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SUSTAINABLE WATER RESOURCES VERSUS CONCEPTS OF FOOD SECURITY, WATER SECURITY, WATER STRESS FOR ARID COUNTRIES

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ABSTRACT: Some countries profess that their national agricultural policy is based on a concept of *water security* and *food security* which dictates self-sufficiency in most food products as a matter of *national security*. They claim that this is necessary in case of a threat of a long term embargo, siege or blockade which would prevent food imports. This paper will show that the modern, rational, economic approach to sustainable water resources development in countries with little water for agricultre should be the acceptance of the reality that it is more rational to import most of the high water consuming food and fodder they need, 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. While the *food security* concept often generates perceived needs for water that is irrational and non-sustainable in arid areas, the concept of *food sufficiency*, on the other hand, requires that there is on-going sufficiency of food for the needs and development of a society, attained chiefly *by trade*.. *Food sufficiency*, does require an economy that generates enough exports to cover the cost of the needed food imports. In the really arid areas, there is, in the long run very little alternative other than developing a sustainable economy based on low water consuming industry, trade, commerce and tourism which will provide employment and a higher standard of living, rather than one based mainly on agriculture.

Two other inter-related concepts which have somewhat complicated the understanding of this question are the *Water Stress Index* and the water supply *benchmark* concept will be evaluated. The 1,000 cubic meters/ person/year *benchmark* level of assured water supply proposed by some authors, assumes that major amounts of water must be available in every country for agriculture and food production. While it is fundamentally correct, that *some place in the world the water must be available to grow enough food for all of the population in the world,* it is erroneous to imply that each and every country, should or must have at its disposal enough water to be self sufficient in agricultural food production. When water is really scarce, the first task, from the point of view of human welfare, a sustainable policy of economic development and rational use of limited water resources, which in the end will provide real *water security*, is to meet the needs for domestic and urban use, as well as the water needed by commerce, tourism and industry, so as to supply employment for the population. The Minimum Water Requirement -MWR concept will be presented. The MWR proposed for the arid areas of the Middle East is a total of 100-125 cubic meters/person/year CM/P/Yr.) for domestic, urban commercial and industrial use. The MWR concept does not include any other direct allocation of fresh water for agriculture, but does assume that additional water for agriculture and/or other industrial or urban non-potable uses can be made available through the *recycling and reuse of some 65% of the water allocated for domestic/urban/industrial use*. Thus, the total effective supply of water could reach 190 CM/P/Yr. (125 CM/P/Yr. from fresh water and 65CM/P/Yr. from recycled wastewater).

WHAT IS "FOOD SECURITY"? DOES IT MEAN THAT EVERY COUNTRY MUST GROW ALL OF ITS OWN FOOD AT ANY COST?

In the efforts of water short countries in arid areas to acheive sustainable freshwater resource development certain controversial concepts such as *food security, water security and water stress*, which have been widely discussed must be dealt with in a candid manner since there is a degree of conflict between the rational sustainable management and planning of limited water resources and those controversial concepts.

A number of authors refer to the importance of *food security and water security* (Falkenmark,1992; Postel, 1995) although their exact meaning is not clearly defined. Some arid countries profess that their national agricultural policy is based on a concept of *food security* which dictates self-sufficiency in most food products as a matter of *national security*. They claim that this is necessary in case of a threat of a long term embargo, siege or blockade which would prevent food imports.

A few oil rich, but water short countries have embarked on a program of seawater desalination for agricultural use on the basis of just such a *food security* policy. These countries did not have enough natural fresh water resources to support enough sustainable agriculture to grow all neccessary food supplies for local consumption. It has been reported that in part the motivation of one such oil rich country, to initiate their program of *food security* based on desalinated water and/or severe mining of limited ground water, may have resulted from an unofficially reported statement by someone in one of the main oil importing countries, which also is one of the main wheat exporting countries, suggesting that there might be *a grain export embargo in response to the oil embargo* initiated by the oil exporting countries during the late 1960's. Such a grain embargo was never actually initiated. It is not clear whether those countries who initiated programs to grow grains with desalinated sea water and by the rapid mining and pumping down of very limited ground water resources, to meet local grain demand, so as to achieve *food security* carefully evaluated the alternatives for achieving the same goal.

One alternative, might be to build cold storage warehouses and grain silos capable of storing most of the food requirements to meet periods of need, such as a food import embargo. The Bible records, that one of the Pharaohs of Egypt, on Joseph advice, did just that when he built grain silos to store food for periods of drought, some four thousand years ago. It is indeed difficult to comprehend the rationale of one of those countries that built seawater desalination plants and deplete their ground water potential in a matter of years, to produce water for irrigation and to achieve so-called *food security* that now has become a major grain exporting country, at a tremendous cost to it's weakened national treasury which subsidies the grain.

What about those less prosperous countries lacking in rich deposits of oil, or one time reserves of " fossil" water, that do not have enough renewable fresh water supplies for such self-sufficient irrigated agriculture? Is it economically and socially rational or necessary, from a security point of view, to desalinate seawater so as to grow crops, including wheat for local consumption and even export, when the actual cost of the locally grown subsidized wheat is 5 times that of the world market price? Is it rational for such a country to aspire to acquiring additional water resources through a confrontation or *water war* with one of its more water rich neighbors?

I would suggest that the rational, economic approach to this question is that countries with little water should import most of the high water consuming food they need, particularly the staples which can be shipped easily and stored for longer 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, oil and even frozen meat and fish and their storage in local warehouses and cold storage facilities is a much 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* under the *food security* concept. However, it might be feasible to grow locally, limited amounts of fresh vegetables and salad crops for local consumption which requires very little water per person .

Naff (1955) has suggested a differentiation between " food security" and " food sufficiency". *Food security,* according to Naff , requires a guarantee of enough food to satisfy a population's minimal needs over a long period of time, a policy usually expressed as self contained , domestically produced 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 of food and animal feed even if the country does not have sufficient local water resources to sustain such a policy.

This has resulted in the perception of needs for greatly increased water resources. This often means increased demands for the reallocation of shared water resources from limited transboundary water resources and the resulting exacerbation of water conflicts. It has also led in some cases to the problematical production of expensive desalinated sea water for agricultural irrigation, regardless of costs and benefits. Naff (1995) correctly points out that the *food security* concept "in the arid Middle East will always be a wasteful and ill-fated policy".

Food Sufficiency, according to Naff, 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.. Food sufficiency,* does require an economy that generates enough exports 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 , trade, commerce and tourism which will proved employment and a higher standard of living, rather than an economy based mainly on agriculture. Such an economy will be able to provide sufficient financial resources to import all the food required to assure for *food sufficiency*.

Under such an urban/industrial economy the main needs for water are limited to that amount required to assure adequate supplies to meet all domestic/urban/commercial and industrial needs, with possibly some minimal amounts allocated to growing fresh vegetables and salad crops for immediate local consumption.

It is one of the fundamental premises of this paper that the concept of *food security* in the arid areas of the Middle East cannot be seen as a realistic one and can only lead to unnecessary increased conflict over very 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* as an acceptable long term policy with important political, economic and security advantages.

THE DEBATE OVER THE *WATER STRESS INDEX*

The question of the amount of water required by peoples living in arid zones has been widely discussed and debated. Falkenmark (1992) has proposed the concept of a *water stress index* based on her estimated minimum level of water required per capita/year to maintain an adequate quality of life in a moderately developed country in an arid zone.

Falkenmark estimates that while only 100 liters/person/day {or 36.5 cubic meters/person/year (CM/P/Yr)} are the rough minimum for basic household needs required to maintain good health, that a water efficient, and moderately developed country requires at least 30-45 times that quantity of water to satisfy all the requirements of agriculture, industry and energy production.

Thus, according to Falkenmark(1992), a level of 1700 CM/P/Yr is required. She holds that when fresh water availability falls below 1,000 CM/P/Yr, countries experience *chronic water stress* and when countries fall below 500 CM/P/Yr they experience *absolute water stress*. Falkenmark's pioneering concept of *water stress* has been much debated and the numerical levels suggested have been challenged. However, a number of authorities including the World Bank(1992) have accepted the 1000 CM/P/Yr level as a *benchmark* which they claim can serve as a general indicator of water scarcity. Gleick(1993) has called it the "approximate minimum necessary for an adequate quality of life in a moderately developed country" However, all of these authors assume that a major allocation of water is necessary for agricultural purposes both to supply local food requirements (*food security*) and/or assure employment for those who have traditionally lived in rural areas and made their livelihood from agriculture.

In some countries, in arid areas, such as Egypt, for example, where irrigation is required for all forms of agriculture and to grow food for local consumption, and sufficient water is still available, as much as 80-90% of the water supply is utilized for such agricultural purposes and some 70-80% of the population derive their livelihood from agriculture, directly or indirectly. Can this ratio of water allocation to agriculture continue as populations grow, along with rapid urbanization and industrialization, with the water resource potential remaining the same?

It is difficult to accept these concepts of *water stress* and *food security* as being politically sound, economically rational or applicable to the really water scarce areas of the Middle East. For the arid countries of the Middle East the concept of *adequate amounts of water* must be quite different than that of countries with plentiful amounts of year round rainfall, rivers for hydroelectric power production and transport, and copious sources of low cost water for supplemental irrigation.

The 1,000 cubic meter/ person/ year *benchmark* level supported by authors from the countries with more temperate climates assumes that major amounts of water must be used for agriculture and food production. This may be fundamentally correct. in that *some place in the world the water must be available to grow enough food, fodder and industrial crops for all of the population in the world.* However as pointed out above on *food security*, it is a serious error to imply or suggest that each and every country can, should or must have at its disposal enough water to be self sufficient in agriculture and food production. This can and has led to irrational and often dangerous perceptions and demands concerning national water needs. This is my fundamental criticism of the Falkenmark (1992) water stress index or the World Bank 's (1992) *water benchmark.*

There are a number of Middle Eastern countries who are already well below the 500 CM/P/Yr level such as Bahrain, Kuwait, Jordan, Israel and Palestine (see Table 1) and are at, or are approaching the 100-200 CM/P/Yr level. After the urban and industrial demand is fully met, such countries will eventually have little or no water left over for agriculture. With time that list will grow.

The question that must be asked is: Can countries facing such severe water shortages, whose main options for increasing water supplies are confrontations with neighbors over

TABLE 1. ANNUAL RENEWABLE FRESH WATER AVAILABLE PER PERSON IN MIDDLE EASTERN AND SELECTED COUNTRIES. RANKED BY 1990 AVAILABILITY[1]

COUNTRY	RENEWABLE FRESH WATER IN CU.M./PERSON/YEAR (CM/P/Yr)		
	1955 CM/P/Yr	1990 CM/P/Yr	2025 CM/P/Yr
A. MIDDLE EASTERN COUNTRIES			
DJIBOUTI	147	23	9
KUWAIT	808	75	57
QATAR	1,427	117	68
PALESTINE		--- (160)[2]	--- (60)[2]
BAHARAIN	627	179	89
ISRAEL	1,229	461(300)[2]	264(150)[2]
U.ARAB EMIRATES	6,195	308	176
SAUDI ARABIA	1,266	306	113
JORDAN	906	327	121
YEMEN	1,098	445	152
TUNISIA	1,127	540	324
ALGERIA	1,770	689	332
LIBYA	4,105	1,017	359
MOROCCO	2,561	1,123	590
EGYPT	2,561	1,123	630
OMAN	4,240	1,266	410
CYPRUS	1,698	1,282	996
LEBANON	3,088	1,818	1,113
IRAN	6,203	2,025	816
SYRIA	6,500	2,087	732
TURKEY	8,509	3,626	2,186
IRAQ	18,441	6,029	2,356
B. OTHER COUNTRIES			
UNITED KINGDOM	2,344	2,090	1,992
CHINA	4,597	2,427	1,818
GERMANY	2,843	2,516	2,284
FRANCE	4,260	3,262	3,044
SWITZERLAND	10,040	7,449	6,492
UNITED STATES	14,934	9,913	7,695

(1)Source- Engleman and LeRoy ,1993)
(2)(---) Estimates based on Shuval, 1992

limited shared water resources or seawater desalination costing about $1.00/CM, consider irrigated agriculture as essential to their security or as an economically rational way to use such expensive water? We have already pointed out that *food security* at any cost is an irrational societal and/or security option. Most experts agree that the growing of basic food crops with desalinated water can never be expected to be economically feasible.

When water is really scarce the first task from the point of view of real *water security* is to meet the needs for domestic and urban use as well as the water needed by commerce and industry, so as to supply employment for the population. In Jordan and other countries of the region, lack of water or irregular supply to urban areas has lead to social unrest and political tensions and to *water insecurity*.

What then is the real minimum amount of water for community and national survival under arid area conditions?

THE "MINIMUM WATER REQUIREMENT" -MWR FOR URBAN USE IN ARID ZONES.

A number of Middle Eastern countries are already facing situations under which the available water supplies are now sufficient only to support most of the population in urban settings where trade, commerce, tourism and industry are the main sources of employment. Similar to the situation in such water and land scarce places as, Bahrain, Kuwait, Hong Kong and Singapore. As populations grow in the future, and the urban/ industrial demands for water increase, the relatively limited quantities of water available for agriculture, whose economic return per unit of water consumed, is relatively low, will by the nature of things, be diverted to cope with the growing demands of the urban/ commercial/industrial sector which can pay a much higher price for water.Unless water is supplied to meet these urban, commercial and industrial needs there is likely to be serious unemployment as well as social and even political unrest.

How much water is required for a reasonable standard of living to meet domestic/urban / industrial demand? In the United States the USEPA reported that in 1981 the mean annual *household* water use was about 90 CM/P/Yr. Since that survey water demand in urban areas has grown in the United States. A survey of 159 utilities serving the 100 largest metropolitan areas in the USA (Environmental Engineering News, 1995) found that the 1994 mean water usage per month was 7000 gallons per household, which, assuming three persons per household, can be estimated as being equivalent to 310 liters/person/day or 114 CM/P/Year for household use only.

In the United States total urban use including water for schools, hospitals, hotels, parks, commerce, and industry is about 180-220 CM/P/Yr. Some urban areas consume as much as 300 CM/P/Yr. In the areas of Europe, which support a high standard of living, domestic/urban/industrial demands for water are lower than in the United States and range between 100-150CM/P/Yr.

According to the Ben Gurion University/Tahal report to the World Bank (Braverman,1994), Israel's domestic/urban water supply consumption averaged in 1993 some 100 CM/P/Yr. Industrial consumption averaged an additional 23CM/P/Yr. That adds up to a mean domestic/urban/industrial water demand of some 125 CM/P/Yr. The report assumes that under proper conditions of highly effective programs of water conservation including the use of water saving devices in the home and water recycling in industry urban/industrial water consumption in Israel can be frozen at its present level (125CM/P/Yr) over the next 30-40 years or even reduced by some 10%.This may well be a somewhat optimistic assumption as to the success of water conservation measures. They also assume that Palestinian domestic water, which now averages some 35MC/P/Yr will eventual rise to almost the same level as that of Israel over the next 30-40 years.. Experience in Israel indicates that a high standard of life can be maintained with a domestic/urban/industrial water consumption of about 100 CM/P/Yr (Braverman, 1994).

This has been achieved by water metering, charging for the full combined cost of water supply and wastewater collection and disposal as part of the urban water bill, punitive increases in prices for overly high, domestic water consumption, as well as public education on water conservation. Water conservation measures such as the introduction of water saving fixtures in the home, and requiring all industries to recycle cooling water and process water, wherever technologically feasible has contributed to this conservation conscious water consumption level. It has been estimated in Israel that this figure might increase to about 125CM/P/Yr within a 30 year period (Braverman, 1994)

In one study in the United States (USEPA,1981) it has been estimated that the potential water savings that would result from the rigorous introduction of optimal water saving devices in the home could be as great as 33% resulting in a mean household water use of 60 CM/P/Yr. For example with proper water saving devices the amount of water used for toilet flushing alone could be reduced by 50% or by about 16 CM/P/Yr. These studies indicate that domestic water consumption can be kept low while maintaining a very high standard of living. The total urban/commercial water use would still reach a level of about 120CM/person/Yr.

However, there is the question of whether or not the urban population will have the economic motivation to invest in water saving devices if it is not required by law. The 1994 survey in the United States (Environmental Engineering News, 1995) found that the total average monthly charges per household was $13.65 for water and $16.24 for wastewater or about $120/person/year. Thus , for example in the United States the total charges for water are less 1% of the mean annual personal income and thus hardly an economic factor that might lead to a strong motivation for major water saving efforts in the urban sector. While this might also be the case for Israel with its high annual GNP/Capita, the high cost of urban water supply in the other countries on the Jordan Basin would most likely be a major factor keeping down urban water consumption or preventing it from rising rapidly. However, this may well change as the socio-economic conditions improve in the Middle East.

Nevertheless, the MWR proposed for consideration for truly arid areas is a total of 100-125 cubic meters/person/year (CM/P/Yr) for domestic, urban and industrial use (Shuval, 1992). In addition there might be a symbolic allocation of 25 CM/P/Yr of fresh, good quality water for minimal growing of fresh vegetables (such as in vegetable gardens adjacent to homes) livestock and chickens that require the use of fresh water of drinking water quality. Based on fresh vegetables consumption patterns in Israel and data on crop requirements for water, 25 CM/P/year would be sufficient, using modern drip-irrigation techniques, to meet the water requirement for the irrigation of the supply of most of the fresh vegetables and salad crops for local consumption.

The MWR calculation will not include any other direct allocation of fresh water for agriculture, but does assume that additional water for agriculture and/or other industrial or urban non-potable uses can be made available through the *recycling and reuse of some 65% of the water supplied for domestic/ urban/industrial use*. In other words there will be, in effect, the possibility of generating an additional 65 CM/P/Yr if an effective, total water recycling program is introduced. Thus, the total effective availability of water of all types could reach 190 CM/P/Yr (125 CM/P/Yr from fresh water sources and 65CM/P/Yr from recycled wastewater).

CONCLUSIONS

I have attempted to point out some of the weaknesses and fallacies of current concepts of food security, water security and water stress and the dangers that can derive from

accepting concepts which can motivate unrealistic expectations as to the water resources needs by countries in arid areas. In such areas it would be best if there is an acceptance of the reality that irrigated agriculture can rarely be justified under conditions of severe water secarcity, that the limited fresh water reserves should be devoted in the first instance to meet domestic and urban water demand and that most food, particularly staples will have to be imported. However, there must be sufficient water to meet human needs for survival and economic growth in an urban/commercial/industrial society. Such an industrialized urban society must have as one of its goals, the earning of enough foriegn currency,through exports, to pay for the import of its food needs, which cannot be met locally. It must also assure that it can obtain the realistic minimum water requirements to meet all reasonable domestic/urban/commercial and industrial demands. While desalination of seawater is clearly not economically feasible for agriculture it is not an unrealistic source of future water supplies for domestic/urban/commercial and industrial purposes.

A consensus on estimates of the future minimum water requirement- MWR to meet reasonable human needs for survival and economic welfare may play an important role in resolving water conflicts of the countries of the Middle East as well as in other areas. In light of this I have proposed as a matter of principle, that the ultimate Minimum Water Requirement- for all nations on the Jordan River watershed be estimated as being equal at a MWR of 125 Cu M./ person/year (Shuval, 1952) It is assumed that the countries now using much less water for domestic/urban/commercial/industrial use will increase their water demands in the future as their standard of living increases and economic growth progresses. Assuming eventual equity among countries of the region in non-agricultural water use on a per capita basis is not unreasonable based on experience in both developed and developing countries. In addition, no less important is the acceptance of the concept of equity as the corner stone of the Helsinki Rules and UN International Law Commission's proposal. The concept of equity is an essential element in achieving a just and lasting peace and in resolving the water conflicts of the Middle East in a manner that would be perceived as being equitable and fair to all..

I have concluded that when one talks in real world terms about *water security and food sufficiency* in the strictly arid areas of the Middle East the rock bottom amount of water required per person per year to meet domestic/urban/commercial/industrial needs for such realistic *water security* is the MWR of about 125CM/P/Yr. The perception and demands that greater amounts of water than that, including major allocations for agriculture and food production, are *"needed, "must be made available" or are "required for security and survival"* are in most cases based on misguided concepts or are politically motivated and are more often than not, unrealistic and misleading.

REFERENCES:

Braverman A (1994) *Israel Water Study for the World Bank*, Ben Gurion University of the Negev and Tahal Consulting Engineers Ltd, August 1994 (R-94-36-1) Beersheba

Engelman R. and P LeRoy (1993) Sustaining Water: Population and the Future Renewable Water Supplies Population Action International, Washington D.C. 56pp

Environmental Engineering News (1995) School of Civil Engineering, Purdue University, West Lafayette ,in Vol. LII no 5&6 May/June1995)

Falkenmark M. and C. Widstrand (1992) Population and Water Resources:A Delicate Balance, *Population Bulletin*,Population Reference Bureau

Gleick P.H.(1993) ed. *Water in a Crisis: A Guide to the Worlds Fresh Water Resources*.Oxford University Press, New York

Naff, T. (1994) Conflict and Water in the Middle East in *Water in the Arab World* Editor Peter Roger, Harvard University Press

Postel, S. (1996) Water in Human Development: Charting a New Course, in Water Resources Development- Proceedings Fifth Stockholm Water Symposium, Stockholm Sweden

Shuval, H.(1992) Approaches to Resolving the Water Conflicts between Israel and her Neighbors-a Regional Water for Peace Plan," *Water International* Vol. 17:133-143

.USEPA- U.S.Environmental Protection Agency (1981) *Flow Reduction Methods, Analysis Procedures,Examples*, USEPA, Office of Water Programs, Washington D.C.

World Bank (1992) *World Development Report*,Oxford Press,New York