A Future for the Dead Sea Basin: Options for a More Sustainable Water Management.

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Abstract

The Dead Sea Basin has been affected, like other areas in the Jordan River Basin, by the economic and demographic changes of the last 50 years. The water level of the Dead Sea has declined over 21 m from 1930 to 1997, to approximately 414m below sea level, and its surface area has shrunk by about 30 %.

This paper presents the results to date from a European Commission FP5 project on integrated watershed management with an emphasis on transboundary waters. The project addresses the options for future sustainable development of the Dead Sea Basin through synthesizing the available data, analyzing the interactions between natural resources and human activities, and establishing strategic development plans.
The underlying assumption of the research is that solutions for a more sustainable development than today scenario will not come from simply providing "more water for more development", but from a new land and water management system that is sensitive to social, cultural and ecological resources. The research includes both the physical and social dimensions, but rather than looking at these dimensions in parallel, the project actively seeks for an interdisciplinary approach in finding the common ground where these dimensions act and interact.

This paper will focus on the development of a socioeconomic systems model that maps out the interactions among social, economic and demographic factors that impact water resources.

Introduction

One of the most important driving parameters to consider in a socioeconomic system is that of economic supply and demand. With regards water resources, establishing the true price of water has always been a challenge. This is because water is inherently a basic human right and thus putting a price on its use can make it unaffordable for some. True cost pricing for water in the domestic sector (i.e.: providing sufficient water to meet the basic needs of all users) is therefore probably unrealistic. Where pricing can be effective is the agricultural sector.

Water resource management in the Middle East is driven primarily by the need to fulfill water requirements for irrigated agriculture. Over 60% of available water resources are allocated solely to irrigation. Both Israel and Jordan have instituted highly centralized policy mechanisms for water management that allow for subsidization of the price of water to farmers. This provides farmers and other users with a false perception of the true value of water and of its availability. In Palestine, water management is becoming more centralized as the Palestinian Water Authority subsumes control from traditional water allocation users. The hegemony of water for agriculture is thus directly linked to the water crisis facing the region. It is also a primary reason for the decline of the Dead Sea. This is because diversion of water from the upper Jordan River basin by both Israel and Jordan for irrigation has left the Jordan River all but a trickle and in effect has dried up the natural flow of water into the Dead Sea.

In our analysis of the socioeconomic system we assume that the system is driven in part by the economic demand for water, primarily for irrigation use. Another important driver is the informal usage of water. In the Middle East this is a valid use and demand for water. Informal usage is not expressed in economic terms but rather in terms of practices operating outside the realm of an economic infrastructure such as the allocation of water based on familial and kinship ties in Palestinian villages. Returning to economics, true cost pricing for water should be reflected in patterns of water consumption. Because water is highly subsidized throughout the region, the true value of water is hidden from the consumer. Therefore, in order for price to affect consumption, policy decisions on subsidies and agricultural favoritism, at least in Israel and Jordan, will need to be revised.

This paper presents the results of a causal loop diagram (CLD) that was generated using the Vensim Systems Analysis software tool. The CLD is an attempt to describe how the formal (economic) and informal demands for water effects the availability of water resources in the Dead Sea basin across all economic sectors.

The Socioeconomic Systems Model

Inputs into the model are in the form of driving forces and driving parameters that feed into the causal loop diagram. These driving forces and parameters will elicit a range of scenarios for water management in the region in general and for the water level in the Dead Sea in particular. The driving forces and parameters used in the CLD are listed in the List of System Elements tables (tables 2 and 3). Further, linkages between the socioeconomic CLD with that of a CLD being developed to describe the physical system (the physical CLD which describes water availability in the Dead Sea basin is being developed by the Jordanian partners of the project) has been developed. Together, these two systems seek to describe water supply and demand in the region.

An important element to consider in the development of the CLD was that of water quality. Different economic sectors will demand and/or be able to use different grades of water quality. This is an important consideration for the management and allocation of water. For example, the domestic sector demands high quality drinking water at a price affordable to consumers whereas agriculture can make use of lower quality water that is suitable to certain crops and meets public health concerns. This means that treated waste water can be recycled. In our model we defined four quality use source categories (Q1, Q2, Q3, Q4; Q1 being the highest and Q4 being the lowest quality). These quality use categories have been included in the causal loop diagrams for both the socioeconomic and physical systems.

The quality of water has important consequences for the demand for water. The tourism and domestic sectors in the Dead Sea region demand high quality fresh water that at a minimum meets WHO guidelines for drinking water. These sectors are therefore relatively inelastic with regards price as a lever in effecting consumption (see below for further discussion). For industrial purposes price is also relatively inelastic as industry will purchase whatever quantity and quality of water is necessary and can also implement technological alternatives for treating and/or reducing use. The most important sector with regards to price elasticity is agriculture. Both water quality and quantity can be manipulated if subsidies to farmers are reduced, new technologies such as desalination are supported and wastewater treatment that can be used in irrigation (Q2, Q3 and Q4) is instituted across a wide range and variety of crops.

It is important to note that demand for water is not solely economic, at least in more decentralized systems such as that in Palestine. Informal or traditional use of water, such as water allocation based on tribal or kinship ties are important elements in the socioeconomic system. A set of rules describing governance is being developed that describe possible informal usage scenarios. These rules will be incorporated into the system integration of the CLD's whereby the governance system will “intersect” with both the socioeconomic and physical systems (see Figure 1). The integration of these three systems is an attempt at an interdisciplinary understanding of water supply and demand in the region that will reflect the complexity inherent in the scenario we are trying to model. This interdisciplinary approach is firstly, an acknowledgement that complexity exists in any social and physical system and that secondly, an understanding of the complexity is essential to sustainable development.

The economic demand for water, which is governed by price, can meet certain needs but not necessarily all needs. In other words, there are needs for water that fall outside the range of price. We have defined these needs as "wishes" for water. A wish is the public’s desire for increased water consumption and hence availability. These wishes may be fulfilled or unfulfilled. Fulfillment can be achieved both formally (i.e.: paying for more water) and informally (i.e.: “stealing” more water by tapping into water pipes). In our model wishes are primarily driven by funding for water projects that increase supply (refer to the causal loop diagram). For example, the proposed Red-Dead canal is aimed at fulfilling the wish for more water to be supplied to Jordan.[1] These wishes, as expressed in water projects, are however a vicious cycle as it is next to impossible to completely satiate one’s wish for water.

[1] The Red-Dead Canal project proposes to build a canal and piping system connecting the Red Sea to the Dead Sea. The benefits of the project are considered as providing water for desalination and stabilizing the water level of the Dead Sea.

More water means an increase in quality of life which means a demand for more water and so on and so on.

Details of the Model

Thus far in our project, two main activates have been carried out in order to better understand the socioeconomic system. The first is the adoption of the assumption that the main driver of the system is the economic demand for water (this is described more fully below). The second is the analysis of survey data of residents within the Dead Sea basin watershed. These surveys are being conducted as part of the data collection phase of the project. These surveys, together with qualitative work to be undertaken in the form of semi-structured interviews and analysis of key stakeholders in the region are an attempt to access the wishes the public and decision makers have for more water. The working hypothesis for the surveys is that one's socioeconomic context (livelihood, gender, income, education etc.) can affect one's use of water and one's wish for more water. The results of these surveys will be spatially analyzed in a GIS model of the region according to community context within the study area i.e.: city, town, village, Bedouin encampment, refugee camp, kibbutz and moshav.[2] A comparative analysis across these contexts will reveal how one's social setting influences one's wish and the capacity to fulfill that wish for more water. The survey data will also provide insight on whether or not the wishes expressed can be met by formal or informal means. These data will be incorporated into the socioeconomic and governance systems as driving parameters for the formal and informal wishes for more water and will then be linked to the physical system that describes water availability (see Figure 1). In this way one will be able to determine which wishes are likely to be fulfilled and those that will not.

The socioeconomic and physical systems interact at the connection between the main sectors of demand for water in the socioeconomic system: Domestic, Public, Industry, Tourism, Agriculture and Nature and the pools of water supply in the physical system.

Finally, the major "Driving Forces" for the system were introduced. These driving forces are defined as scenarios that have a possibility of occurring in the region and of impacting the water resources of the Dead Sea basin. These are forces which are independent of the system models but which will affect the system through the driving parameters. In the socio-economic system the Driving Forces that have so far been identified are: The Level of Cooperation, The Role of Agriculture and Climate Change. These Driving Forces will also play a major role in another aspect of the project which is to be developed later: the Scenario Management Tool and the Scenario Analysis.

[2] A kibbutz and moshav are Israeli agricultural communities. Both base their livelihoods on socialist ideals where labor and resources are pooled. On a kibbutz there is no private ownership and all benefits are spread equally among the members. On a moshav individuals own their own property and their income is not distributed among the members.

The methods used to analyze the socio-economic system consisted of literary review, consultations with experts in the field of water demand management, project team consultations and the opinions of the local population in the study area that were analyzed by means of surveys. The analysis depended heavily on water demand research done in Israel, Gaza and the West Bank by Dr. Nir Becker from the University of Haifa. The method used by Dr. Becker was to create demand functions for water used in agriculture for a variety of typical crops grown in the region and to determine the value of the product produced by the marginal cubic meter of water. These demand functions have been converted into driving parameters in the causal loop model for the demand for water in industry, agriculture, tourism, municipalities (domestic and public use) and nature. These driving parameters serve to describe the socioeconomic system operating primarily according to the economic demand for water in the fulfillment of wishes and needs for water providing the price for the water demanded can be met. However, the causal loop diagram for the system also includes the noneconomic informal demand for water that is not price dependent but rather operates under a series of traditional rules for the use of water. The degree to which these informal wishes and needs can be met depends largely on the governance system that will be analyzed at a later stage in the project.

The Economic Demand for Water

Water allocation in Israel and Jordan is supported by a price-quota system that favors agriculture. In the causal loop diagram this is considered a driving parameter, which is affected by the driving force, political support for agriculture. In both countries, agricultural users are charged only a fraction of the cost of water that is allocated to them. In Palestine water for agriculture has been fixed at 1967 levels by the Israeli authorities. According to 1990 figures water for irrigation in the Gaza Strip and Israel costs 0.14 US$/CM (US dollar per cubic meter) whereas in the West Bank it is 0.172 US$/CM (Trottier, 1999). In Jordan the price for irrigated water is 6 fils/CM or 0.84 US$/CM (1 fil = 0.14 US$ as of 02/02/04). This price covers only about 12% of the investment, operation and maintenance costs and reflects the high degree of subsidization in Jordan (Salameh and Bannayan, 1993).

In Israel, industrial users pay approximately 0.15 US$/CM irrespective of the use to which the water is put. The price of domestic water (after the municipalities have added the approved levies for operation, maintenance and waste disposal) is about 0.70 to 1.00 US$/CM (Bruins, 2002). As a comparison, 1.23 US$/CM, is comparable to the cost of desalinated water (Bruins, 2002). The marginal cost of water varies between 0.02 to 0.50 US$/CM, over 40 % of Israel's water; most of it sold for agricultural use (Bruins, 2002), and is sold at less than its economic value if true cost pricing were to be taken into account and subsidies removed. The situation is comparable in Jordan.

In Jordan, the price of water for industrial and domestic use is the same and is based on a block rate structure. The first block is 100 fils/CM, rising to 600 fils/CM for over 150 CM of water (Salameh and Bannayan, 1993).

In Palestine, the price of water for domestic uses ranges from 0.35 to 0.80 US$/CM whereas an Israeli settler would pay 0.15 US$/CM (Trottier, 1999). Thus, at least for Israel and Jordan, household consumers and taxpayers subsidize agricultural users. According to these figures Jordanian farmers pay the most for agricultural water whereas Israelis and Palestinians pay the most for municipal water (Table 1). Nonetheless caution must be taken in interpreting these data especially when considering subsidies for water for irrigation and the possible differences in price according to water quality and crop type. These data also do not reflect geographical differences within the countries. For example, farmers in the south of Israel pay less for water than those in the north. This is because the price for water is determined by quality. Freshwater is the most expensive to use with saline water being the cheapest. In the south, most water used for irrigation is saline and thus cheaper than the better quality water available in the north.

	Israel (1990 figures)	**Palestine (1990 figures)**	**Jordan (1993 figures)**
Agriculture	0.11	0.11 in Gaza 0.14 in West Bank	0.66
Industry	0.12	--	0.11-0.68
Municipal	0.26-0.99	0.28-0.64 for Palestinians 0.12 for IS settlers	0.11-0.68

Table 1: Prices per cubic meter of water in Euros (US Dollar: Euro rate as of 02/02/04).

Our approach thus assumes economic rationality. That is, if water is priced at its true value the demand for water should be a function of what people can or are willing to pay for water. It is important to point out that even though prices for water across all economic sectors are low; the ability of the population to afford the cost of water varies. This is most glaring in Palestine where Palestinians pay twice the cost of water as that of Israeli settlers (see Table 1). Many Palestinians struggle to afford the cost of water delivered by the Palestinian Water Authority (PWA) or Mekorot, the Israeli National Water Company, and in many cases this leads to the development of a black market for water where prices are even higher. This situation leads to a rise in informal uses of water such as “stealing” water from water pipes or sinking wells without permits and is reflected in the informal use of water in the CLD. This practice is common in Gaza. In Israel, the average family spends up to US$150 for 100 to 180 cubic meters of water annually. This represents about 1% of the annual expenditure of an average family (Bruins, 2002).

If the water is not affordable then it will not be purchased and used. Of course, this only reflects the formal and not the informal use of water. When any resource, and water is no exception, is priced below its real price, which should reflect extraction and delivery costs, including capital investment costs, as well as scarcity or rent value at source, scarcity is liable to result (Becker, 2003). For historical and political reasons in the Middle East, this problem particularly concerns agricultural water use. This results from each country insisting on self-sufficiency in food products for its citizens, even when importing many foodstuffs is economically viable such as in Israel. Under pricing is consequently, liable to create artificial scarcity that is initiated by holding the market at the state of excess demand and not letting it converge to equilibrium.

Conversely, appropriate pricing may turn a water-deficient country into one with a surplus. This is where governance becomes important because restructuring prices can only come from a top-down government directive and a rethinking of agriculture's hegemony over water (Lipchin, 2003).

Both the formal and informal demands for water have been mapped out in the causal loop diagram (CLD). The CLD reflects the relationships between the various demands for water across economic sectors and the wishes and needs (both formal and informal) for more water. Theses relationships as reflected in the CLD are considered to be influenced by the driving forces of level of cooperation in the region, climate change and the political support for agriculture.

The socio-economic system focuses on water resources and their accessibility for various economic sectors as well as for nature. The following nomenclature describes some of the driving parameters in the system (refer to the CLD and Table 2):

- "Wishes": this is the amount of water that people wish to fulfill. It consists of essential wishes ("needs", see above) and additional wishes. The wishes can also be divided according to fulfilled and unfulfilled wishes.
- "Needs": this is the essential basic water requirement (BWR) as defined according to Gleick (1998). The BWR for drinking water and sanitation needs is 25 liters per person per day. A BWR of 50 liters per person per day includes water for cooking and cleaning.
- "Non-essential Wishes": These may come from the following sources:
    - Economic demand for water. These are wishes people seek to fulfill if they can afford the cost.
    - Rising expectations for domestic water consumption in line with Western consumption levels as incomes rise. These wishes can drive funding for large-scale water projects such as the Red-Dead canal project and can make demand management policies like conservation measures difficult to implement.

- o Non-economically motivated desire or "wish" to use water in agriculture, based on ideology or tradition. In Israel this is expressed by the Zionist ethos of the "Jew working the soil" despite agriculture's minimal contribution to the country's GDP (2-3% of GDP in 1992; Lipchin 2003). In Palestine it may be reflected in keeping ownership of land that is under threat of occupation despite the land being unproductive.

Wishes can be channeled through two different systems:

- ➢ "Economic Demand": this is the part of the total wishes that is channeled through the market. The market will then set the price for water and those that can afford the cost will have their wishes fulfilled.
- ➢ "Informal wishes" are the part of the total wishes that is satisfied by non-market mechanisms and operate outside of the market. This can be reflected in traditional water allocation measures for irrigation in Palestinian villages (see Figure 1).

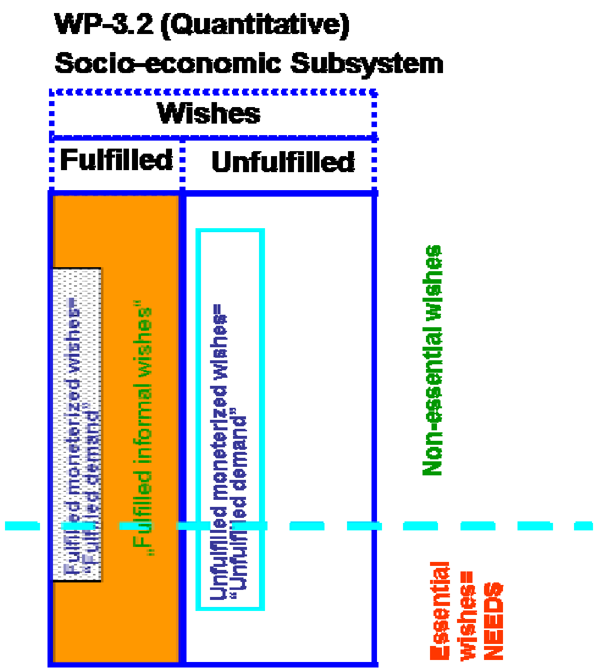


Figure 1: Schematic of fulfilled and unfulfilled wishes according the socioeconomic system.

"Consumption": This reflects those wishes that are actually satisfied (these are "fulfilled wishes"). The remaining are "unfulfilled wishes" that may or may not be fulfilled at a later date. Driving parameters such as the level of cooperation and funding for water projects may fulfill some of these wishes. For example: greater cooperation between Israel and Palestine could free up more water for irrigation in the West Bank as Israel reduces its water supply to farming. Consumption may fulfill the wishes that are channeled through the market ("fulfilled demand") or informal wishes ("fulfilled informal wishes") In the CLD these appear as the relationship between the following driving parameters (DPS): DPS wishes, DPS unfulfilled wishes, DPS fulfilled informal wishes and their influence on DPS agricultural demand for water and DPS domestic demand for water.

“Unfulfilled water wishes” are all remaining wishes that are not met. This amount is an important element for the system feedback cycles. There are three sub-categories of unfulfilled wishes:

- “Unfulfilled demand” is unfulfilled wishes that are not met due to a lack of supply.
- “Unfulfilled needs” are the essential water requirements of the population that are not met due to a lack of supply or due to an inability of the population to pay the price of water.
- “Unfulfilled informal wishes” (see Figure 1) are also essential because they can be driving parameters for nepotism and clientilism that could develop for example under a black market system.

The economic demand for water is defined as the amount of water demanded at any given price. The demand function is the formula which defines the relationship between the independent variable price (P) and the dependent variable quantity (Q). Calculating the value of Q at each P arrives at the demand curve and plotting these points on a graph in which the x-axis is Quantity and the y-axis is the Price. Though price is the independent variable it is customary in economics to place price on the y-axis (Figure. 2). In order to find the expected demand for water in a given region in Figure 2, find the current price of water on the y-axis and move across until reaching the demand curve for that region. Then trace down to the x-axis to see the amount demanded. For instance, the current price for water for agriculture in Israel is about 0.20 US$/CM.

This price creates a demand of 5.5 billion cubic meters a year. Of course, most of this demand is “Unfulfilled Demand” because it is much more than is available to Israeli farmers who are limited in their use of water by government supervised water quotas (refer to the Driving Parameter Water Quotas in the CLD). The area of the demand curve, which is virtually vertical, represents the “inelastic” demand for water meaning that there is a certain minimum amount of water that is demanded regardless of price. This is primarily water for domestic needs.

The demand for water is derived from three sectors: household and municipal demand or domestic demand, industrial demand (which includes tourism) and agricultural demand. In addition, nature’s demand for water must also be taken into account and could be translated into a human demand for water for nature (refer to the CLD that maps out these relationships).

Domestic Demand

We assume that the domestic demand for water is not dependent on the price of water (inelastic). It is largely dependent on the size of the population and the level of income (Becker, 2003). The demand for domestic water is made up of water needs, the minimum basic amount of water a human being needs as defined by Gleick (1998) and water wishes as influenced by rising incomes causing residents in the Middle East to expect a life style similar to the West including water consumption levels found in the water abundant countries of North America and Europe. For example, Canada uses 1,600 cubic meters of water per person per year (Boyd, 2001). It may also be assumed that public awareness of water scarcity may have some effect on water demand especially for public and private landscaping. As it is assumed that women have a larger influence over water use in the home, higher levels of education for women could affect their ability to be influenced by public awareness campaigns. The survey data now being gathered will shed some light on these assumptions. When water needs are not met, that is consumption is below basic human water needs due to a shortage in supply or due to the inability of the population to pay the cost of meeting minimal needs, the result is unfulfilled needs. When water wishes based on rising expectations of the population are not met due to a water supply scarcity, the result is unfulfilled demand for water and unfulfilled informal wishes. The unfulfilled wishes (unfulfilled demand, unfulfilled informal wishes, see figure 1) create pressure in two directions: a pressure to increase spending (local, national or international) on new water projects and a weakening of government ability to enforce water policy (prices and allocation).

Industrial Demand

We assume that the demand for water in industry is also not dependent on the price of water (inelastic).[3] It is largely dependent on the growth of industry as a whole or in other words the growth rate of the GNP (Becker, 2003). Demand for water in industry may also depend somewhat on the type of industrial growth. If industrial growth is in traditional industries such as manufacturing, chemicals, textiles etc, the demand for water may be higher than if industrial growth is in services and high-tech industries where water is not as large of a production factor. The tourist industry must be considered separately as the demand for water in this industry, especially high-quality (Q1) water may be dependent on price. Growth in the tourist industry could also increase demand due to intensive use of water for pools, laundries, hotels, golf courses, etc.

[3] The terms elastic and inelastic refer to the degree of flexibility that price has on water consumption. An inelastic situation refers to price having little influence on water consumption whereas elastic means that price can affect water consumption habits.

Agricultural Demand

The demand for water in agriculture is dependent on price (elastic). "Agricultural water demand is derived from the value of marginal product, which is the value of the crop that is produced by the marginal cubic meter of water."(Becker, 2003). If the price of water goes down, farmers will demand more water in order to produce crops that were not worth producing at the higher price. If the price of water goes up farmers will demand less water because they will stop producing crops with a lower marginal value. The relationship between the price of water and the quantity demanded by Israel, the West Bank and Gaza are described in the following demand functions (Becker, 2003):

$Q(Gaza) = 177,200\ P^{(-0.833)}$
$Q(Israel)= 662,000\ P^{(-0.833)}$
$Q(Negev)=894,800\ P^{(-0.680)}$
$Q(West\ Bank) =300,000\ P^{(-0.775)}$

These demand functions were used to create the demand curves for Figure 2.

Movement along the demand curve signifies an increase or a decrease in demand for water and is caused by changes in the price of water. These changes in the price of water may be centrally determined as is the present situation in Israel, Jordan and to some extent in Palestine or by reaching equilibrium with the supply curve under free market conditions. The price of water for agriculture is primarily influenced by the level of political support for agriculture through price subsidies in each country. A decision to move to demand management of water (allowing water to be bought and sold at market value prices) would no doubt be seen as a loss of political support for agriculture (a driving force in the CLD), which has kept prices below market value and therefore kept water demand high.

The Demand Curve

The demand curve itself can also move, depending on the factors other than price, which influence agricultural demand for water. The factors, which will cause the demand curve to move, are all of those factors other than changes in the price of water, which cause farmers to increase or decrease their demand for water. Some of these factors are as follows (refer also to the CLD):

1) Technology (Process in the CLD) – Improvements in irrigation technology can improve crop yield per drop of water and reduce water demand i.e.: more crop per drop.
2) Sustainable Agricultural Practice (Process in the CLD) – The introduction of minimal water use crops and efficient water use methods of farming will cause a decrease in the demand for water in agriculture.

3) Population (Pool in the CLD) – Increased population will create an increase in demand for food and increase prices for agricultural produce, increasing the demand for water for agriculture. Clearly the rate of increase in population in the study area will be influenced by a variety of factors including the level of cooperation in the area, income levels and education, especially for woman.

4) Level of Cooperation in the Region (Driving Force in the CLD) – The level of cooperation in the region may influence agriculture in two directions. A higher level of cooperation than today may allow Palestinian agricultural workers to return to agricultural jobs in Israel reducing labor costs and increasing the demand for water for farming. On the other hand open borders between Israel, Gaza and the West Bank could bring an influx of cheap agricultural produce, which would lower prices and cause a decrease in water demand in Israel but an increase in water demand in Palestine. It must also be assumed that with a higher level of cooperation between Israelis and Palestinians, it is likely that agreements will be reached on transfer of water from Israel to Palestine and to Jordan (as is currently stipulated in the Israel-Jordan Peace Treaty). It is not clear whether this will create an overall increase or decrease in water demand in the region. Finally, an increase in the level of cooperation in the area will likely increase economic growth and raise incomes in all three areas allowing for higher consumption rates and increasing demand for agricultural produce, therefore increasing the demand for water for agriculture. Greater economic prosperity can also lead to a rise in living standards that will demand more water.

5) The Role of Agriculture in the Study Area (Driving Force in the CLD) – The role of agriculture in society can influence the demand for water in many ways. If agriculture is seen as an important part of national security as in Israel or has political overtones as in Israel and in Palestine strong political pressure will be created to keep prices below actual extraction costs (subsidizing water prices). In a large part of the region, water use may be viewed as a basic historic right of every farmer to free water.

The sense that water rights should be associated with a physical tract of land is a natural transition in perception ‘inherited’ from the association of rainfall and a tract of land in the natural order. If nature does not deliver water free to users then users tend to assume that other agencies, such as governments, should emulate nature. However this inclination to consider all water to be similar to rainfall, that is free, has very powerful consequences with respect to the perception of the value of the water compared with the real costs of engineering the water to points where it can be used. Those who use engineered water to irrigate crops are particularly prone to valuing water below its delivery cost (Allan, 2002).

High levels of political support for agriculture provide subsidies to other agricultural inputs including land and financing. These benefits translate into higher levels of income per water unit and therefore a higher demand for water in agriculture and higher consumption. If the role of agriculture in the region becomes less central as has happened in the past 30 years in Israel, this could lead to a reduced demand for water for agriculture. If the role of agriculture remains central to the region, demand for water and consumption of water for agriculture (over 60% of Israel's and Jordan's water consumption is for agriculture) will continue to be high and an important driving force in water use in the region. As demand remains higher than the supply, the resulting unfulfilled demand translates into unfulfilled wishes, which lead to a pressure for investment in new water projects (such as the Red-Dead Canal and large-scale desalinization projects) and negatively affects the ability of governments to implement water policy (pricing and allocation).

Human Demand for Water for Nature

At this point in time, there is no mechanism for an individual to express his or her personal demand for water for nature. Demand for water for nature can be expressed through support for higher prices for water (reduced support for agriculture), which would tend to divert water from human use back to nature. Another way for the individual to "demand" water for nature could be through a willingness to fund public water works projects through taxes, which would essentially mean buying water for nature. The surveys being carried out as part of the project will include information on the public's willingness to pay to support projects that supply water for nature as well as the public's perception on the importance of agriculture in the region.

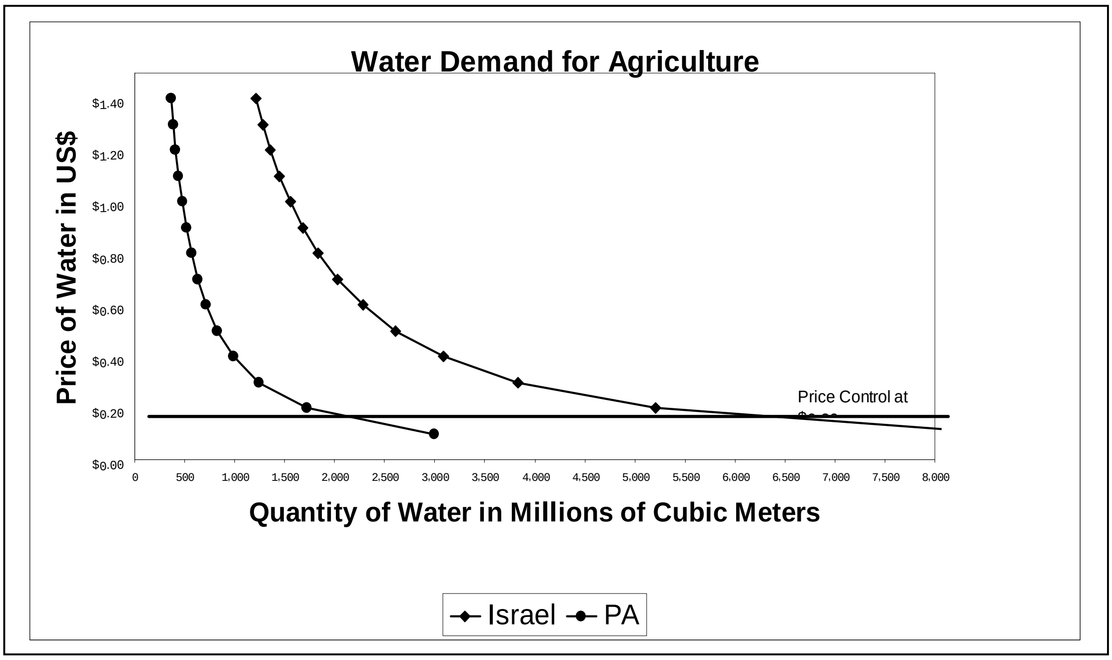


Figure 2: Water demand for agriculture in Israel and Palestine. Data derived from Becker (2003).

Project Uncertainties

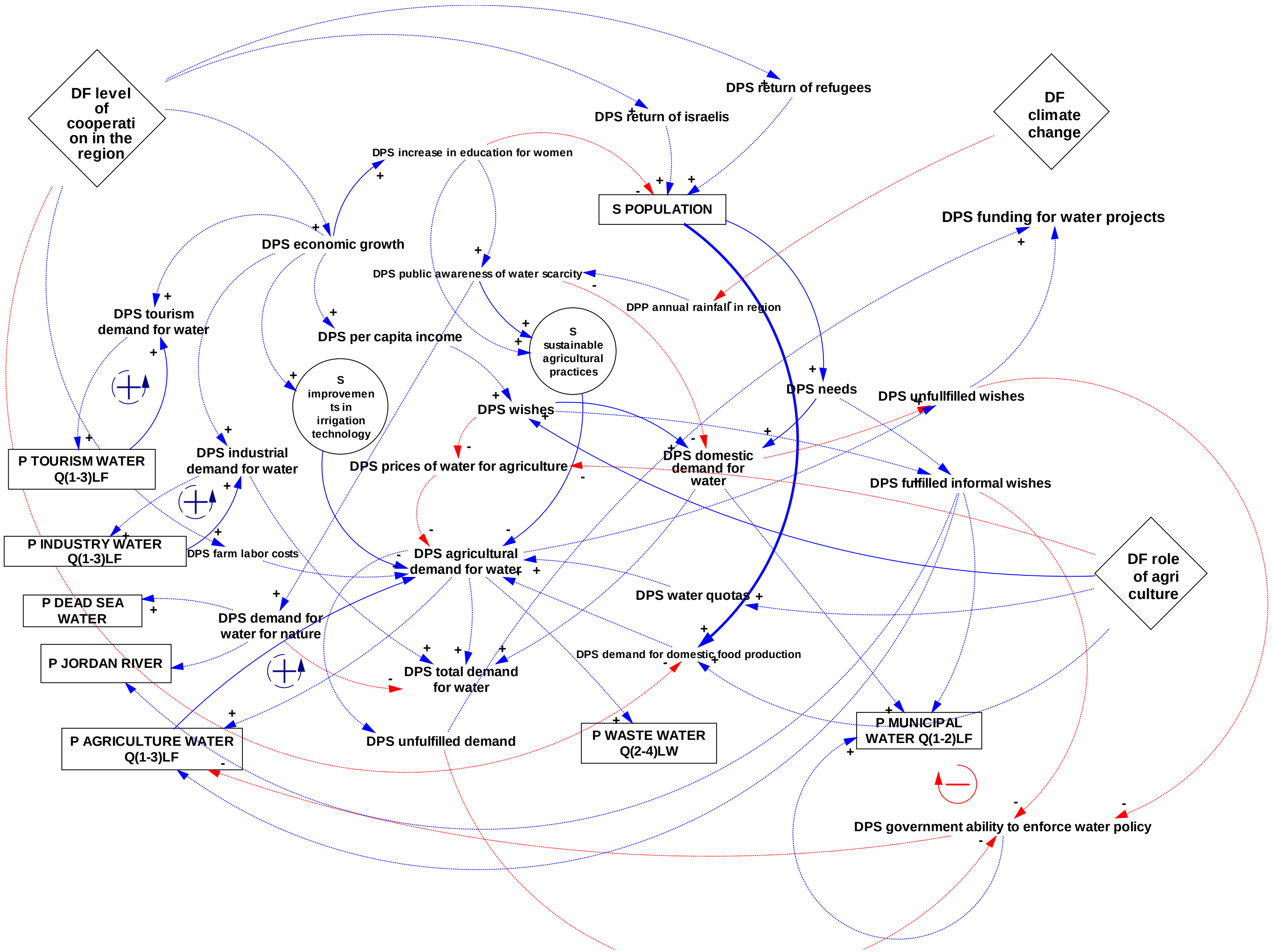
There are still of course many uncertainties in the systems analysis. Some of these are as follows:

A. Demand Curves for Jordan: We do not as yet have water demand curves for Jordan and such functions may not have been generated.

B. Demand Curves for Domestic and Industrial use in Israel, Palestine and Jordan: We do not have demand curves for domestic and industrial water use. The assumption we have made is that the demand is inelastic however there may be evidence to the contrary for instance the water price for domestic use in Jordan appears to have been affected by an increase in price. This clearly needs to be studied. The survey results may generate some insight, as data on the public's willingness to pay to support public water works projects as well as their support for water for agriculture, are being collected.

C. All the Driving Forces are by definition uncertain however it is not clear whether the uncertainty of Climate Change will in fact be great enough to continue to include it as a driving force. It is possible that over the next 20 years, the possible effects of climate change will only minimally impact the already water stressed Middle East. Ironically, it may be the certainty of climate change in the area that may disqualify it as a major Driving Force.

Causal Loop Diagram



Description of Feedback Loops in the CLD

1. Feedback Loop 1 – Tourism: Tourism's demand for clean water increases the supply of water to tourism because the tourist industry is willing to pay higher prices for water. The availability of clean water for Tourism increases the attractiveness of tourism in the area and the demand for water for the tourism sector increases.
2. Feedback Loop 2 – Industry: Industry's demand for clean water increases the supply of water to Industry because industry is willing to pay higher prices for water. The availability of clean water for Industry increases profitability attracts further industry to the area and the demand for water for Industry increases.
3. Feedback Loop 3 – Agriculture: Agriculture's demand for water increases the supply of water to Agriculture because Agriculture uses its political support to increase the supply. The availability of cheap water (often free) for Agriculture increases profitability encourages more farming in the area and the demand for water for Agriculture increases.
4. Feedback Loop 4 – Agricultural Demand, Unfulfilled Wishes and Demands and the Ability of the Government to Enforce Water Policy: Higher demand for water for agriculture creates an increase in both unfulfilled wishes and demands. Both unfulfilled wishes and demands (informal needs), decreases the ability of the government to enforce water policy through formal (economic) needs because farmers may for example over pump aquifers and informally access surface water. The inability of the government to enforce water policy will decrease the amount of water available for agriculture in the long run.

Table 2: List of the main system elements (S=socioeconomic system, DF=driving force, DPS=driving parameter)

System	Name	Description	Kind	Unit
S	DF_level of cooperation in the region	Different plans and agreements representing levels of cooperation	Driving Force	High medium low etc.
P	DF climate change	Global warming due to green house effect	Driving Force	Degrees Celsius
S	DF_role of agriculture	Historical, ideological and political support of agriculture	Driving Force	Suggestion: Percentage of water subsidies for agriculture
S	DPS_funding for water projects	Amount of money invested into new water or waste water recycling projects	Driving Parameter	Euro, JD, NIS, (calibrated in Euros)
S	DPS_return of Israelis	Number of Israelis returning to Israel from abroad	Driving Parameter	Number of people per year
S	S_POPULATION	Number of inhabitants	Pool	Number of people per year or population growth rate
S	DPS_return of	Number of Palestinians	Driving Parameter	Number of people

	refugees	returning to Palestine from abroad		per year or population growth rate
S	DPS_increase in education for women	Percent of women with high school and/or post-high school education	Driving Parameter	Percentage of women per education category
S	DPS_public awareness of water scarcity	Level of awareness of water scarcity	Driving Parameter	Can be high, medium low etc.
P	DPP_annual rainfall in region	Amount of annual rainfall in Israel, PA and Jordan	Driving Parameter	mm of rain per year
S	DPS_economic growth	Measure of economic growth in the region	Driving Parameter	Annual HDI (includes GDP)
S	DPS_per capita income	Average annual income of population	Driving Parameter	Euro/Year
S	S_sustainable agricultural practices	Shift from conventional agriculture to sustainable agriculture	Process	ha/year shifted
S	S_improvements in irrigation technology	The spread of technology that will reduce water consumption per ha in agriculture	Process	ha/irrigation method (drip, pivot etc.)
S	DPS_wishes	Public desire for increased water consumption	Driving Parameter	CM/year
S	DPS_needs	Minimum annual human need for water – WHO Drinking Water Standard	Driving Parameter	CM/year
S	DPS_prices of water for agriculture	Costs of water used in irrigation	Driving Parameter	Euro/CM, crop type and irrigation type
S	DPS_farm labor costs	Cost of employing agricultural labourers	Driving Parameter	Euro/hour
S	DPS_demand for domestic food production	Amount of food demanded at each price per type of food/crop	Driving Parameter	kg/Euro at each price/type of food or crop
S	DPS_industrial demand for water	Amount of water demanded for industry/type of industry	Driving Parameter	CM/Euro at each price/type of industry
S	DPS_agricultural demand for water	Amount of water demanded in agriculture/crop type	Driving Parameter	CM/EU at each price/crop type
S	DPS_tourism demand for water	Amount of water demanded in tourism	Driving Parameter	CM/EU at each price
S	DPS_domestic demand for water	Amount of water demanded for home and municipal use	Driving Parameter	CM/EU at each price
S	DPS_demand for water for nature	Amount of water demanded by public for nature	Driving Parameter	CM per year
S	DPS_unfulfilled demand	Amount of water demanded for agriculture that is unaffordable	Driving Parameter	CM/EU at each price
S	DPS_water quotas	Amount of water allocated to agriculture according to price and per crop type	Driving Parameter	CM/EU at each price/crop type
S	DPS_fulfilled informal wishes	Wishes for water met by supply or affordable need	Driving Parameter	CM per Year at each price
S	DPS_unfulfilled wishes	Wishes for water not met by supply or unaffordable need	Driving Parameter	CM per Year at each price

S	DPS_government ability to enforce water policy	The ability of the government to enforce pricing and allocation of water	Driving Parameter	Percent of unregulated consumed water i.e.: water that is consumed without paying for it
S	DPS_total demand for water	Total aggregate demand for water in the region	Driving Parameter	CM per Year

Table 3: List of major interactions to the other systems (P=physical system, G=governance system)

Origin System	Name of element	Description	Link to System	Unit	Kind
S	DPS_domestic water demand	Domestic water demand	P	CM/EU at each price	DP
S	DPS_industrial water demand	Industry water demand	P	CM/EU at each price	DP
S	DPS_agricultural water demand	Agriculture water demand	P	CM/EU at each price	DP
S	DPS_tourism water demand	Number of inhabitants	P	CM/EU at each price	DP
S	DPS_nature water demand	Amount of water needed to maintain natural elements	P	CM/Year	DP
S	DPS_unfulfilled wishes	Pressure created on Governance and New Water Projects	P & G	CM/Year	DP

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