 30, 1996), while in drainage catchments the salinity of water varies between 1.56-3.12 dS/m. In the Delta, near the coast, the concentrations of drainage water increases significantly to the values up to 7.8-9.36 dS/m (high

[1] Electrical Conductivity (EC) is used as a indicator of soil salinity and is measured in dS/M (deci-simens per meter)

salinity partly is determined by presence of saline groundwater in the north (MADWQ, 2000) (see for comparison table 3).

Table 3: Classification of water quality according to the total salt concentrations (Source: Hillel, 2000)

Water	Electrical Conductivity in dS/m	Category
Fresh water	< 0.6	Drinking, irrigation
Slightly brackish	0.6-1.5	Irrigation
Brackish	1.5-3	Irrigation with caution
Moderately saline	3-8	Primary drainage
Saline	8-15	Secondary drainage, saline groundwater
Highly saline	14-45	Very saline groundwater
Sea Water	>45	Sea water

There is a clear tendency of declining yield as quality of irrigation water is deteriorated. Table 4 presents the average crop yields in the Delta for different types of irrigation water. The effects on crop production levels are sizable. The rice yields are subjected to 40 percent decline in comparison to the production rates from the land irrigated with fresh water. For wheat this figure is 29 and for cotton 23 percent.

Table 4: Average crop yield (tone per feddan) (Source: DWIP, 1997)

Crop	**Yield irrigated with Fresh Water** (EC_{iw} – 0.72 dS/m, ECe – 2.27 dS/m)	**Yield irrigated with Mixed Water** (EC_{iw} – 1.47 dS/m, ECe – 3.01 dS/m)	**Yield Irrigated with Drainage Water** (EC_{iw} – 2.61 dS/m, ECe – 3.93 dS/m)
Cotton	0.84	0.76	0.65
Wheat	2.75	2.42	2.0
Maize	2.03	1.92	1.75
Rice	3.5	3.0	2.1
Berseem	6.34	5.84	4.14

EC_{iw} – Electrical conductivity of irrigation water
EC_e – Electrical conductivity of soil

Irrigation with marginal quality water requires strict adjustment of irrigation practices to the soil and crop in order to avoid negative impacts on crop yields. The production losses and increase in inputs[1] can bring to zero the benefits from water reuse on the large scale. The effects on crop productivity are very important as the Egyptian farmers practice subsistence farming and produced crop is mainly sufficient only for meeting the family needs.

[1] Use of drainage water for irrigation requires more frequent applications and weeding, therefore more labor force is needed and production costs increase. (DWIP, 1997)

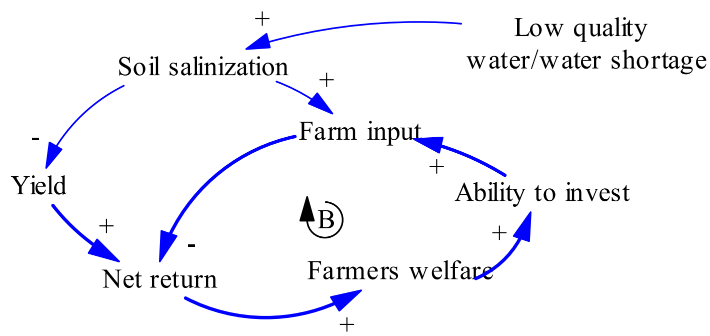

Figure 9: CLD for the impacts of low quality water reuse and water shortage conditions on welfare. (Under farm input is considered any kind of input needed for farm production purposes)

Social impacts:
The drainage water reuse has negative impact on farmers' income. As shown in figure 9, low quality drainage water causes the salinisation of land, therefore decrease in yields and increase of inputs lower down the net returns. This reduces farmer's ability to invest. Farm inputs are declining negatively affecting the crop production rates. As DWIP report (1997) states the average net return per feddan for crop mixes on lands irrigated with drainage water is 80 percent of the net returns from the fields irrigated with fresh water. The drainage water reuse has some positive effect on reduction of fertilizer requirements for crops (as it contains the fertilizers residues from previous use) but in this case the careful and precise land management of land is needed to avoid salinity.

In the concluding remarks of the final report is stated " farmers using the drainage water will be more at risk that those using mixed water and therefore with require more technical assistance and other support mechanism". It goes further by suggesting the establishment of compensation fund financed by fresh water users (DWIP, 1997). So the small farmers, which constitute the majority of farmers in Egypt, are vulnerable to the impacts from irrigation water quality. In regard to soil salinity much the same applies to the underirrigation and water shortage conditions. The applications of lower water quantity results in poor leaching of salts and further salinisation of soil with all its negative outcomes for farmer.

<u>Health:</u> Another factor, which makes reuse cautious, is the concentrations of pathogens in drainage water. As the bacteriological and parasitological examinations of fresh, mixed irrigation water and drainage water show the concentration of fecal coliform bacteria and parasitic eggs usually exceed standards set by World Health Organization (WHO) for unrestricted use of irrigation water. According to the study only 15 percent of drainage irrigation water comply WHO guidelines for unrestricted use with regard to fecal coliform bacteria and parasite eggs concentration in water[1].) WHO standard is 100 MNP/100 ml (MADWQ, 2000)

[1] The figures for fresh water are not better either; only 22 percent of fresh water meets the WHO requirements (DWIP, 1996).

Table 5: Percentage of suitable irrigation water in The Nile Delta according to WHO standards (source: DWIP, 1997)

Type of irrigation water	**Nile Delta**	
	Fecal coliform	**Parasites**
Fresh water (in percent)	42.1	84.21
Mixed water (in percent)	23.07	90.9
Drainage water (in percent)	15.38	76.92

Other concerns in respect of water reuse but from non-irrigation sources are evoked by wastewater reuse with its high concentrations of nutrients, heavy metals, toxic materials that can enter food chains. Wastewater contain also salt and thus pose the danger of soil salinisation as well. (Umali, 1993)

Table 6: Impacts of irrigation water use on different variables (+ is used to indicate increase; - points to the decrease, double plus and minus indicate greater change)

Type of irrigation water	**Soil salinity**	**Efficiency**	**Yield**	**Farm Inputs**	**Farmer's vulnerability**
Fresh water	0	0	0	0	0
Mixed water	0	+/-	-	0	+
Drainage water	+	+ / -	--	+	++

The constraints for technical efficiency improvement are the same - increase of soil salinity problems. As the on farm irrigation efficiency increases the applied water on field drops down which makes leaching non sufficient enough and can lead to the soil salinisation (Perry, 1999; Hillel, 2000; Bazza & Ahmad, 2003; El-Quosy, 2003). Some respondents of interviews used this point for justification of overirrigation and low farm efficiency. However, the precise application of water to the crops and careful management of land could probably ease a problem.

5.1.5. Supply side water conservation in Fayoum

The Fayoum governorate could represent the development trends of Egypt on a smaller scale. Population of 2 million (1996) has a growth rate of 2.5 percent (Water management in Fayoum, 2000). Cultivated land is about 705 600 feddans (HDR, 2003). 50 percent of farmers manage land less than 3 feddans and only 22 percent have holdings more than 5 feddan. 60 percent of the labor force is engaged in agricultural activities. Annual available water is 2 300 million cubic meters and can not be subject to further changes. Growing population and need for land extension can be implemented only through efficiency increases which also includes drainage water reuse. Presently 240 million m^3 of drainage water is reused per year[1] and it is expected to rise up to 375 million m^3. Increment of drainage water reuse will be reflected in expected increases of efficiency from 73 percent in 1999 to 77. (Water Management in Fayoum, 2000)

Land expansion plans can subject the cultivated land area to the water shortage conditions and as it is stated in Mission Report 30 (1996), even slight reduction of water supply can have serious results for the sustainability of agriculture in Fayoum “at present there is a fragile equilibrium which

[1] 30 percent of the water requirement in Fayoum (Mission report 30, 1996)

can be upset quite easily by overstretching the area served by the same amount of irrigation water". In order to meet increasing demands on water additional supply sources can be found in drainage water reuse. Avoiding underirrigation and water shortages through increment of drainage water reuse farmer can still experience the problems of soil salinization. With a proper management and application of drainage water, as it is suggested in Mission report 30, between 26 000 and 28 000 additional feddans can be cultivated for salt tolerant and partly for salt sensitive crops under conditions of proper drainage flow (as the frequent application of drainage water needs to be drained faster in order to avoid salt accumulations in soil) (Mission report 30, 1996).

"In case of drainage water reuse irrigation practices and cropping patterns need to be adjusted" and higher capacity of drainage system is needed in order to balance increased leaching fraction and prevent the rise of water tables. (Mission report 30,1996) The quantitative data about effects of underirrigation in Fayoum is missing leaving the opportunity just to make an assumption and conclusions on theoretical base.

According to monitoring and analysis of drainage water quality, less polluted drainage systems can be found in Fayoum, though values of fecal coliform is very high about 50 000 MPN/100ml while WHO standard for direct use of drainage water is in a range of 1000 MPN/ 100ml. (DWIP, 1997) The main reason for this is untreated sewage, which is discharged into the drainage catchments. In rural Egypt and in Fayoum governorate is not an exception from the rule where domestic sewage ends up in drainage canals.

The dilemma that we are facing here is as follows: on one hand there is a need for water saving and efficiency increase, but on the other hand efficiency improvements and water savings can lead to soil salinization. The short-term benefits in water savings cannot be achieved on expenses of long-term irreversible damage for soil and adverse impacts on welfare of the society. Presented the above constraints for efficiency increase do not intend to diminish the role of water reuse as such. The study just highlighted the fact that recycled water reuse is unlike to the fresh water and needs be more cautious in irrigation to avoid adverse social and environmental effects. Farmers' agricultural practices must strictly follow recommendations and setup of rules for drainage water use. Here comes again into mind the question: should we rely on natural recycling of water in order to present high figures of efficiency and totally ignore the fact that quality of water is degrading? Conserving water through improvements in conveyance and on farm applications at least can make it possible to provide farmer downstream or at the tail of canal with fresh water instead of exposing his fields to drainage or saline groundwater.

5.2. Demand side conservation measures

As it was already argued in chapter 4, subsidies on irrigation have contribution in emergence of water scarcity conditions. Free resources send to the water users misleading message about abundance of water. The illusion of affluent resources finds its confirmation in high rates of farmers (43 percent) who simply do not know if there is likely to be a problem with enough water supplies in the future (El-Zanaty & Associates, 1998).

The irrigation water pricing is one of the important and widely recognized measures for demand regulation. The pricing mechanism can serve as an effective instrument for the water allocation improvement and lightening the water stress or scarcity situations as it is encouraging water savings (Dinar & Subramanian, 1997). The user charge on water would induce incentives for eliminating wasteful irrigation practices and alter the cropping patterns shifting it towards crops which consume less water but have high values (Ahmad, 2000; Bazza & Ahmad, 2003; Massarutto, 2003) Taking into account the water scarcity threats in Egypt, limited and almost exhausted sources for supply and heavily subsidized irrigation service naturally arises the question why this economic instrument has not been implemented in country?

The definition of irrigation water pricing applied in this study must be given clarity before we will go into details. Under the term of water pricing is not meant pricing water itself, but is considered only as cost recovery for operation and maintenance of irrigation system. The last is a component of supply cost[1] (financial cost) but as "nowhere users pay anything near the financial cost of water let alone its opportunity cost" (Bazza & Ahmed, 2003) our study was restricted to the cost recovery discussion only. The cost recovery seems to be the main objective of irrigation water pricing policy worldwide.

Water pricing as one of the demand management based instruments was considered as non-acceptable for Egyptian reality in most of the interviews that were conducted during the fieldwork. The representatives of MWRI and Ministry Social Affairs, NWPSWD, ORDEV, University of Cairo (faculty of Irrigation Engineering) confronted the idea of imposing the irrigation service charge due to affordability reasons. However, there were some respondents who do recognize the significance of water pricing policy for valuing water. To the cost recovery is given important mission to deliver the main massage to the users about water scarcity problems. Lessening the burden from public funds and provision an addition source for the financing the irrigation service improvements is another important reason for supporting the water pricing policy suggested by some respondents.

The model of possible outcomes of water pricing policy is given in figure 10. It was taken attempt to identify wider spectrum of factors involved in pricing issue, their relations and the character of these impacts.

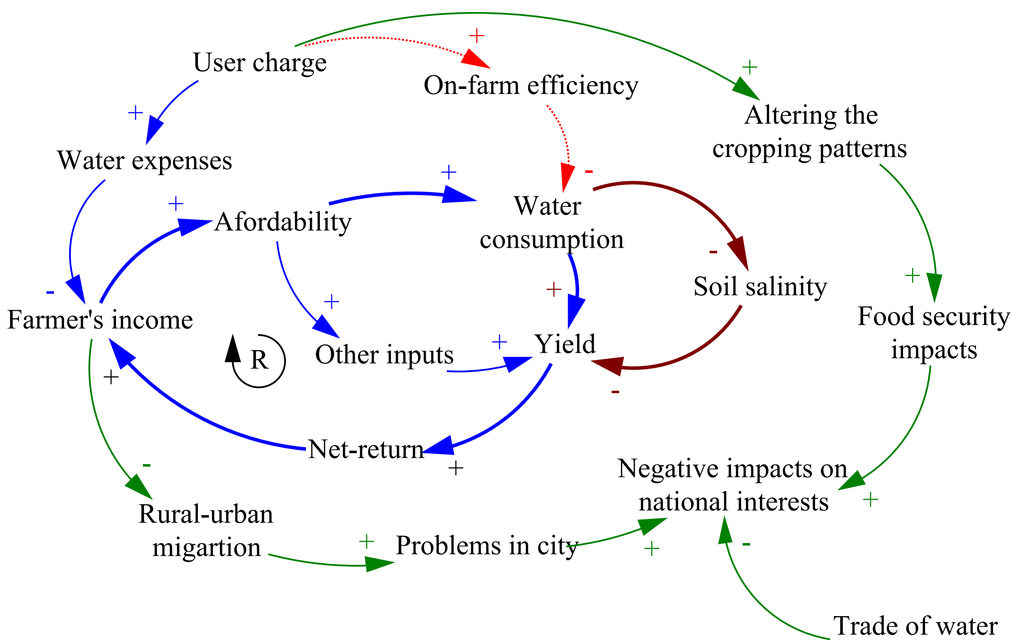

Figure 10. CLD for impacts of water pricing in Egypt
High user charge increases farmer's expenses on water and negatively affects the income levels. This makes farmer more vulnerable as his affordability is decreasing. This means that farmer has to reduce the water consumption. Decreased water application leads to lower yields and further

[1] In discussion of financial cost study only implies operation and maintenance (O&M) cost living out investment cost, interest and depreciation on borrowed capital as the practice shows at this stage hardly any country apply to full financial cost recovery (Bazza & Ahmad, 2003).

worsening the farmer's income situation as net-returns are dropping down. This loop has a reinforcing character. Declining yields limit the ability for proper farm management, this leads to emigration to cities with hope for better life. Overpopulated cities cannot absorb large numbers of emigrants from rural areas and will cause problems, which would have negative consequences for national interests. Declining water consumption levels enhanced by imposed user change will negatively contribute in emerging soil salinity problems, which has harmful effects on yield and farmer's income as well (the linkage between user charge and increased farm efficiency and declining water consumption levels is not that obvious and was questioned by some respondents and some authors. This will be discussed later on in details). Under such conditions the gloomy perspectives make the water pricing policy unacceptable for social sustainability reasons.

Short summary of the main obstacles, which hinder introduction of water pricing instrument, is as follow:

- Cultural acceptance
- Affordability
- Effectiveness of pricing for water conservation
- Environmental limitations
- Other constraints posed by respondents

The factors, listed above, are based on the interviews and bring into discussion the Egyptian perspective of the pricing issue. However, at the end of the chapter there are suggested some other constraints, which at certain extent, do have an impact on implementation of water pricing policy in Egypt.

5.2.1. Cultural acceptance

Being in Egypt one often comes across to the clay jars or their modern substitutes – the water-cooling machines standing in the middle of the street and supplying water for thirsty passers-by. Water is given to everyone for free. In Egyptian culture, as explained by Diaa El-Quosy, water, grass and fire are believed to be the free gifts from God, therefore they cannot be traded. The Islam further supports the idea, prescribing water as " a substance provided by God for all to share"(Young, 1992). During interviews often was emphasized the cultural constraints for adoption of water pricing polices. As it was stated, imposing the charge for the irrigation service would be perceived in society as violation of their basic right: to have a free access to the water.

However, purchasing water from the vendors or selling allocated irrigation water to the neighbors is not rare in Egypt (interview with farmers)[1]. Of course the importance of cultural acceptability as one of the factors, which is slowing down the reforms, cannot be neglected. Although cultural resistance can be partly attributed to the confusion created by notion of "water pricing" itself. During the interviews with farmers in Byahmo (village where was conducted the interviews with six farmers) by making clear distinction between the charge for water resources and irrigation service fee the last did not meet any objections from any of the respondent farmers. The necessity of making a clear distinction between the cost recovery and the water pricing was suggested by Robert Young (1992) in his study as well. This points to the fact that the principle of the supply cost is not as misunderstood by farmers as it was suggested by respondents of interviews in Cairo.

[1] The price of irrigation water bought from neighbors is 30-50 Egyptian Pounds for a hour (Interview with farmers. Village Byahmo, Fayoum Governorate, June, 2003)

5.2.2. Affordability

The majority of poor population is settled in rural Egypt and is mainly involved in agricultural activities (Poverty reduction in Egypt, 2002; HDR, 2003). The average land size is quite small (see land fragmentation in 5.1.) and majority of farms are subsistence farms. Produced food in such farms is mainly for family uses; surplus some times is sold on markets. Therefore the vulnerability of such farms is quite high and can be easily affected by small changes in price of inputs.

Even though water provision in canals is free of charge farmer has to bear indirect cost of water supply, which includes the expenses for conveyance water from mesqa to the fields. The state finances all costs only below the delivery point (MWRI, 2002a).

The gravity based irrigation system of Fayoum governorate is more an exception from the rule in this case. The fresh water in Fayoum fields flows from higher to lower elevations by gravity, averting farmers from pumping expenses. In contrary, the most of farmers other parts of Egypt do need to pump water from canal to deliver it to fields. The annual investments of farmer in irrigation and drainage services countrywide are estimated to be from 350 to 400 LE (MWRI, 2002b). The main cost elements are presented in table 7.

Table 7: Total annual investments by farmers in irrigation and drainage service (Based on MWRI, 2002b)

The main cost elements of irrigation and drainage services for farmers	**Costs** (LE/year)	**Share in total irrigation cost** (In Percent)
Pumping irrigation water	250	67
Capital cost recovery of subsurface drainage	35	9
Cleaning marwas, mesqas and drains	60	16
The land tax	30	8
Total	375	100

As we see the major part of expenses is determined by pumping, which accounts 67 percent of the total costs. Total farm production cost is about 3000 LE per feddan, which makes the irrigation and drainage cost only 12 percent of total production cost (MWRI, 2002b). Introduction of charge for irrigation service would move ahead the expenses. Farmers can bear the costs up to the certain extent but then they would gave up cultivation for economic reasons (Bazza & Ahmad, 2003). This would create negative social background and drive society to more severe economic and social consequences. The situation would favor bigger landholders, which are more commercially oriented. It can not be so bad either for production and efficiency reasons unless the population left out from agriculture can be absorbed in another sectors and avoided migration to already overpopulated cites (see figure 10).

The present heavy subsidies of the irrigation sector ease the field extension of high water demanding crops such as rice and sugarcane. These crops became economically feasible to grow with free input (irrigation water). The crop choice mostly is affected by availability of water; to the household usage (rice is an important staple of and Egyptian's diet) is given the same importance and third determinant for crop choice is market price. In total, nationwide about 30 percent of farmers do select crops for market reasons. (El-Zanaty & Associates, 1998) If currently cultivation of rice is economically feasible for farmers and ensures food security of family and is an additional income source, introduction of user charge would change the situation to worse. Imposing the charge for irrigation service could result in decreases of water consumption levels but at what expenses? As suggested by respondents of interviews, yields might be subjected to reduction, as low affordability of farmers would not allow purchasing the water. The farmers would rather shrink the crop area than subject the whole yield to the risk of water shortage (Mission report 30, 1996). This would lie as a heavy burden on small subsistence farms with restricted ability to put up with all living costs.

As suggested in interviews with government officials, imposing the user charge would only negatively affect the social welfare of farmers' families. It would have further going consequences for the whole Egyptian society such as rural-urban migration and food security.

5.2.3. Effectiveness of pricing for water conservation

In interview with Dr. Tarek Morad (2003) was questioned effectiveness of water pricing for generation of large water savings, pointing to the problem of Price-Consumption elasticity. Imposing the charge on water would just eliminate the low-income group from agriculture activities and reallocate water to big users. This would have minimal effects on water consumption level, especially referring to so-called flat rates when the charge is based on land size[1]. Let's take a closer look at this problem.

As Perry showed in his study (2001), in Egypt "…the price required to induce a 15 percent fall in demand for water would have reduced farm incomes by 30 percent". The water pricing polices in China do not give much hope either. The farmers, in surface water irrigated areas, which are charged by land for irrigation service, has very little incentives to improve their irrigation practices and conserve the water. Main reasoning behind this is the low prices. The elasticity of demand shows positive correlations to the price level (see figure 11). The elasticity increases with increased levels of user charge but it directly affects the income of farmers and impact is obviously negative. So there is very little change in consumer's behavior as response to the water charges but very big changes in income levels. (Berbel & Gomez-Limon, 2000; Yang, 2003) Thus when charges are fixed per hectare per crop even full cost recovery is not enough incentive for farmer to save water. "He (farmer) will either take as much as he can use while the fixed price allows a profit to be made or not irrigate at all if he cannot make a profit" (Perry, 2001)

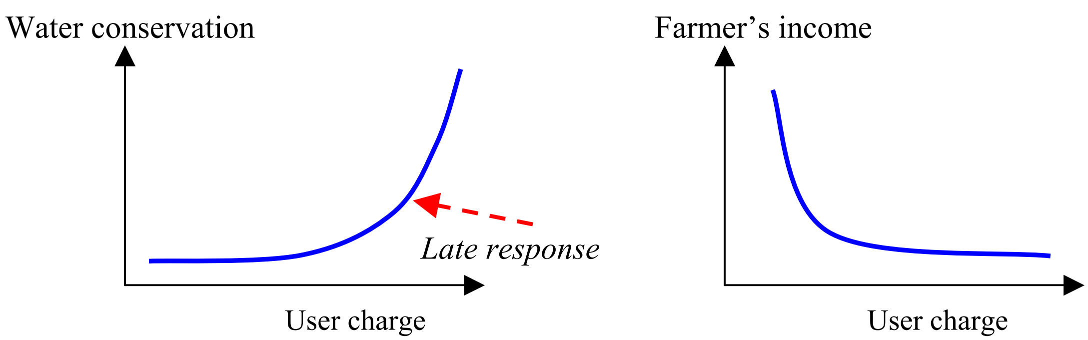

Figure 11. a) Price-consumption elasticity graph b) Behavioral Patten of Farmer's income with regard of user charge

As the modeling regarding the impacts of water pricing policy in Spain done by Berbel& Gomez-Limon (2000) shows, extensive effects of water saving emerge only with a significant increase of water price in case of volumetric pricing. Up to certain level it just affects income of farmer as the expenses of crop production increase. In order to reduce the expenses farmers might select substitute

[1] Versus to the flat rates volumetric charge is based on used amount of water and is charged per cubic meter of water

crops with lower net returns but less water intensive (in Byahmo all farmers said that they would change the cropping pattern. Currently all of the except one, is cultivating the rice. Under condition of priced water provision all would gave up rice cultivation). In model farm income was subjected to 25-40 percent reductions before there was observed any significant changes in water demand. (Berbel & Gomez-Limon, 2000) There might be effects on labor employed in agricultural. As the increase of expenditure on inputs rises, farmers tend to decrease their expenses by saving on labor (Berbel & Gomez-Limon, 2000).

As we see inducing optimal use of water resources by user charge based on land area and some times by volumetric pricing is quite doubtful. However, the volumetric pricing is considered as most effective instrument for altering the irrigation practices and reduction of water consumption. (Mohamed & Savenije, 2000) Some respondents of interviews do not share this optimism as the O&M cost of 1000 cubic meter of irrigation water varies from 10 to 20 Egyptian pounds and is quite low to make any significant responses to the Price-Consumption relationship at these rates even in case of volumetric pricing.

An implementation of water pricing polices only is not enough incentive for water conservation. Even though charge on water assists the adoption of water saving technologies, it does not necessarily lead to water conservation. With water saving technologies farmers tend to increase their production rates by planting more and water intensive crops. (Varela-Ortega & Sagardoy, 2000) So the issue of water pricing must be considered carefully with all possible outcomes to find the optimal conditions in which it really can give desired result of water conservation without sacrificing farmer's welfare.

5.2.4. Additional constraints referred by respondents

Among the other constraints of water pricing policy in Egypt referred by respondents in interviews were: technical reason, national security and regulation of rural-urban migration.

The ***technical implications*** that accompany imposing the charge for irrigation service imply installation of water meters on each land holding. As it was shown few times during the discussion, the size of land per farm is relatively small in a majority of cases. The land fragmentation makes it technically difficult and economically infeasible to install meters on each farm (Seckler, 1992) as their number can reach 10 billion. Installing the meters just in the head of canal will not solve the problem either. Moreover, it can induce more severe inequalities between farms located at the head and tail of canals. The ones at the head consume more and can further increase their consumption levels in order to get maximum net return whereas the farmers at the tail has to manage crop production with less available water and pay more for service. (El-Quosy, 2003)

Another obstacle is linked to the crop selection. With introduction of charge for water, farmer tend to shift to the high value added crops which can effect the variety of produced crops and therefore ***change the market supply and food security*** of the country (Yang, 2003). President of FEDA does not share this fair, as he told in interview, food security does not imply full self-sufficiency of country. The pressure on water supply from high water demanding crops can be lessened though importing so called "virtual water" crops. Here I would not share the optimism of Doctor Bishay as the dependence on food imports in Egypt is already quite high (in 1998 cereal imports to total supply amounted 40% (UN CCA, 2000)) and a considerable share of foreign currency is used for purchasing the cereals[1].

Another objection to the water pricing in Egypt mentioned in the interviews, is connected to ***the national interest of country***. If water is treated as an economic good it will be a subject to allocation through competitive market which will make it possible to trade the water as many other

[1] The cereal is subsidized in Egypt (UN CCA, 2000)

economic goods. The market conditions in this case favor these from nearby countries with rich financial resources as they can afford to pay more. So the withdrawal of the water resources from already limited supply sources can harm national interest of Egypt. Although, it does not seem too complicated to overcome this threat if the water rights are properly defined.

5.2.5. Environmental constraint

About environmental effects of reduced water consumption was mentioned in section 5.1. It is important to point out it again with respect of water pricing. The last is an instrument for increasing on-farm efficiency and water savings. The most acute environmental problem, which might emerge with reduced applications of water, is salinity. As it was shown in Mission report 30, salinity balance in Fayoum governorate is especially fragile and could be disturbed easily by reducing the quantity of irrigation water. This points to the fact that it is necessary to find appropriate range for altering the water applications on field so that the last will not lead to irreversible changes in soil quality.

With regard of environmental implications accompanying the introduction of user charge in irrigation service, it must be taken into consideration following: The fresh water irrigation can be substituted with lower quality drainage water, in case farmers cannot afford paying for fresh water. For example in Nubaria and nearby regions (Fayoum governorate) farmers are forced to use drainage water mixed with sanitary waste water in order to compensate the water shortage they have been experiencing. In the Delta unofficial reuse of drainage water reaches up to 2 BCM per year, which is almost 50 percent of official data of current drainage water reuse (DWIP, 1997). The figures are alarming as the damage to the soil with increase of the salt concentration can be irreversible and low awareness of possible implications for farms increases their vulnerability It is crucially important to match accurately water application to the plant requirement and need for salt flushing from root zone so that the user charge introduction will not alter the balance irreversibly.

5.2.6. Personal observations and suggestions regarding the constraints to pricing

Beside the constraints discussed during the interviews and presented above, the present study suggests to add few more. These must be taken into consideration in order to have as inclusive picture of water pricing as possible.

"Unwillingness to charge": The justification of heavy subsidies relies on low ability of farmers to financially contribute to the operation and maintenance of irrigation schemes. However, this in not the single reason for postponing the reforms. As it was shown in discussion of issue of subsidy, there can be traced clear linkages between retaining the free of charge approach and political interest. About unwillingness to charge in Egypt is mentioned by Young (1992) and Bazza (2003) in their articles as well. The weak political will and little determination to address the demand side management in decisions is present reality. So for example in spite of the fact that it has been highly recognized the need for changing focus from supply side management to demand side management, very little progress has been made. The main objective of demand side management in Egypt is establishment of Water User Associations (WUA) and Local Water Boards (LWB) and water boards and on-farm irrigation improvements (MWRI, 2000a). In fact very little are the responsibilities of WUA and LWB in water management. Moreover, they are not a legal entity and do not have authority for decision-making. Their responsibilities are restricted only to an advisory role. The LWB are not eligible for collection of money from water users (Bron, 2003; Water Management in Fayoum, 2000), leaving very little scope for manoeuvre and little incentive for water saving.

By some respondents "Unwillingness to charge" was justified not only by farmers' low affordability, but by farmer's negative attitude towards user charge as well. The idea is not as unacceptable as it first seemed from interviews in Cairo. As the National survey shows acceptability of user charge largely is dependant on service level. For example as survey shows that 76.4 percent of farmers are willing to share costs of upgrading the irrigation system to provide continues flow[1] for upgrading the drainage system. 72.7 percent of farmers are willing to contribute financially.

The linkages between the service level and willingness to pay can be visualized in following way:

Poor maintenance ⟶ **Poor service** ⟶ **Low productivity**

Low productivity ⟶ **Unwillingness to pay** ⟶ **Low public funds**

The interviews carried out in Byahmo were conducted with these linkages in mind and questions were structured accordingly. Interviews with Byahmo's farmers showed dissatisfaction of irrigation service. Among the services they lack or desire, were: continues flow, reliability, proper maintenance of canals and accessibility to the water saving crops. All of them were willing to make financial contribution for the improving the irrigation service. Most of the farmers said that they would pay for the whole amount of water they use except the one located to the head of canal, who suggested the charge based on land size (here it must be noted that the question regarding the user charge was phrased in following way: if all your suggestions referring to service improvements are fulfilled would you agree to pay for irrigation service). It is impossible to generalize the outcome of 6 interviews but at least it points to the fact that attitude is not as negative as suggested in interviews with officials and depends on many factors. In order to deal with low acceptance of user charge the quality of water services must be improved. As it was mentioned in most of the interviews with farmers, the unreliability and problems with cleaning mesqa or absence of the drainage would not encourage them to pay for irrigation service unless some changes happen.

While discussing the issue of water pricing policy from social perspectives must be mentioned the moral aspect of question as well. As we have seen in chapter 4, other water users: households and industry are still heavily subsidized. Would it be morally acceptable to impose the charge for water in sake of water conservation while other users are still under favored conditions? The most of respondents in interviews pointed out that present price on water for domestic and industrial uses must be increased to achieve water savings in system. Water pricing measure seems especially unfair, as the efficiency gains (water savings) at the field level would make little change in total saving unless there are efficiency improvements in whole supply system (see figure 12).

[1] Presently the irrigation has rotational character and is provided in canals according to the schedule

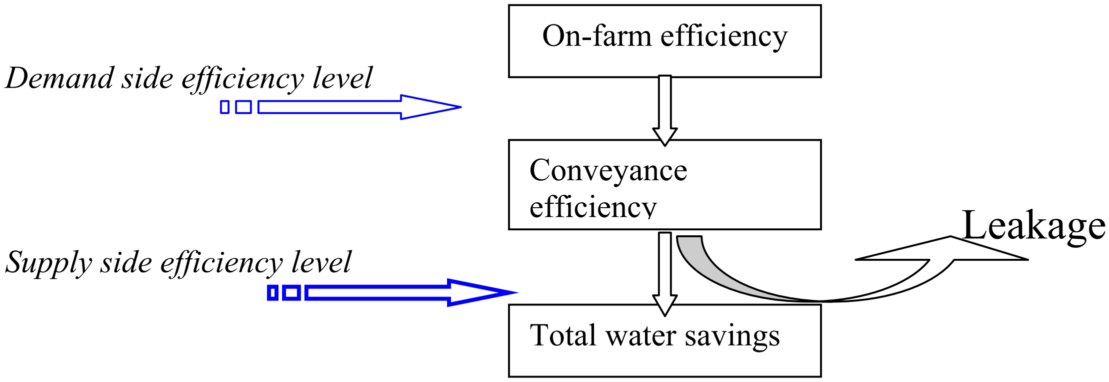

Figure 12: The scheme of efficiency and total water saving relationship. (The savings generated from on-farm efficiency can be lost in system and give no results for total water savings unless the conveyance efficiency is addressed as well)

6 DISCUSSION

6.1. Why do we need to save water?

During the fieldwork, a couple of times I faced situation when I had to justify my questions regarding the water saving. Some of my respondents questioned the necessity of such actions with remark - why we would need to save water? To release more water to the Mediterranean Sea? This brought me to the thought that objectives and aims of water conservation have to be given more clarity. The water saving at this stage might seem a measure just for sake of conservation itself, since the supply and demand are still in balance. Listed below a short summary of arguments, collected from literature and during the fieldwork, support the importance of addressing the issue of irrigation water conservation. Water becomes scarce, increasing the need for efficient management of a valuable resource and the water conservation is an instrument, which allows:

- To avert acute water deficits, where the water needs outrun the supply;
- To respond to the loss of existing water supplies for agriculture due to population growth, urbanization and completion from high value users;
- To ensure enough water supply for agriculture (including the expanded lands) which can be a guarantee for the food supply and secure level of food self-sufficiency (The last can be regarded as a strategic plan, which makes country less vulnerable to the unfavorable price fluctuations on global market. As it has been suggested, the cut back of subsidies in OECD countries can shift prices on food upwards (Carruthers, et al. 1997));
- To slow down the depletion of non-renewable water reserves;
- To lessen the pressure on groundwater extraction as the last is very fragile system and needs careful management to avoid the overuse;
- To provide water equally between regions and the farms;
- To reduce the water quality deterioration;

- To avoid rural-urban migration since there is already enormous pressure on overpopulated cities;

To achieve these objectives the water conservation measures must be applied. However, the issue of implementation of water saving instruments is not as easy task as it seems in the beginning. In the figure 13 presents the mechanism of the efficiency and pricing measures in relation to the water saving [1]. The pricing is a bridge, which spans on-farm and irrigation system efficiency. It gives an incentive for water saving enhancing improvements in land management practices and technology. This leads to a reduction of water misuse to the minimum. At the same time the pricing measure ensures the cost recovery and further investments in maintenance and operation of irrigation system, which affect the service levels and irrigation system performance positively. What are the factors that disturb the functioning of above drawn water saving engine?

As it was argued in the previous chapter, there are factors that limit the efficient implementation of each measure (the main limiting factors are presented in the figure 14): 1) On-farm efficiency measures are restricted by ***soil salinity*** dangers; 2) ***Effectiveness of pricing measure*** for achieving the water conservation is in doubt; 3) The service charge which is collected in funds and is used for O&M and for upgrading the system performance, leads to improved service and water conservation. However, the effective user charge, which would ensure desired levels of conservation, must be higher than cost recovery levels. But in this case we might confront the social welfare interests by affecting negatively large group of population involved in agricultural activities in Egypt. Those small farmers who cannot put up with the charge for irrigation service might simply be withdrawn from the agriculture and stream to the cities with hope to find the job and source of income in other economic sectors. The ***social implications*** include also increased competitions of already limited job market, implications for food security. 4) Here such factor as "***Unwillingness to charge***" has its contribution to postponing the water pricing policy not only for the social reasons only but for political interests as well; 5) Irrigation system's performance is billow its potential. As suggested by some authors and respondents of interviews, the opportunities for further improvements are already exhausted due to ***high efficiency rates***. As it has been argued in chapter 5.1, high performance rates are achieved at the expenses of deteriorated water quality. While discussing the efficiency concept with wider framework, including the environmental efficiency, the results might not look as promising.

[1] In figure are given only efficiency and pricing measures as study is focused only on these two means for water saving

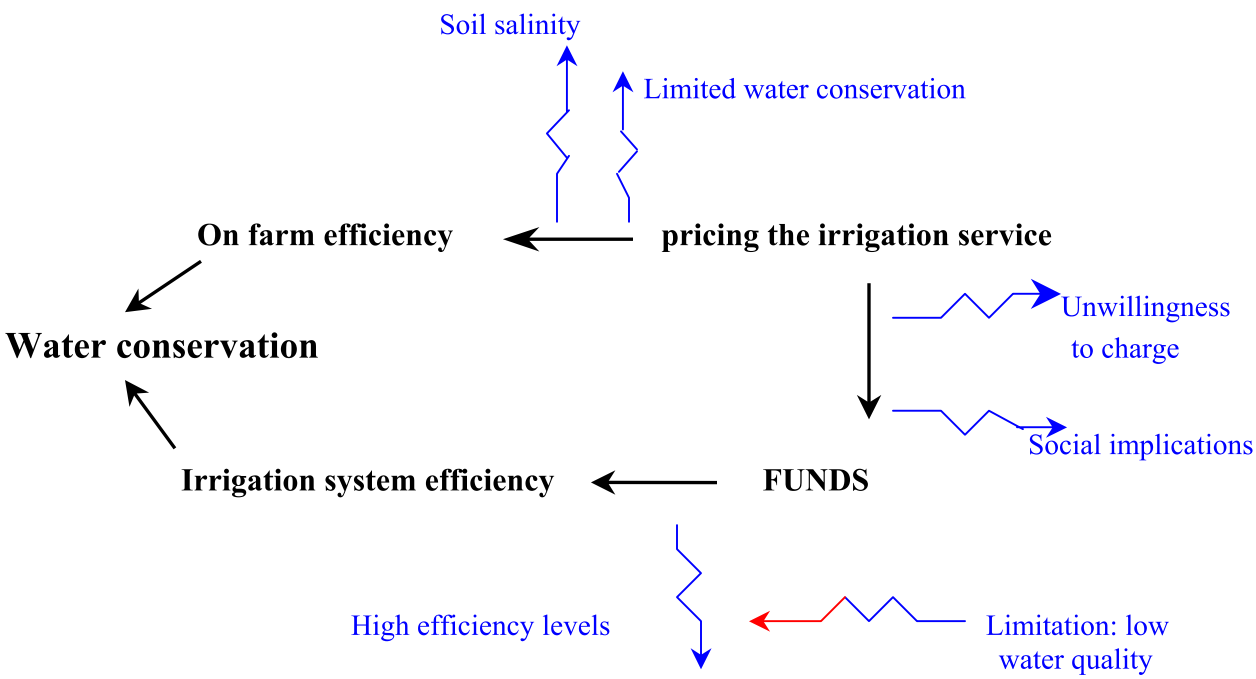

Figure 13: Efficiency and pricing measures in relation to water conservation

The main purpose of water conservation on a bigger scale serves the national interests of Egypt, which includes not only present generation's social, economic and environmental interest but also would guarantee future development of country by securing the livelihood of future generations.

The dilemma is as follow: On the one hand the scarce resource is heavily subsidized from the public funds in order to ensure the minimum favorable conditions for 57 percent of population in rural area. Thanks to these subsidies the large army of farmers in Egypt enjoys free access to water and produce cheap food to satisfy their family needs and to supply it to the urban poor and middle class for low prices. On the other hand, Egypt is a country with limited water and land resources and has a fast growing population. So the increased need for food and water supply for population and rising demands on water in other sectors of economy make it urgent to introduce the water saving measures. The environmental and social limitations of water saving instruments, and low financial ability of public funds restrict their implementation and further complicate the problem. Is there a way out from this dead lock, which would mean a balanced synergy of three elements: conservation measures, social and environmental acceptability?

As the concept of sustainability entails social, economic and environmental interests and seeks for balanced development each of its components without compromising any, using these tools is most appropriate for evaluation of possible outcomes of the applied conservation instruments. Therefore the user charge and efficiency improvements must undergo the sustainability test the criterion[1] of which will be: water saving, social welfare and environmental safety.

[1] There are economical criteria as well, which are out of scope of present study and probably would be the next level of investigation including the legal and economical issues of the study subject.

6.2. Sustainability test

In order to evaluate development trends in irrigation system, effectiveness of water pricing and water reuse for conservation, present study suggests making sustainability test. Sustainability criteria are the most effective measure, which could give holistic evaluation of possible consequences of undertaken strategy in irrigation system.

6.2.1. Sustainability test for present situation with presence of irrigation water subsidies and "high" irrigation efficiency

Farm level- The overall availability of irrigation water ensures the self-sufficiency in food supply for millions of tiny plot holders and urban inhabitants who depend on cheap food. The irrigation water is used not only for field irrigation but for sanitation and for livestock as well (interviews with farmers in Byahmo). As Meinzen-Dick & Hoek (2001) point out, water from irrigation canals often can be a major source also for brick making, home garden cultivation and other production activities. It decreases the incidences of hygiene related diseases as it is used for sanitation in areas where the irrigation water is the only available domestic supply.

Country level- The present development trends with heavy subsidies, restricted rights of WUA or WB, the lack of funds that hinder termination the IIP, do not allow maneuvers for significant alteration of irrigation water savings. At the same time subsidies carry a dual character: they promote wasteful practices, inefficient farming choices but at the same time have important positive externalities for society such as food security, abilities for additional income generation, less vulnerable health conditions and affordability of irrigation service. As suggested by Shatanawi & Salman (2002), the key issue for irrigation is to improve the access of poor to the benefits, so the basic needs can be met at affordable price. Present situation mainly does meet this requirement.

The current free of charge approach taken by government meets the social welfare needs and interests of present generations. But in longer time perspective "free provision of water is costly and inefficient way of sustaining the farmer's income. In fact it encourages wasteful use of water and inefficiency farming choices, with limited gains for farmers huge costs for the society as whole" (Massarutto, 2002) Present practices are imposing the water scarcity constraints for development for future generations.

6.2.2. Sustainability test for irrigation system efficiency

Farm level: Irrigation system's efficiency, which is considered by some authors high enough to be subjected to further improvements, mainly relies on the water reuse. Reused water increases the efficiency levels of system performance and solves the problems of water shortages in same areas by supplying farmer with drainage water. However, it is not an easy task as the salinity implications of drainage water reuse threaten soil quality and yields. So it does not really pass the environmental and social sustainability test in long run, unless the drainage water reuse is carefully managed by farmers and is avoided any quota violation with its reuse.

Country level: Increased share of drainage water reuse for irrigation means results in declining agricultural production rates because of soil salinization effects. On the national scale it can have negative consequences for whole society. Worsening the social welfare might divert rural populations to the cities, which will not solve the problem for people either, let alone the food security implications for country.

On the other hand, improvements of conveyance efficiency would avoid the losses of fresh, high quality water. Thus, instead of re-catchments of this water in groundwater and aquifers farmer downstream who lacks the access to the high quality fresh irrigation water can use it. So the efficiency improvements with respect of environmental efficiency concept would have positive effects for irrigation water provision, equal distribution of water in regions and to the farms as well.

6.2.3. Sustainability test for farm efficiency induced by pricing

Farm level: Imposing the charge lays as a burden on low-income framers. As the experience shows, the low levels of user charge do not give significant changes in consumer behavior but negatively affect their living standards. The higher charge is needed for conservation purposes but it is limited by low financial ability of farmers. So at the present stage effective user charge hardly passes the sustainable welfare test. Optimizing the water use by reducing water applications might have negative environmental impacts as later farmer has to deal with soil salinity. Imposing the user charge needs very careful and balanced land management practices. So does the drainage water reuse in order to avoid the accumulation of salt.

Country level: Water pricing policy and its environmental limitations will place the rural population at the risk of becoming food and livelihood insecure. The imposing charge might face the resistance from the population involved in agricultural activates. Reluctance might end with social unrest for country or result in higher food prices and transferring the problems of social insecurity to the urban-poor and middle class. At the same time imposing the fee for service would ensure the flow of finances to the funds, which must be used for improvement of the irrigation service.

Sustainability test of each measure just shows us that present free of charge approach and hiding behind the high efficiency figures does not really pass the sustainability test. Application of each instrument is limited by many factors, which need careful, planed management and addressing the issue of awareness.

Table 8: Relationship between water conservation measures and the multiple objectives.

Conservation measures	Water conservation	Environmental effects	Social effects
Efficiency due to water reuse	+	-	+/-
On-farm efficiency	+	+/-	+/-
Conveyance efficiency	+	+	+
User charge	+ *	+/-	-

* Conservation can be achieved only at high price levels

6.3. Some remarks

Discussed above issues of conservation measures with all constraints accompanying the implementation leave little hopes for the possibility to achieve the multiple objectives such as: protection of ecosystem, further development of agriculture production and social welfare. Does the future generation's water availability have to confront the present generations social welfare?! Is it the cost the present farmer has to pay for water conservation?

Everything is not as dramatic as it seems at once. By finding an appropriate balance between economic efficiency and farmer's ability to pay might solve many problems (Young, 1992). Introduction of some charge (even less than the supply cost of 1 cubic meter of irrigation water which is about 20 LE) would deliver to farmer the message that water resources have value and are scarce in country. Secondly, it would make possible to ensure the cost recovery of the system and possibilities for improved service and system performance, which would lead to the significant savings of water. Improved service levels would facilitate to the acceptance of increased user charge further to the levels that will not deprive farmer from its achieved living standards but would achieve the significant water saving. As suggested by Mohamed and Savenije (2000), "the welfare of low income users can be maintained using a non water related compensation" This might be the next step to be taken and can be accomplished trough other measures as well, such as taxes and quota violation penalty (it would be drainage water overuse, over cultivation of some crops and etc) and awareness campaigns.

There are other suggested measures, which can ease the task. Those mentioned by respondents in interviews are: improvements in irrigation system efficiency and land management, farmer's awareness, and establishment of WUA, community managed canals, imposing the irrigation fee on new lands, which are not as fragmented and land consolidations on old lands.

7 CONCLUSIONS

The agricultural sector is considered as critical for tackling poverty in developing countries. Egypt is not an exception as the large population is engaged in agricultural activities. In future irrigation water, which is the absolutely crucial part of Egypt's agriculture, has to satisfy demands of even larger population and increasing living standards. Till now, the main means the water shortages were tackled with, were increased extractions of resources and development of new supply options for irrigation system. However, most of supply options are already exhausted and cannot be subjected significant enlargements. Some improvements can be achieved through efficiency increase. The demand side management entails some potential for water saving which might be possible though water-pricing as one of the financial instruments for water conservation.

The main objection provoked by efficiency and water-pricing measures are negative social effects and environmental implications. The problem discussed in context of sustainability, which usually implies the concerns for future generation's welfare, seems to introduce social and environmental pressure on the present generations. Without building favorable preconditions for water pricing policy, introduction of user charge at this stage might face inevitable problems. Preconditions imply community involvement in canal management, well-defined rights, responsibilities for quota violations in case of drainage water reuse and rice cultivation. Whatever conservation measure will be applied the main problem for environment will remain the same. Soil salinization due to drainage water reuse or reduced water applications on fields will be the threat. Balanced approach in pricing and adequate knowledge of the soil salinity itself can ease the task. This would mean intensive awareness campaigns enriching farmer's information about salinity management, spreading the information about new water saving and salinity resistant crops. Water scarcity is not easy to deal but still there are hopes that the negative effects of it can be minimized. In order to do it we must have as inclusive picture of problem as possible with all factors involved. In current study was taken attempt to view just only some parts of whole, but for further understanding of issue other factors needed to be added, which might be the subject for future study.

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