Fertigation Potentials in the Near East Region

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ABSTRACT

About 10% of the world population lives in the Near East region, with a population increase of 2.7% per year. The Near East region receives only 3.5% of the world precipitation and has only 2.2% of its renewable water resources. In the N.E region 80-90 % of the water is used to irrigate nearly 55 million hectares, and because of the increased demand on this vital resource, it should be used more efficiently. Surface irrigation is practiced on 87%, sprinkler on 11% and trickle irrigation on less than 2%. The later method of irrigation should be encouraged and increased because it saves about 50% of the water used in surface irrigation and therefore, will allow for more land to be put under irrigation in the region without the need for increasing the quantity of the utilized irrigation water. Fertigation is a common practice in modern irrigated agriculture because it improves efficiency of fertilizer recovery and allows flexibility in timing of fertilizer application in relation to crop demand. Since farmers' market water through their crops, any means of improving water use productivity will help in the return of investment and increase profit. Proper fertilization program had shown to directly increase water use efficiency and improve production. In the Mediterranean region more than 60% of the food demands are imported, beside, the impending crises of land and water scarcity implies that fertigation research should be encouraged to keep pace with the alarming situation and increase the productivity of available land and water resources in sustainable manner.

Key words: Water resources, irrigation systems: surface, sprinkler, trickle or localized

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1. Introduction

Aridity prevails in the Near East region and makes it one of the poorest regions in the world in water resources, globally and per inhabitant. The total population of the region is about 600 million, of which about 50% rural. Population increase ranging from 2.2% in Maghreb and North Africa to 3.1% in Central Asia compared to 1.7% in the world. Over 42% of the population of the N.E region is concentrated in Central Asia; 25% live in Pakistan, which occupies only 4% of the N.E area. Population density is lowest in Maghreb, with 13 inhabitants per km^2, and highest in the Middle East, with an average of 71 inhabitants per km^2. The least density-populated country is Mauritania, with 2 inhabitants per km^2. Malta and Bahrain are the most density-populated countries with 1200 and 825 inhabitants per km^2 respectively, followed far behind by Lebanon and Pakistan with 300 and 200 inhabitants per km^2 respectively. All the remaining countries have less than 125 inhabitants per km^2.

The Near East covers 14% of the total area of the world and contains 10% of its population. The water resources are only about 2% of the total renewable water resources of the world. Around 85% of the water is used for irrigation; therefore this vital resource should be used more efficiently and utilized very carefully.

2. Water Resources

The Food and Agricultural Organization (FAO) conducted a survey in relation to development of an information system on water use for agricultural and rural development called AQUASTAT that was implemented in the Near East in 1996 "Irrigation in the Near East in figures". The renewable water resources in the Near East are presented in Table 1.

Table1. Sub-regional distribution of the renewable water resources

Region	Area	Population 1995	Annual Average precipitation		Annual internal renewable water resources			
	1000 km^2	1000 inhabitants	mm	Km^3	mm	Km^3	As % of precipitation	m^3 per inhabitant
Maghreb	5 777	71 544	86	495	8	48	9.8	677
N.E - Africa	4 168	100 856	306	1 275	10	43	3.4	427
Arabian Peninsula	3 103	39 110	79	246	2	8	3.1	197
Middle East	1 512	106 635	421	637	162	245	38.4	2 294
Central Asia	3 926	243 316	304	1 195	138	541	45.3	2 226
Total Near East	18 486	561 461	208	3 848	48	885	23.0	1 577
World	134 223	5 716 407	820	110 000	298	40 000	36.4	7 000
N. East as % of world	13.8	9.8		3.5		2.2		22.5

Note: Rainfall figures have been estimated for Afghanistan, Tajikistan and Turkmenistan (FAO, 1996)
Source: Irrigation in the Near East Region in Figures, FAO Water Report, 1996

The internal renewable water resources per inhabitant in the Near East are among the lowest in the world. The average for the region is 1577 m^3 / person per year, against over 7000 m^3 / person per year for the whole world. It ranges from near 0 for Kuwait, to about 10 000 m^3 / person per year for Tajikistan and Kyrgyzstan. For 16 out of the 29 countries the internal renewable water resources / person are below 500 m^3 /yr and for 11of them even the total actual renewable water resources are below 500 m^3/ yr.
The internal renewable water resources per inhabitant are above 2000 m^3 /yr only in four countries: Turkey, Kyrgyzstan, Tajikistan and Afghanistan.
Non – renewable groundwater basins (fossil) are often shared with neighboring countries. In Saudi Arabia, United Arab Emirates and Libya the largest part of withdrawn water is fossil water. Although ground water reservoirs may contain huge amounts of water accumulated during the pluvial periods of Quaternary, this source can't be considered sustainable in the long term. The lack of recharge for these water aquifers leads to slow depletion of the aquifers, increase in cost of pumping as well as deterioration of the water quality. Table 2 shows the amounts of internal and actual renewable water resources for selected Near Eastern countries.

Table 2. Countries with a renewable water resources dependency ratio above 50%

Country	Internal Renewable Water Resources million m^3 / year	Actual Renewable Water Resources million m^3 / year	Dependency ratio * %	Main source of incoming water
Kuwait	0	20	100.0	Groundwater from Saudi Arabia
Turkmenistan	1 000	71 000	98.6	Amu Darya river
Egypt	1 800	58 300	96.9	Nile river
Bahrain	4	116	96.6	Groundwater from Saudi Arabia
Mauritania	400	11 400	96.5	Senegal river
Syria	7 000	26 260	80.3	Euphrates, Tigris rivers
Sudan	35 000	88 500	77.3	Nile river
Somalia	6 000	15 740	61.9	Shebelli, Juba rivers
Iraq	35 200	75 420	53.3	Euphrates, Tigris rivers

The dependency ratio is equal to the part of the renewable water resources, which originates outside the country.

Source: Irrigation in the Near East Region in Figures, FAO Water Report, 1996

In the Near East 80 - 90% of the water is used by agriculture (Table 3). Central Asia has the highest use for agriculture (95%). In Afghanistan 99% of water directed to agriculture in 1996. Malta with 12% is the country with lowest percentage of water directed towards agriculture and that is due to the high population density 1200 persons / km^2) and the extensive developed tourism.

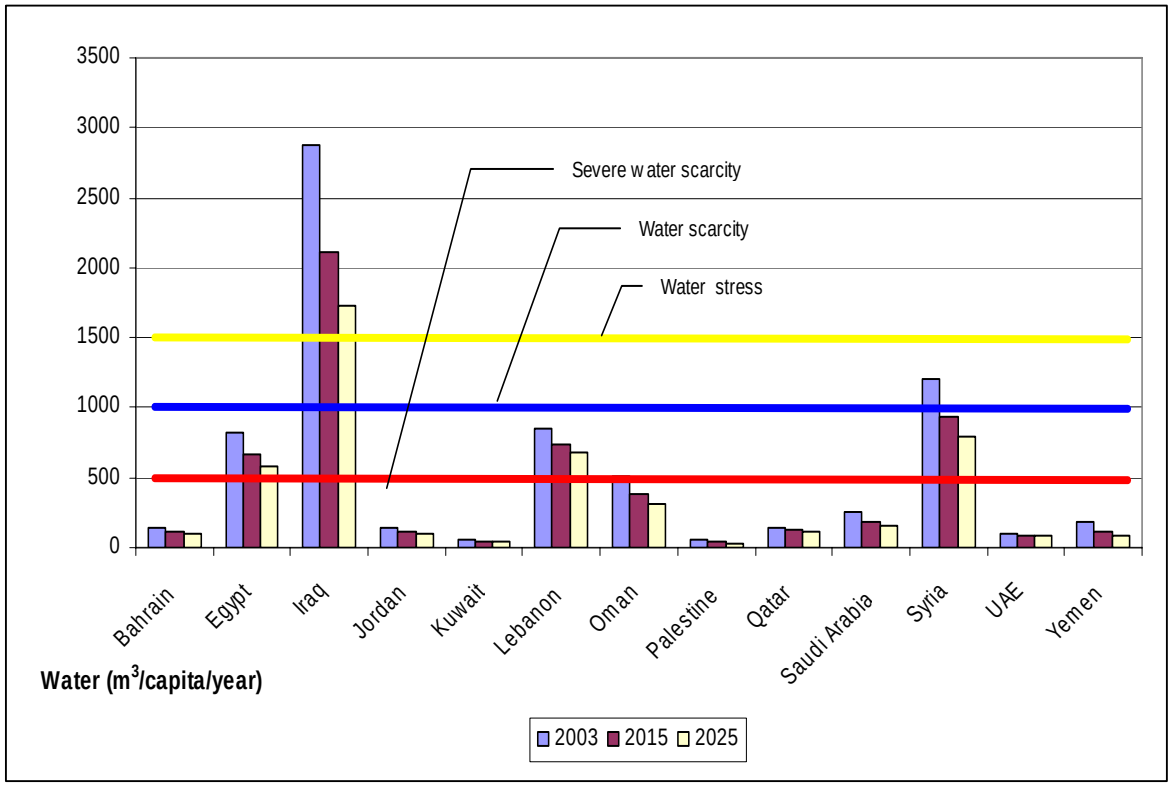
Table 3. Sub-regional distribution of water withdrawal in N.E. countries

Region	Water withdrawal by sector							% by region	m^3/year per inhabitant (1993)
	agricultural		domestic		industrial		total		
	Km^3 per year	% of total	Km^3 per year	% of total	Km^3 per year	% of total	Km^3 per year		
Maghreb	21.1	85	2.5	10	1.2	5	24.8	4.8	363
North-eastern Africa	65.0	88	3.9	5	4.8	7	73.7	14.4	764
Arabian Peninsula	21.2	87	2.6	11	0.5	2	24.3	4.8	659
Middle East	77.7	85	7.7	8	6.0	7	91.4	17.8	907
Central Asia	282.9	95	8.3	3	7.0	2	298.2	58.2	1 302
Total Near East	467.9	91	25.0	5	19.5	4	512.4	100.0	964
World	2 235.6	69	259.2	8	745.2	23	3 240.0		660
N. East as % of world	20.9		9.6		2.6		15.8		146

Source: Irrigation in the Near East Region in Figures, FAO Water Report, 1996

It is estimated that 1800 million m^3/yr of desalinated water is used in the Near East. Saudi Arabia, the UAE and Kuwait are by far the largest users of desalinated water, with Saudi Arabia accounting for more than 40%.
The total quantity of reused treated water in the N.E is estimated at 1500 million m^3/yr. Syria, Saudi Arabia and Egypt are the largest users of treated wastewater, with Syria alone accounting for more than 30%. Availability of water resources in some N.E. countries is summarized in Fig. 1.

Figure 1. Estimated water availability, per capita, in some N.E. countries



Source: Osman M.E. "Comparative Analysis of Agricultural Policies in Selected ESCWA Countries". Symposium on "Agricultural Policies in the Arab World" 18-June-2004, Amer. Univ. of Beirut, Lebanon

3. Irrigation

Table 4 gives a summary about distribution of main crops in the Near East region. It indicates that only 7% of the area is cultivated with vegetables versus 37% wheat, 20% cereals and 14% cotton.

Table 4. Sub-regional distribution of the main crops (based on partial information)

Region (unit: 000ha)	wheat	other cereals *	fodder crops	vege-tables **	cotton	other annual ***	perma-nent crops	total
Maghreb	158 8%	507 25%	125 6%	573 28%	16 1%	179 9%	464 23%	2 022 100%
N-eastern Africa	1 077 16%	2 024 31%	1 098 17%	409 6%	704 11%	858 13%	386 6%	6 556 100%
Arabian Peninsula	916 45%	243 12%	323 16%	178 9%	13 1%	23 1%	326 16%	2 022 100%
Middle East	784 29%	576 21%	38 1%	307 11%	408 15%	396 15%	197 7%	2 706 100%
Central Asia	10 331 46%	3 769 17%	1 187 5%	896 4%	3 846 17%	846 4%	1 615 7%	22 490 100%
Total Near East	13 226 37%	7 119 20%	2 771 8%	2 363 7%	4 987 14%	2 302 6%	2 988 8%	35 796 100%

* Total includes 3 449 000 ha rice, 1 143 000 ha maize, 945 000 ha barley and 568 000 ha sorghum

** Total includes 225 000 ha tubers (mainly potatoes) and 374 000 ha pulses

*** Total includes 386 000 ha sugar cane, 286 000 ha oil crops (exc. olives) and 168 000 ha sugar beet

Source: Irrigation in the Near East Region in Figures, FAO Water Report, 1996

Irrigation covers about 16 million hectares in the Arab countries, nearly 6% of the world's total. Detailed information on the irrigation techniques were available from 13 countries only (Table 5). Surface irrigation is by far the most widely used technique, practiced on 75% of the total area, followed by sprinkler irrigation 22% and trickle or localized irrigation 3%.
In Libya and Saudi Arabia, sprinkler irrigation is the most dominant, while in Cyprus, Malta, Jordan and the UAE, trickle and localized irrigation is the most used technique. In Kuwait and Lebanon both sprinkler and drip techniques are practiced on about 40% of their irrigated area.
In the Near East region, surface irrigation is the most widely used technique; it is practiced on about 87% of the total irrigated area; Sprinkler irrigation on 11% and trickle or localized irrigation on less than 2% of the total area.

Another indicator of the importance of water scarcity in the Arab countries is the amount of food the region must import to compensate for the lack of water necessary for agricultural production (27×10^9 $/yr). Table 6 shows estimated quantities for the amount of water necessary, under the prevailing climatic conditions of the region, to produce selected food items.

Table 5. The Arab Countries: Full or partial control irrigation techniques

COUNTRY	Year	FULL OR PARTIAL CONTROL IRRIGATION: Equipped area				% of equipped area actually irrigated	COUNTRY
		surface	sprinkler	micro	Total		
		ha	ha	ha	ha		
		(1)	(2)	(3)	(4)= (1)+(2)+(3)	(5)	
ALGERIA	1992	-	40 000	-	445 500	82.2	ALGERIA
BAHRAIN	1994	2 497	130	538	3 165	100.0	BAHRAIN
DJIBOUTI	1989	-	-	-	674	60.4	DJIBOUTI
EGYPT	1993	3 046 000	117 000	83 000	3 246 000	100.0	EGYPT
IRAQ	1990	-	-	8 000	3 525 000	54.9	IRAQ
JORDAN	1991	20 300	5 700	38 300	64 300	-	JORDAN
Jordan	2004	23 760	5 100	56 000	84 860		
KUWAIT	1994	3 020	600	1 150	4 770	100.0	KUWAIT
LEBANON	1993	53 500	21 000	13 000	87 500	-	LEBANON
Lebanon	2004	60 000	30 000	20 000	110 000		
LIBYA	1990	0	470 000	0	470 000	51.1	LIBYA
MAURITANIA	1994	-	-	-	49 200	54.4	MAURITANIA
MOROCCO	1989	986 000	103 200	4 000	1 093 200	-	MOROCCO
OMAN	1993	57 820	1 640	2 090	61 550	100.0	OMAN
QATAR	1993	-	-	-	12 520	66.4	QATAR
SAUDI ARABIA	1992	547 000	1 029 000	32 000	1 608 000	100.0	SAUDI ARABIA
Saudi Arabia	2004	450 000	1 000 000	55 000	1 531 000		
SOMALIA	1984	-	-	-	50 000	-	SOMALIA
SUDAN	1995	-	-	-	1 900 000	63.2	SUDAN
SYRIA	1993	981 273	30 000	2 000	1 013 273	-	SYRIA
Syria	2004	1 117 359	137 400	46 400	1 301 154		
TUNISIA	1991	294 000	55 000	6 000	355 000	90.7	TUNISIA
UAE	1993	25 382	3 748	37 552	66 682	81.7	UAE
YEMEN	1994	382 450	350	400	383 200	-	YEMEN
Arab Countries					14 439 534		Arab Countries
For 13 countries (ha)		6 399 242	1 837 368	220 030	8 456 640	77.3	For 14 countries
For 13 countries (%)		75.7	21.7	2. 6			

Source: Irrigation in the Near East Region in Figures, FAO Water Report, 1996

Table 6. Water equivalent of main food products in the region

Product	Unit	Equivalent water in (liters/unit)
Meat bovine fresh	Kg	20,000
Meat sheep fresh	Kg	10,000
Meat poultry fresh	Kg	6,000
Palm oil	Kg	2000
Citrus (orange, tangerine, clementine)	Kg	1000
Pulses	Kg	1000
Root & tubers	Kg	1000
Cereals	Kg	1000

Source: Saraff, S. Water Resources and Irrigation in the Arab Countries. "AFA/IFA International conference". Cairo – Egypt, 18-20 Feb. 1997.

On the bases of the FAO trade statistics (FAO, 1996), net import of food could be estimated for each country and transformed in water equivalents (virtual water). The results as presented in Table 7 indicates that net food import amounted to 73.45×10^9 m^3 of water per year, a volume close to the total natural flow of the Nile River at Aswan (84×10^9 m^3 / year). The figures are negative of Somalia and Mauritania because these two countries are exporters of animals (sheep and goats).

Table 7. Water equivalent (virtual water) of Import (1994) of food in Arab Countries

Country	Water equivalent in 1000 m^3 of import – export
Algeria	12 369 700
Bahrain	679 600
Djibouti	1 100
Egypt	18 171 100
Iraq	2 179 100
Jordan	3 467 200
Kuwait	2 783 600
Lebanon	1 765 800
Libya	3 236 600
Mauritania	-1 700
Morocco	2 419 100
Oman	1 349 000
Qatar	657 300
Saudi Arabia	13 863 200
Somalia	-851 000
Sudan	1 118 300
Syria	1 014 000
Tunisia	2 463 200
UAE	3 362 000
Yemen	3 375 100
Total	73 450 000

Source: Saraff, S. Water Resources and Irrigation in the Arab Countries. "AFA/IFA International conference". Cairo – Egypt, 18-20 Feb. 1997.

4. Water management and fertigation potential

The basic principle in water resource demand management is the reduction in losses. Losses can be in leaking from close conduits, seepage from open watercourse and illegal connections. The main objective in demand management is to improve the efficiency of all users. For example, to increase the efficiency in the industrial usage, water quality standards should be implemented; this will force the industry to reuse water. While in the domestic domain escalating the price of water demand induces self management and more efficient use of water in the house hold. Whereas, in irrigated agriculture efficiencies at the farm level are low, and should be improved via the reuse of water or encourage the use of systems of high efficiency to reduce losses of water drainage. Many countries in the N.E region started to shift from gravity irrigation to pressurized irrigation as in Jordan, Saudi Arabia, Egypt, Morocco, and many others to improve water use efficiency as indicated in Table 8.

Table 8. Comparing water use efficiency between surface, sprinkler and drip systems

Irrigation System	Wetting area (%)	Amount water used (m^3/ha)	Water Losses (evaporation and conveyance) (%)	Water saving relative to surface (%)
Surface	100	500	40-45	--
Sprinkler	100	320	15-20	30%
Drip	< 50	122	Very low (1-2%)	75%

New horizons in irrigation techniques. Khalifeh, F. Professional and Technical Development of Agriculture in Lebanon. (2002).

Let us assume that in the Near East funding is made available to shift 1 million hectares from surface to drip irrigation (Table 8). The same quantity of water will be sufficient to put 2 million hectares of land under drip irrigation for production of vegetables and perishable products instead of cotton or cereals. The cost and return of such a project based on Lebanese prices are presented in Table 9.

Table 9. Cost and return of changing surface irrigation to drip (vegetables)

Cost of 1 ha drip irrigation	3500 $
Life time of the project	10 Yrs
Cost per Year	350 $/ha
Annual Interest on investment + maintenance = 6%	213 $/ha
Supporting facilities (per year) (cold storage, packaging, marketing …)	100 $/ha
Total annual cost	663 $/ha/yr
Value of saved labor + fuel	- 118 $/ha/yr
Net extra annual cost	545 $/ha/yr
Others	55 $/ha/yr
Net increase in annual cost	600 $/ha/yr

Total annual cost for fruit trees will be about 1100USD /year for orchard establishment.

The reported values in Table 10 show exact numbers of fixed and variable of a 5-hectar operation under drip and surface irrigation systems in Bekaa Valley in Lebanon.

Table 10. Costs for a 5Ha operation

Fixed Costs for a 5Ha Drip Irrigation System				
Item	Quantity	Description	Price per Unit	Total Price
Main Pipes	2	465m	4.3$	$2,000
Sand Filters	3		800$	$2,400
Disk Filters	3		210$	$630
Distributor Pipes		600m	1.66$	$1,000
Drip Tubes		30000m	15.5Cent	$4,650
Drip Tubes		20000m	22.5Cent	$4,500
Fertilizer Mixer	1			$300
Accessories	Valves & T-pipes & Etc,			$500
Labor for Central Station				$300
Labor for System Implementation		Ha	300$	$1,500
			Total	$17,780
				$3556/ha

Variable Costs for a 5Ha Drip Irrigation System for 225 Days (120 Days Potato, 70 Days Lettuce, and 35 Days Spinach)				
Item	Quantity	Description	Price per Unit	Total Price
Labor	0.5	Salary for 8 months	250$	$1,000
Fuel	8900 L	890 Hr Irrigation	0.45$/L	$4,000
Maintenance		Extremely Variable		$400
			Total	$5,400
				$1080/ha

Variable Costs for a 5Ha Surface Irrigation System for 225 Days (120 Days Potato, 70 Days Lettuce, and 35 Days Spinach)				
Item	Quantity	Description	Price per Unit	Total Price
Labor	2	Salary for 8 months	250$	$4,000
Fuel	11200L	1120 Hr Irrigation	0.45$/L	$5,040
Maintenance		low		$300
			Total	$9,340
				$1668/ha

Berro Farm - Bekaa – Lebanon (personal communication – real numbers)

Table 11 shows economical evaluation for same cropping system when farmers grow the same crops under surface and drip irrigation systems (cotton & field crops). The investment to shift from surface to drip will not be economically feasible, but there will be a saving of 25-50% of the irrigation water.

Table 11. General evaluation for shifting surface to drip irrigation (same cropping system)

Item	Return $/ha/yr
Surface irrigation	1000
Drip irrigation	1200 (20% increase in yield) + 118 (fuel & labor savings) = 1318
Net increase in annual cost	600
Net profit (same cropping system)	=1318 – 600 = 718
Balance	- 282

However, Table 12 shows that if farmers change their cropping system from cotton and field crops (surface irrigation) to vegetables (drip irrigation) there will be a very high increase in net return.

Table 12. General evaluation for shifting surface to drip irrigation (new cropping system)

Item	Return $/ha/yr
Drip irrigation	6000
Flood irrigation	1000
Drip irrigation extra return	5000
Net profit (shift from cereals to vegetables)	6000-(1000+600) = 4400

The total net profit from converting 1 million hectares from flood (field crops) to drip irrigation (vegetables) = 4400 $ /ha/yr x 1,000,000 ha = 4,400,000,000 $ /yr and the total annual cost is 1,000,000 ha x 600 $ / ha / yr = 600,000,000 $ / yr.
Therefore, the annual return = (4,400,000,000 / 600,000,000) x 100 = 733 % and the annual return for fruit trees will be about half of that for vegetables.

5. Potential Increase in Fertilizer Consumption

As reported earlier shifting from surface irrigation to drip irrigation will allow for doubling the cultivated area and therefore leads to a two-fold increase in the used amounts of N and P fertilizers. However, the amount of K fertilizers will increase 3-folds due to shifting from cereals to vegetable and fruit trees. Assuming that farmers apply for flood irrigation an average of 100 kg/ha of K_2SO_4 ($1*10^6$ ha X 100 kg/ha = $1*10^8$ kg = 10,000 tons). The quantity of K_2SO_4 that will be utilized from converting 1 million hectares flood into 2 million hectares drip is about $2*10^6$ ha X 300 kg/ha = $6*10^8$ = 60,000 tons = 600% increase in SOP usage.
From the above figures one wonders if the fertilizer industry should cooperate with local governments in the Near East region to encourage conversion from surface to drip irrigation and help farmers reach their production potentials. The governments in the N.E. region should also support fertigation research. The shift to drip irrigation / fertigation will definitely

save water, double the irrigated area and also provide environmental benefits, which are beyond the scope of this paper.

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