

# **The Use of Water Allocation Models in Managing Trans-boundary Water Resources: A Case from Palestine**

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## **ABSTRACT**

In many regions of the world, water is scarce. This scarcity of water resources usually causes conflicts. These conflicts in case of trans-boundary water resources are often between political entities or states. Different states put forward conflicting arguments as to their water rights to a certain trans-boundary source. These conflicting arguments are usually based on different conflicting principles. If arguments are between states of different political and military abilities, Caesar's Law often replaces the principles of International Law. A good example of the above is the conflict over the trans-boundary water resources between Israel and Palestine. In such case, the use of water allocation models, especially by Palestinians, can prove the inequitable distribution imposed by the Israelis in addition to the gain that parties can get through cooperative management of trans-boundary sources. Such gains can be estimated through the use of water allocation models. An example of such models is the WAS tool. The Water Allocation System (WAS) is a tool developed by a group of scientists from Massachusetts Institute of Technology (MIT) along with the involvement of a group of scientists from Palestine, Israel and Jordan. The model presents a different way in looking at water disputes. That way is based on economic principles in its broad perspective. The WAS model tries to maximize net benefits for each region from the different water using sectors based on the requested water demands, available water resources, water infrastructure, the existence of treatment plants and desalination units, water conveyance, policy considerations, and penalties imposed. The model shows how efficiently the different states can efficiently implement the water related policies. This paper presents the results of different future scenarios in terms of shadow values, water allocation quantities, social benefits and others. These scenarios are developed taking into consideration two driving forces; economy and political stability. Results show that present water allocation between Palestinians and Israelis is not based on equitable foundation and indeed is unjust. WAS presents a more equitable and economic based allocation of water between Palestinians and Israelis. In addition, the paper demonstrates the prospective benefits from cooperation between different riparian of the trans-boundary water resources.

**Key words:** Palestine, Water allocation, Management, WAS, Trans-boundary

## **1. INTRODUCTION**

Water has unique features that make it difficult to regulate using laws designed mainly for land. Water is mobile, its supply varies by year and season as well as location, and it can be used simultaneously by many users. There are several types of conflict likely to arise: absolute shortages, shortages in a particular time or place; diversions of water that reduce the flow available to others; pollutants or other changes (such as temperature or turbidity) that render water unfit for others' use; and the need to maintain "in-stream flows" of water to protect the natural ecosystems.

Water law involves controversy in some parts of the world where a growing population faces increasing competition over a limited natural supply. Disputes over rivers, lakes and groundwater usually cross national borders. Although water law is still regulated mainly by individual countries, there are international sets of proposed rules such as the Helsinki Rules on the Uses of the Waters of International Rivers and the Hague Declaration on Water Security in the 21st Century.

Long-term issues in water law include the possible effects of global warming on rainfall patterns and evaporation; the availability and cost of desalination technology; the control of pollution, and the growth of aquaculture. History proves that international law cannot be implemented successfully

between different states when these states have different political and military abilities. For that, using models that can incorporate long term issues is seen necessary. An example of such models is the Water Allocation Model (WAS) and its implementation on the Palestinian- Israeli case is the main theme of this paper.

## 2. INTERNATIONAL WATER LAW

Modern international law has considered the environment and water in numerous sources. The international community eventually recognized a human right to water explicitly (UN, 2002). Although these rights are likely binding international law, the human rights to water and to participation in environmental decisions do not impose any substantive responsibilities upon individual countries. Instead, one must consider other documents to define the scope of the right. The academic literature almost entirely depends upon codified customary international water law to define the range of these rights in regions lacking binding water treaties. The two main sets of principles that are seen applicable to the Palestinian- Israeli case are:

### *The Helsinki Rules (1966)*

The International Law Association (ILA), a law-related nongovernmental organization, drafted the Helsinki Rules, "the first comprehensive expression of equitable utilization and international river (drainage) basin principles." Article V of the Rules notes that "the weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors." These addendums force each basin state to argue over what weight each factor should be given (Elmusa, 2004). Thus, the Rules do little more than provide structure for future riparian negotiations (Stephen, 1992).

### *The Convention on the Law of the Non-Navigational Uses of International Watercourses (1997)*

Aware of the Helsinki Rules' shortcomings, the United Nations soon took its own steps to codify international water law through the International Law Commission (ILC) (Jonathan, 1995). Much like the Helsinki Rules and the ILC Draft Articles, the Convention drew heavily upon equitable utilization. Moreover, the convention included consideration of "optimal utilization, which can improve the condition of any watercourse, including perhaps the Jordan River, by forcing riparians "to achieve the optimal use of the watercourse as if no State boundaries existed." This optimal use could be determined through the implementation of greater joint, technical analyses of the condition of disputed watersheds. This discussion shows that for the law to be implemented, allocation models like the WAS model is needed to provide answers to many questions that might arise during negotiations on weights, optimal utilization and others.

## 3. DESCRIPTION OF THE WATER ALLOCATION SYSTEM (WAS)

The water Allocation System is based on the view that water is an economic good, although it is one with special qualities (Amir and Fisher, 1999). This view implies that:

- Water has a cost (composed of at least the production – and distribution cost)
- Users produce benefits from using the water. If the availability of water is limited, only the most beneficial activities will be realized. As a consequence, the demand for water will be reduced if the price increases
- The economic optimum water distribution is the one that produces maximum benefits for the users of water
- However, water in certain uses (i.e. agricultural or environmental protection uses) can have value that exceeds its private value to water users. These social values must be respected

Environmental issues were handled in several ways. First, water extraction is restricted to annual renewable amounts; second, an effluent charge can be imposed on households and industry; finally, the use of recycled water in agriculture can be restricted.

The WAS model generates the water distribution for the region that produces the optimal benefits to the model user. It computes the value of an additional quantity of water and the shadow value at a particular location. The distribution of water over the areas is such that the total benefits from water related activities are maximal. The model can be used wide and may also aid in setting water disputes (Jayyousi, 2001).

The model has been applied to the Israeli, Jordanian and Palestinian water systems under the Institute for Social and Economic Policy in the Middle East (ISEPME) project. Each of the three countries was subdivided into districts, which are treated as homogeneous units. Each district has access to specific data on water related activities.

The model assumes that water consumption is influenced by the price of water in the form of a constant price elasticity demand curve. The formula for the demand curve is (Amir, 1999):

$$Q = a P^b$$

where P is the price paid for the water, Q is the quantity of water consumed, a is a scale parameter and b is the demand price elasticity. The coefficients a and b may represent sectors or districts. Values of these coefficients were obtained from available data.

#### 4. STUDY AREA EXISTING WATER SOURCES

The study area (The West Bank and Gaza Strip, Palestine) was divided into a number of districts according to the Palestinian administrative division. Within each district, water demand curves were defined for each household use, industrial use, and agricultural use. The annual renewable amount of water from each source was taken into account. The option of wastewater recycling was considered and the possibility of inter district conveyance was taken into account. This procedure was followed using actual data for the year 2007 from the Palestinian Water Authority (PWA) and projections for the future year 2020. Data on the Israeli side for the regional simulation runs of the WAS model were obtained from the Hydrologic Survey of Israel (HSI) reports. The table below (Table 1) summarizes the renewable shared water sources adapted for the simulations presented in this paper.

**Table (1). Renewable Water Sources and Overall Water Consumption (mcm/year)**

<b>Water Resources</b>	<b>Annual Recharge</b>	<b>Israeli Consumption</b>	<b>Settlements' Consumption</b>	<b>Palestinian Consumption</b>	<b>Total Water Consumption</b>
Mountain Western Basin	362	344	10	22	376
Mountain NE Basin	145	105	8	35	148
Mountain Eastern Basin	172	40	50	69	159
Coastal Aquifer	305	260	0	140	400
Jordan River	890 (available after the use by other riparians)	890	0	0	450

(Adapted from the water supply report of PWA and HSI report, 2007)

## 5. SIMULATION RUNS AND RESULTS

Alternative scenarios for the year 2020 were considered. For the year 2020 many parameters are uncertain outside the water sector. Perhaps the most important of these for our purpose is the projected population. This is especially true for the Palestinian population, a politically sensitive matter. Hence, we examine the effect of quite a large increase in Palestinian population. We begin, however by using the population projection provided by the Palestinian Center Bureau of Statistics (PCBS, 2007). Ten different simulation runs were performed. A certain parameter or a group of parameters was changed for the different simulation runs and the effect on the different output parameters was assessed. These different runs with their main output results are presented in Table 2.

**Table 2. Description of the Performed Runs and their Main Outcomes**

<b>Run ID</b>	<b>Run Description</b>	<b>Main Outcome</b>
1	Existing conditions where lack of cooperation and the deficiency in infrastructure and inequity in the allocation of water	The results signal a crisis situation all over the West Bank and Gaza Strip. The shadow values of water in some Palestinian districts are alarmingly high
2	Allow reallocation of additional water to Palestine but with no additional infrastructure	The gain in total surplus is \$525 million per year with \$420 million to Palestine and \$105 million per year to Israel
3	Do not allow reallocation, no cooperation but with removal of fixed price policy	As compared to run 1, the Palestinian situation is improved by \$22 million per year. The shadow value of water increase but only by a cent or two per cubic meter
4	Allow reallocation of additional water to Palestine, allow cooperation, remove fixed price policy but with no additional infrastructure (Similar to run 3 but with additional reallocation of water and cooperation)	The gain is much higher than in run 3 with \$419 million per year with most of it going to Palestine. Based on this run, Palestinians take 68 mcm/year from the Jordan River and also receive a substantial amount from the mountain aquifer
5	Allow reallocation of additional water to Palestine, allow cooperation, add recycled wastewater infrastructure	The total surplus in Palestine is increased by \$161 million over run 4 where no infrastructure is added. The run shows that additional development in infrastructure is a must especially in the northern part of the West Bank
6	Allow reallocation of additional water to Palestine, allow cooperation, additional conveyance lines are added	The total surplus in Palestine is increased by \$ 155 Million over run 4 where no infrastructure is added. The run shows major international movements of water due to allowing cooperation
7	As run 6 but with additional increase in population by 1.75 million persons	Shadow values rise but no obvious crisis is observed due to additional population. Per capita domestic water consumption decreased from 74 to 63 cubic meter but still well above actual current levels

Run ID	Run Description	Main Outcome
8	As run 6 but with additional increase in population by 3.5 million persons	Like the previous run, shadow values rise but no obvious crisis is observed due to additional population. Per capita domestic water consumption decreased to 59 cubic meter but still well above actual current levels
9	As run 6 but with drought conditions by reducing all available natural resources by 30%	The total surplus is reduced by \$87 million compared to run 6. The per capita domestic consumption falls to 67 cubic meter per year from 74 in run 6. Shadow values rise making desalination a likely option in Gaza Strip
10	As run 6 but with no additional reallocation and no cooperation	Total surplus, relative to run 6, declined by \$242 million per year. These are the gains from reallocation and cooperation in the presence of substantial Palestinian infrastructure

## 6. CONCLUSIONS

Water as an economic commodity has at least two implications for the design of a lasting water arrangement that is to form part of a peaceful agreement among neighbors. The first of these has to do with negotiations over the ownership of water quantities. The second, and more important implication has to do with the form and the basis that a water agreement should take. Based on the reviewed literature, it is noted that for international law to be implemented between countries, there is a need for allocation models to provide answers to many questions regarding optimal use, weights and others especially models that can incorporate long term issues. The main conclusions obtained with the current version of the WAS model for the Palestinians can be summarized as follows:

1. Additional quantities of water should be allocated to the Palestinians from the renewable water resources in the area (the Mountain Aquifer System and the Jordan River System). Based on the above simulations, these quantities ranges from 250-300 mcm/year
2. Cooperation is a "win-win" policy that can be worth \$100-\$200 million dollars per year by 2020. Model results show that both parties would always gain from cooperation. The exact gains from cooperation naturally depend on the assumed allocation of ownership rights
3. Desalination on the Mediterranean coast will not be needed during normal years. With cooperation in water and the construction of infrastructure (recycling plants and conveyance systems, largely for the Palestinians), there will only be a need for additional sources of water in 2020 in years of considerable drought
4. The need for desalination will crucially depend on the status of cooperation in water. Without such cooperation and with the 2007 ownership allocations, the Palestinians will find desalination at Gaza an attractive option by 2020
5. The construction of recycling plants in the West Bank and particularly in Gaza will be highly beneficial regardless of water ownership or cooperation
6. Finally, the usefulness of using allocation models does not end at the international border and such modeling effort can also be used in the resolution of water disputes. That use is seen to reduce property rights in water to monetary values. Moreover, the availability of seawater desalination means that the monetary value of disputed water property rights will generally not be very large. If this is realized, negotiations over water should be facilitated

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