THE ROLE OF "VIRTUAL WATER" IN THE WATER RESOURCES MANAGEMENT OF THE ARID MIDDLE EAST

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ABSTRACT
Agriculture and rural village life have historically played central roles in the life, economy and culture of the Palestinians, Jordanians and Israelis. However, in the 21st century these nations are facing the reality that their natural fresh water resources will shortly become fully utilized and that there is an urgent a need to reevaluate long term water resources management strategy. While calls for food security based on growing all food locally arouse popular support, this paper will show that the modern, rational, economic approach to this question is, that the arid countries in the Middle East, with little water should accept the reality that priority in utilization of their limited fresh water resources should go to meet the immediate human needs of drinking water, domestic and urban use as well as for high income producing commercial, industrial, tourism use and assuring the quality of life with green open spaces. It is more rational to import most of the high water consuming food and fodder, particularly the staples which can be shipped and stored easily from those countries with plenty of water from natural renewable sources. In other words, to import "virtual water" in its most economical form-food. Our study shows that in reality Israel has de-facto adopted this policy and imports 80% of the national caloric intake from abroad while the Palestinians import over 65% of their caloric intake. Plans must be made over a 20-30 year period to retrain the agricultural population for alternatives employment in a modern economy.

KEYWORDS: Israel/Palestine/Jordan water resources, Middle East, virtual water, food security, agriculture, water for nature/ecology

INTRODUCTION
Agriculture and rural village life have historically played central roles in the life, economy and culture of the Palestinians, Jordanians and

Israelis. However, in the 21st century these nations are facing the reality that their natural fresh water resources will shortly become fully utilized and that there is an urgent need to reevaluate long term water resources management strategy. While calls for food security based on growing all food locally sound appealing and inspire strong national feelings, these concepts generate unrealistic perceived needs for water for agriculture that are illogical economically and socially. They tend to create non-sustainable demands for massive water allocations for agriculture from rapidly dwindling water resources or the production of irrationally expensive water for agriculture by desalination and/or water transport over long distances. This paper will show that the modern, rational, economic approach to this question is, that the arid countries in the Middle East, such as Israel, Palestine and Jordan with little water should accept the reality that priority in utilization of their limited fresh water resources should go to meet the immediate human needs of drinking water, domestic and urban use as well as for high income producing commercial, trade, crafts industrial, tourism use and assuring the quality of life with water allocated to nature and green open spaces. It is more rational to import most of the high water-consuming food and fodder, particularly the staples which can be shipped and stored easily from those countries with plenty of water from natural renewable sources. In other words, to import "virtual water" in its most economical form-food.

HOW MUCH WATER IS REQUIRED TO ACHIEVE COMPLETE FOOD SECURITY?

How much water is really needed to grow all of the food needs of an individual? A few selected examples based on calculations made by Gleick (2000) from data in the FAO Production Yearbook of 1989 of the water input required in cubic meter/ton (m^3/ton) to produce various foods based on data from the generally water efficient agriculture of California are presented in Table 1 below:

TABLE 1. Water Input in Various Foods Produced in California in m^3/Ton (Gleick ,2000 and FAO,1989)

WHEAT	**1,273**
RICE	**2,005**
MAIZE	**978**

POTATOES	**147**
SUGAR	**2,731**
SOYBEAN OIL	**21,692**
BEEF	**16,193**
PORK	**5,760**
POULTRY	**5,730**
EGGS	**3,740**
MILK	**971**
BUTTER	**22,274**

Table 2. Total Amount of Water Required to Grow all Food Requirements in m^3/capita/year (Gleick ,2000 and FAO,1989)

CALIFORNIA-	**2,156 m^3/cap/yr**
EGYPT	**1,540 m^3/cap/yr**
TUNESIA	**1,082 m^3/cap/yr**

Professor Gleick's estimates based on the FAO data have indicated that the total water input in the human diet varies from country to country depending, of course, on the consumption of food products that require very high water consumption per unit, such as meat, oil and butter and the efficiency of the local agriculture, in water use in food production. Table 2 presents a few examples of the total water requirement to supply the complete food requirements of an individual in m^3/capita/year (m^3/cap/yr). From the above, it is obvious that those countries with a total water resources potential of significantly less than 1000 m^3/cap/yr. can never approach total food self-sufficiency/food security based on locally grown food.

WATER AVAILABILITY TO MIDDLE EASTERN COUNTRIES

There are very limited water resources available to the Jordanians, Palestinians and Israelis who are partners in the geography and hydrology of the Jordan River Basin and the adjacent areas. They are currently using essentially all of the natural fresh water resources potential available and then some. We have estimated that for Israel, based on the 2003 population of 6.5 million and a fresh water resources potential of 1600 million m^3/yr. (mm^3/yr.), the per capita availability of water is about 250 m^3/cap/yr. For the Palestinians,

with a population estimated at 3.2 million and a currently estimated available water supply limited to 250 mm^3/yr., their per capita consumption would be some 80 m^3/cap/yr. The Jordanians with a 2003 population estimated at 5 million and a total fresh water supply estimated at about 1000 mm^3/yr have a per capita use of some 200m^3/cap/Yr (See Table 3.).

Table 3. Current Fresh Water Availability in m^3/capita/year (2003)
Palestinians- 80 m^3/cap/yr
Jordanians- 200 m^3/cap/yr
Israelis 250 m^3/cap/yr

Our studies have shown that the estimated *Minimum Water Requirement* (MWR) to meet all of the hygienic, social and economic requirements for domestic/ urban/commercial/ industrial/tourist uses for a reasonably high standard of urban living in arid areas in the Middle East is some 125m^3/cap/yr (Shuval, 1992) This assumes little fresh water for agriculture and import of most food. Israel and Jordan are not much above that level today, while the Palestinians face serious water deprivation and are already well below the MWR.

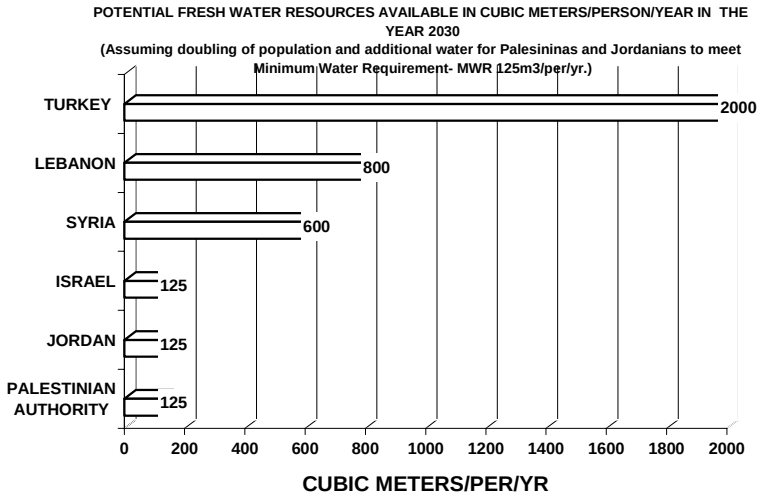
Currently, some 60-80% of the water resources, of these three nations, are utilized by agriculture. However, it can be estimated that there will be a doubling of the population in each of these nations in some 30 years time, with the additional population living mostly, if not entirely, in the urban sector. There will likewise be a significant increase in per capita urban water consumption, in particular among the Palestinians and Jordanians, due to raised standards of living, which will result in at least a doubling if not more of the water demand in the urban/commercial/industrial sector. If we assume a scenario of no additional water supplies becoming available, then the only way to meet the rapidly growing urban demand, would be through the *reallocation of the high quality fresh potable water supplies, currently used in agriculture to the domestic/urban/ commercial/ industrial sector*.

From a social and economic view point this policy can be justified since the marginal value of water and the income produced from its use for the domestic/urban/ commercial/ industrial and tourist sector has been estimated as being some 100 times greater than its value in

agriculture. In addition there would be no alternative employment for the increased population other than in commerce, building, crafts, trade, tourism and industry in the urban sector. Thus, the transfer of the fresh potable water to the urban/commercial/ industrial/tourism sector would result in a major cut-back in irrigated agriculture with all of the difficult social implications involved. Israel's water planners have already reluctantly accepted this water transfer and reallocation policy as inevitable. The Israeli farming sector has not fully readjusted to this reality.

For comparative purposes an estimate of the total fresh water resources that may be available from all sources per capita/year (m^3/cap/yr) in the five riparian countries on the Jordan River basin and Turkey in the year 2030 are shown in Figure 1. This estimate assumes that the Jordanians, Palestinians and Israelis will obtain some additional water resources through the development of alternative sources such as desalination and reallocation of water resources among them in the framework of the peace process in order to achieve at least the *Minimum Water Requirement* to assure a reasonable standard of living for all the peoples of each of these nations on an egalitarian basis.

Figure 1.



From this rough estimate based on figures from the World Bank (1992) and other sources it can be seen that by the year 2030 Jordan, Israel and Palestine will have just enough fresh water to meet their

domestic/urban/commercial and industrial demands with essentially no fresh water for agriculture, other than recycled wastewater, while Syria and Lebanon, the relatively more water rich neighbors to the north, will still have some fresh water resources available for agriculture. Turkey, on the other hand, even in the year 2030, will remain a truly water rich country with enough water to meet all local need including agriculture and food production, plus enough water to spare to enable it to sell and transfer significant amounts to their less fortunate neighbors to the south.

IMPORT OF LOW COST *VIRTUAL WATER* IN THE FORM OF FOOD STAPLES TO ASSURE FOOD SECURITY

Under these conditions of water scarcity with little or no water available for agriculture, how will Jordan, Palestine and Israel assure their population with the food required – in other words to assure what is often called *food security*? The modern, rational, economic approach to this question is that countries with little water should import, what Professor Tony Allen of the University of London (1995) has termed *virtual water*. That is, importing the high water consuming foods they need, particularly the staples which can be shipped easily and stored for long periods, from those countries with plenty of water from natural renewable sources and sufficient areas of arable land. Import of staple foods such as grains, dried beans, food oil, fodder and even frozen meat and fish and their storage in grain silos, local warehouses and cold storage facilities is a more economical way of assuring an adequate supply of food while avoiding the irrational implications of the misguided goal of *local self-sufficiency in food production* under the *food security* concept. Our studies (Buchwald and Shuval, 2000) show, for example, that in reality Israel has de-facto adopted this policy and in the year 2000 imported 80% of the national calorie intake of food from abroad in the form of virtual water (see Table 4.) while it is estimated that the Palestinians import over 65% of their caloric intake.

Table 4. Examples of Food Staples, 100% of which are Imported by Israel Supplying Some of 70% of Israel's Total Calorie Intake* (Buchwald and Shuval, 2000)

Wheat/Grains/Starch/Sugar/Candy
Sesame /Fats/oils/Frozen-Salt Fish
Dried Fruit /Dried Lentils

*Calculated as percent of total mean calorie intake in imported foods based Israeli mean food basket. Total mean calorie intake = 3000 calories/day.

As an example of the economy of virtual water, ever ton of wheat has imbedded within it some 1200 tons (or m^3) of water required to grow it. The world market price of wheat is about $150-$200/ton so that if two thirds of the cost of growing it are labor, seeds, fertilizer, harvesting, storage and transport then the cost of the water imbedded in wheat is estimated at 4-5 US cents/m^3. There is no cheaper source of produced or imported water. What about fresh vegetables and salad crops which cannot be so easily imported from abroad? The growing of limited amounts of fresh vegetables and salad crops for local consumption requires very little water and I have estimated that with an allocation of fresh water of some 25 m^3/cap/yr, a country can grow most if not all of the fresh vegetables and salad crops used locally.

Naff (1965) has suggested a differentiation between " *Food Security*" and " *Food Sufficiency*": *Food security*, according to Naff , requires a guarantee of enough food produced locally to satisfy a population's minimal needs over a long period of time. Such a policy traditionally has implied self-contained, domestically produced food sufficiency. In the water short areas of the Middle East, insisting on a national policy of *food security* often implies generating a perceived need to assure local irrigated agricultural production even if the country does not have sufficient local water resources to sustain such a policy. While public policy insisting on assuring *food security* and *water security* may appeal to national pride and be politically popular it has often resulted in the perception of unrealistic needs for greatly increased water resources. This often means increased demands for the reallocation of shared water resources from limited trans-boundary water resources and the resulting exacerbation of water conflicts between nations. It has also led in some cases to the problematical construction of expensive and uneconomical massive water projects such the huge pipe-line 500 km long in Libya transporting a one time reserve of fossil water from deep in the desert to the more arable coastal areas or the use of desalinated sea water for the irrigation of wheat and other staples in Saudi Arabia, regardless of

costs and benefits. In both of these cases the cost of the food produced with such expensive water is many times greater than the price of the same food products on the world market. Naff (1995) correctly points out that the old concept of f*ood security* "in the arid Middle East will always be a wasteful and ill-fated policy".

Food Sufficiency, on the other hand, only requires that there is on-going sufficiency of food for the needs and development of a society, attained chiefly by trade based on the import of *virtual water*. However, it must be understood that this strategy, to assure *food sufficiency* (as an alternative to *food security*) requires an economy that generates enough income, particularly foreign currency, from exports, commerce and tourism to cover the cost of the needed food imports. In the arid areas of the Middle East there is, in the long run very little alternative to developing the economy based on low water consuming industry, crafts, trade, commerce and tourism which will proved employment and a higher standard of living rather than an economy based mainly on low income producing agriculture. The studies by Beaumont (2000) have shown that for Middle Eastern countries the economic return on one cubic meter of water allocated to agriculture is about $2.00 (US) while a cubic meter of water used in commerce or industry yields a return of $100 to $500. Such an economy based on commerce, industry and tourism will be able to provide sufficient financial resources to import and store all the food required to assure *food sufficiency* and as well a higher standard of living for all (See Table 5).

It is one of the fundamental premises of this paper that the conventional concept of *food security*- meaning total local self-sufficiency in food production in the arid areas of the Middle East and other arid regions of the world, cannot be seen as a realistic or sustainable one and can only lead to unnecessary, increased conflict over limited water resources or the irrational waste of economic resources, which in the long rum can lead to a decrease in security. Middle Eastern countries facing current and/or future severe water shortages must carefully consider the more realistic and less conflict arousing policy of *food sufficiency* based essentially on the import of *virtual water* as an acceptable long term policy with important political, economic and security advantages.

TABLE 5.
WEALTH GENERATED BY WATER IN VARIOUS SECTORS* in $/m3 (Based on Beaumont, 2000)

Country:	Agriculture	Industry	Commerce
EGYPT	0.96	19	686
IRAN	1.22	93	512
ISRAEL	1.49	120	687
JORDAN	1.80	170	360
KUWAIT -	-	1889	237
MOROCCO	1.47	110	2036
SYRIA	2.18	53	1512
TURKEY	2.54	93	512
AV.	1.86	533	650

*GDP of sector/water used by sector

What about those arid countries in the transition stage that cannot yet generate enough foreign currency to purchase all their vital food needs in the world market? The international community should create institutions such as a *World Food Bank*, to assure that all countries, including the weakest of those in the third world, are assured adequate food supplies from the reserves of the surplus food producers in the world.

WHAT WILL HAPPEN TO THE FARMERS/FALACHIM?

What will happen to that sector of the population that currently bases its life and livelihood on agriculture in rural villages- the farmers/the falachim? The transition from a quasi-agricultural economy to an economy based mainly on commerce/industry/ trade and tourism—a high-tech economy, is in fact already occurring. In Israel it is in an advanced stage with only 3% of the population employed in agriculture and producing only about 2% of the GPD. In Palestine and Jordan the population employed in agriculture is about 30-40% but their share in the GDP is relatively small. The high numbers employed in agriculture today among the Palestinians is partially a result of the present political situation and strife and the lack of employment in other sectors which previously employed many Palestinians. Never-the-less, employment in the commercial/ trade/

industry and tourism sectors is growing even in this difficult period and is expected to grow rapidly in an era of peace. There will have to be a well planned, well financed and carefully phased program of training and education of the younger farmers and the children of the farming sector to prepare them for more productive occupations in the commercial/trade/industry and tourism sectors of a modern economy as the years go by.

The question is asked: if the agricultural sector will shrink considerably in the years to come, how will Palestine be able to absorb the several hundred thousand refugees expected to return to the new Palestine State once it is established? Some Palestinians planners have suggested that the agricultural sector could absorb these refugees. This is a difficult question to answer at this time but, it is questionable if many of the returning refugees will be interested in settling in agricultural occupations even if their forefathers were farmers and falachim. Over the years, many, if not most of the refugees, have left agricultural occupations far behind and many have learned trades and skills in other more economically rewarding professions. Despite the present very poor economic and social conditions of most of the refugees it is not unreasonable to anticipate that their expectations for employment on return to Palestine will be different than those of their forefathers. The more productive occupations in the commercial/trade/crafts/building/ industry and tourism sectors will bring a higher standard of living than a return to agriculture which in any event will not be practical since there will never be enough water available to support a significant portion of the population in agriculture.

WHAT WILL THE COUNTRY-SIDE BE LIKE IF THERE IS A MAJOR CUT-BACK IN AGRICULTURE?

Environmentalists, ecologists, lovers of nature and the public at large will undoubtedly ask the very legitimate question- "*What will the country-side be like if there is a major cut-back in agriculture? Agriculture keeps the country green*! " What is happening in Israel in this area, is of great concern. Particularly in the central areas of Israel, near the major urban centers, where land values are high, the farmers have become the major promoters of the sales of their farm-land for housing projects. This is profitable to the farmers and is turning large areas into densely built-up red tiled roofed houses. This

not only is an environmental eyesore but green areas are rapidly disappearing and the impervious roofs, asphalt roads and parking areas have reduced the infiltration of rain water into the vital ground-water aquifers and have increased storm water run-off to the sea.

There is an urgent need to develop strategies and operational plans to prevent this process and for the gradual conversion of agricultural areas into low water consuming "green lungs"- parks, nature reserves, lakes, pastures, sport fields and green recreational areas of all kinds- so vital to assure the quality of life in a densely populated society. While allocations of fresh water to agriculture will have to be reduced over the years there is a need to accept a new priority concept that in order to live in a high-tech urban society in an arid area, major allocations of water for nature, ecology and green lungs must be assured.

CONCLUSIONS

In conclusion, there needs to be a fundamental revision in the understanding of such concepts as *water security* and *food security,* in relation to the arid countries of the Middle East. These can only achieve the needed levels of water and food security by developing economies based on commerce, trade, crafts, tourism and industry which can earn sufficient cash and foreign currency to enable them to import low cost *virtual water* by purchasing all the required food staples on the world market. A *World Food Bank* may be required to help poorer countries in transition to meet these needs, while the countries rich in water resources and arable land must be encouraged to grow the food for those countries that will never have enough water to grow all of their own food.

As populations grow in Jordan, Palestine and Israel and the demand for water in the urban/commercial/industrial sectors increases, water from the agricultural sector will have to reallocated to the urban/commercial/industrial sectors so as to assure the maintenance of the quality of life, decent levels of hygiene, the economic viability and standard of living of the majority of the population living in the urban sector. Thus, as less water becomes available for irrigation in the agricultural sector there will be less employment in agriculture. There will have to be a well planned, well financed and carefully phased program of training and education of the younger farmers and

the children of the farming sector to prepare them for more productive occupations in the commercial/trade/industry and tourism sectors of a modern economy as the years go by. Arid countries based on a sound commercial/industrial economy who are adjacent to the sea coast, never need to face shortages of drinking quality water for domestic/urban/ commercial/tourism and industrial use since relatively low cost desalination of seawater has now made it possible to produce all the water they will ever require to meet those needs. However, desalinated sea water is still far too expensive to justify its use in agriculture.

This paper has shown that the modern, rational, economic approach to this question is, that the arid countries in the Middle East- Jordan, Palestine and Israel with little water should accept the reality that priority in utilization of their limited fresh, potable water resources should go to meet the immediate human needs of drinking water, domestic and urban use as well as for high income producing commercial, industrial and tourism use. It is more rational to import most of the high water consuming food and fodder, particularly the staples which can be shipped easily and stored for longer periods, from those countries with plenty of water from natural renewable, sustainable sources and sufficient areas of arable land. In other words, to import "virtual water" in its most economical form-food. The recycling of highly treated urban wastewater can provide an important and economically feasible source of additional water for use in support of “green lungs” and some agriculture as well as other industrial and urban non-potable water uses. Imports of "virtual water" can provide the *food security* and low cost desalinated seawater can now meet all domestic/urban/commercial and industrial needs.

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