Food and Agriculture Organization
of the United Nations

Rice Irrigation in the Near East:
Current Situation and Prospects for Improvement

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Contents

1. Overview of Water Resources in the Near East Region

The Near East Region extends from the Atlantic Ocean (Mauritania and Morocco) in the west to Pakistan and Kyrgyzstan in the East, and from Turkey and Kyrgyzstan in the North to Somalia in the South[1]. The total population of the region was about 621 million in 2000 (around than 10% of the world), 52% of which rural. Over 41% of the population of the region is concentrated in Central Asia which occupies 21% of the total area.

While the area of the Near East Region represents 14% of the total area of the world, its water resources are less than 2% of the total renewable resources in the world. In addition, water is not equally distributed within the region; some countries have very limited water resources (Maghreb, North Eastern Africa and Arabian Peninsula), while others in the Middle East and Central Asia have higher quantities, thanks mostly to the abundant flows generated in the mountain areas of Turkey and the Himalayas (Table 1).

Because of the climatic conditions prevailing in the region, the Near East is the poorest in terms of water resources, globally and per inhabitant. The region average is less than 1500 m^3/inhabitant per year, in comparison with over 7200 m^3/inhabitant per year for the whole world. The problem of water shortage is a developmental issue, since it is seriously impeding economic growth in water scarce countries. Even countries that are quite advanced technologically are experiencing restraints on their future development. The twin phenomena of depletion of the existing water resources and their pollution is causing growing hardship in the area.

In the Near East Region, 91% of the total water use is directed towards agriculture. At the country level, the highest percentage is in Afghanistan with 99%. Central Asia (Iran and Pakistan) has the highest level of water use in agriculture with 95%. In this sub-region, 80% of the cultivated area is irrigated, as compared to 16% in the Maghreb. In absolute terms, Central Asia represents over 58% of the total water withdrawals in the Near East; with Pakistan alone accounting for 30%. At sub-regional level, the water withdrawal per inhabitant in Central Asia (1300 m^3/year) is on the average 3.6 times that in the Maghreb (360 m^3/year).

Rapidly expanding demand for food in the Near East is not matched by growth in agricultural production, with the main constraint on increases in farm output being water shortage. To guarantee food security, agricultural development efforts must focus on increasing the efficiency of water management systems and increasing water productivity - in other words, on getting "more crops per drop". Increase of the irrigated area and the loss of large quantities of water, through traditional methods of application have led to shortage of water and an alarming drop in groundwater levels. This trend is impacting productivity, increasing pumping costs and reducing farmers' income (FAO, 2002).

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[1] The countries covered by FAO Regional Office for the Near East are: Afghanistan, Algeria, Azerbaijan, Bahrain, Cyprus, Djibouti, Egypt, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Kyrgyz Republic, Lebanon, Libya, Malta, Mauritania, Morocco, Oman, Pakistan, Qatar, Kingdom of Saudi Arabia, Somalia, Sudan, Syria, Tajikistan, Tunisia, Turkey, Turkmenistan, United Arab Emirates, and Yemen.

Table 1: Water Resources in the Near East Region (Source: FAOSTAT 1997 and Review of World Water Resources by Country, 2003)

Country	Total Area (FAOSTAT) 1999	Total Population (FAOSTAT) 2000	Average Precipitation 1961-1990 (IPCC)	Internal Resources surface	Internal Resources groundwater	Internal Res. Overlap	Internal Res. Total	Ext. Res. Natura l	Ext. Res. actual	Total Res. natural	Total Res. actual	Dep. ratio	IRWR per capita	TRWR actual per capita
	Km^2	1 000 inhab.	km^3/year	km^3/year	km^3/year	km^3/year	km^3/year	km^3/year	km^3/year	km^3/year	km^3/year	%	m^3/year inhab	m^3/year inhab
Afghanistan	652 090	21 765	213.4	-	-	-	55.0	10.0	10.0	65.0	65.0	15.4	2 527	2 986
Algeria	2 381 740	30 291	211.5	13.2	1.7	1.0	13.9	0.4	0.4	14.3	14.3	2.9	459	473
Azerbaijan	86 600	8 041	38.7	6.0	6.5	4.4	8.1	22.2	22.2	30.3	30.3	73.2	1 009	3 765
Bahrain	690	640	0.1	0.004	0.0	0.0	0.004	0.11	0.11	0.12	0.1	96.6	6	181
Cyprus	9 250	784	4.6	0.6	0.4	0.2	0.8	0.0	0.0	0.8	0.8	0.0	995	995
Djibouti	23 200	632	5.1	0.3	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	475	475
Egypt	1 001 450	67 884	51.4	0.5	1.3	0.0	1.8	85.0	56.5	86.8	58.3	96.9	27	859
Iran	1 633 190	70 330	372.4	97.3	49.3	18.1	128.5	9.0	9.0	137.5	137.5	6.6	1 827	1 955
Iraq	438 320	22 946	94.7	34.0	1.2	0.0	35.2	61.2	40.2	96.4	75.4	53.3	1 534	3 287
Jordan	89 210	4 913	9.9	0.4	0.5	0.2	0.7	0.2	0.2	0.9	0.9	22.7	138	179
Kuwait	17 820	1 914	2.2	0.0	0.0	0.0	0.0	0.02	0.02	0.02	0.02	100.0	0	10
Kazakhstan	2 724 900	16 172	680.4	69.3	6.1	0.0	75.4	34.2	34.2	109.6	109.6	31.2	4 664	6 778
Kyrgyzstan	199 900	4 921	106.5	44.1	13.6	11.2	46.5	0.0	-25.9	46.5	20.6	0.0	9 439	4 182
Lebanon	10 400	3 496	6.9	4.1	3.2	2.5	4.8	0.04	-0.4	4.8	4.4	0.8	1 373	1 261
Libya	1 759 540	5 290	98.5	0.2	0.5	0.1	0.6	0.0	0.0	0.6	0.6	0.0	113	113
Malta	320	390	0.2	0.0	0.05	0.0	0.05	0.0	0.0	0.05	0.1	0.0	129	129
Mauritania	1 025 520	2 665	94.7	0.1	0.3	0.0	0.4	11.0	11.0	11.4	11.4	96.5	150	4 278
Morocco	446 550	29 878	154.7	22.0	10.0	3.0	29.0	0.0	0.0	29.0	29.0	0.0	971	971
Oman	212 460	2 538	26.6	0.9	1.0	0.9	1.0	0.0	0.0	1.0	1.0	0.0	388	388
Pakistan	796 100	141 256	393.3	47.4	55.0	50.0	52.4	181.4	170.3	233.8	222.7	76.5	371	1 576
Qatar	11 000	565	0.8	0.001	0.050	0.000	0.051	0.002	0.002	0.1	0.1	3.8	90	94
Saudi Arabia	2 149 690	20 346	126.8	2.2	2.2	2.0	2.4	0.0	0.0	2.4	2.4	0.0	118	118
Somalia	637 660	8 778	180.1	5.7	3.3	3.0	6.0	7.5	7.5	13.5	13.5	55.6	684	1 538
Sudan	2 505 810	31 095	1 043.7	28.0	7.0	5.0	30.0	119.0	34.5	149.0	64.5	76.9	965	2 074
Syria	185 180	16 189	46.7	4.8	4.2	2.0	7.0	39.1	19.3	46.1	26.3	80.3	432	1 622
Tajikistan	143 100	6 087	98.9	63.3	6.0	3.0	66.3	33.4	-50.3	99.7	16.0	16.7	10892	2 625
Tunisia	163 610	9 459	33.9	3.1	1.5	0.4	4.2	0.4	0.4	4.6	4.6	9.0	439	482
Turkey	774 820	66 668	459.5	186.0	69.0	28.0	227.0	4.7	2.3	231.7	229.3	1.0	3 405	3 439
Turkmenistan	488 100	4 737	78.7	1.0	0.4	0.0	1.4	59.5	23.4	60.9	24.7	97.1	287	5 218
U.A.Emirates	83 600	2 606	6.5	0.2	0.1	0.1	0.2	0.0	0.0	0.2	0.2	0.0	58	58
Yemen	527 970	18 349	88.3	4.0	1.5	1.4	4.1	0.0	0.0	4.1	4.1	0.0	223	223

Aggregation of data can only be done for internal renewable water resources and not the total renewable water resources, as that would result in double counting of shared water resources.

For some countries large discrepancies exists between national and IPCC data on rainfall average. In these cases, IPCC data were modified to ensure consistency with water resources data.

At present, many countries of the region have to rely on fossil and non-conventional waters to cover the gap in water resources. Extension of existing irrigation areas to cover food needs in these countries would depend essentially on improving water use efficiency of existing irrigation schemes, mobilization of existing available resources, if any, and the use of low-quality and non-conventional water resources.

2. Rice Production and Consumption in the Near East

Rice (Oryza sativa) is not only the staple food for nearly half of the world's population, but also a key source of employment and income for the rural people most of whom live in developing countries. The crop occupies one third of the world's total area planted by cereals and provides 35-60 percent of the calories consumed by 2.7 billion people (Guera et al., 1998). It is the most widely grown crop under irrigation. In 2002, 2.6% of the rice harvested area was located in the Near East Region (Table 2)

During the last decades, rice has seen consistent increases in demand and its growing importance is evident in the strategic food security planning policies of many countries. With the exception of a few countries in the Near East Region that have attained self-sufficiency in rice production, rice demand exceeds production and large quantities of rice are imported to meet demand at a huge cost in hard currency. In Egypt and Pakistan, rice is considered one of the potential export crops that can provide foreign exchange to the country. It also has an important socio economic impact since a large number of the labor force is employed in the rice sector. The inability to reach self-sufficiency in rice is the result of several major constraints but mainly water scarcity.

2.1 Rice Production

To cope with the world's rising rice consumption level, the world's rice production also expanded. Rice production has increased greatly since the 1960s. Globally, the amount of energy (kcal) supplied by rice has jumped from 411 kcal/capita in 1960 to 577 kcal/capita in 2002, corresponding to an increase of 40% (FAO, 2002_b). A breakdown by region shows that trends in dietary energy supplied by rice (kcal/capita/day) increased 90% in Sub-Saharan Africa and 28% in Asia and Latin America (FAOSTAT, 2001).

Rice is grown in 16 countries in the Near East Region, namely: Afghanistan, Algeria, Azerbaijan, Egypt, Iran, Iraq, Kazakhstan, Kyrgyzstan, Mauritania, Morocco, Pakistan, Somalia, Sudan, Tajikistan, Turkey and Turkmenistan (Table 2). FAO commissioned country case-studies on the irrigation of rice in Egypt, Iran, Morocco, Pakistan, and Turkey, to assess irrigation and water management of rice in these countries, which in 2002 represented 90% (3,453,717 ha) of the total harvested area in the region and produced 94% (14,474,780 tons) of the region's rice production. Pakistan, with 2.2 million ha of total harvested area (1.5% of the world's total harvested area) has 6,343,000 tons of produced rice. Rice production in Pakistan, Egypt and Iran, accounts for 92% of the region's rice production.

Annex (1) shows the evolution in the harvested areas, yields and total production in some of the rice-producing countries in the region over the past 42 years. It can be noticed that while in the countries affected by water scarcity the area has decreased drastically, in the others it has substantially increased. In Algeria for instance, the rice area has gone from 2090 ha in the early sixties to only 200 ha in the late 90s.In Kazakhstan, another water-deficit country, the area has gone from 117,000 ha in 1992 to less than 66,000 ha in 2002, whereas in Uzbekistan it went down from over 195,000 ha in 1995 to only around 60,000 in 2002. In Tajikistan, the area increased steadily between 1192 and 2000, and then decreased thereafter. In Afghanistan, Iraq and Somalia, the area has also decreased, probably because of conflicts, but also as a result of droughts and water shortage. The countries where the area increased are Azebaijan, Kyrjyzstan and Turkmenistan, but their respective areas are small in absolute terms. The countries where the area has grown substantially are Egypt, Iran, Mauritania and Pakistan, whereas in Turkey it remained stable over the last forty years.

Paddy output in the region has rebounded strongly since the year 2000 in the countries that were affected by drought in the late nineties, reflecting heavy precipitation that helped to reconstitute water reserves. This and other incentives to farmers are expected to boost rice production in the main rice producing countries. For instance in the Islamic Republic of Iran, attractive support prices are expected to stimulate an increase in the paddy area and improve the application of inputs, which could increase production by 4% in 2003. In Pakistan the forecasted production increase is 13%. In Egypt, the rice cropped area is subject to a ceiling set by the government because of constraints on water availability; however, it is generally not enforced and, as rice continues to be a profitable crop for producers, its production is forecast for the year 2003 at 6 million tons, similar to last season's record outcome (FAO, 2003). Rice production in the main rice-producing countries of the region is summarized below.

Egypt

Rice is one of the major field crops in Egypt. It occupies about 0.65 million hectares, produces approximately 6 million metric tons of rough rice annually (RRTC, 2002) and contributes about 20% to the per capita cereal consumption. The country has several production zones and ranks as one of the highest in the world in terms of productivity per unit area.

The rice area was stable during the eighties with over 400,000 ha, except in 1985 and 1988 where it declined to around 370,000 ha. Since 1990, it has significantly increased until it reached around 655,000 ha in 2000. The total increase from 1980 to 2000 is estimated at about 61% (RRTC, 2002). The expansion was due mainly to the removal of government regulations on crop choices by farmers since mid 1980's, the relative profitability of rice on local and international markets, the food security associated with rice as home-consumption crop, and the government support of rice prices relative to cotton, through import tariffs (Oad et al., 2001).

Table 2: Rice producing countries and production in Near East
(FAOSTAT Database, 2003)

Paddy Rice	Harvested Area (ha)		Yield (ton/ha)	Production (tons)	
	Mean (1961-2002)	2002	2002	Mean (1961-2002)	2002
Afghanistan	187,088	135,000	2.87	367,900	388,000
Algeria	805	200	1.50	2,361	300
Azerbaijan	2,469	3,407	4.88	10,063	16,640
Egypt	464,119	612,616	9.14	3,038,389	5,600,000
Iran	456,995	550,000	3.85	1,597,116	2,115,000
Iraq	78,199	100,000	0.90	187,996	90,000
Kazakhstan	85,039	65,733	3.03	260,591	199,089
Kyrgyzstan	4,798	6,008	3.17	10,797	19,029
Mauritania	7,581	16,975	4.00	27,741	67,900
Morocco	5,343	5,100	3.29	23,785	16,780
Pakistan	1,861,799	2,201,000	2.88	4,459,130	6,343,000
Somalia	2,258	2,500	1.60	5,775	4,000
Sudan	4,101	4,762	3.31	4,283	15,748
Tajikistan	13,728	10,000	2.90	35,475	29,000
Turkey	58,105	85,000	4.71	268,583	400,000
Turkmenistan	35,782	42,000	1.07	49,848	45,000
Total in Near East	**3,161,206**	**3,840,301**	**Mean: 4.00**	**10,071,217**	**15,349,486**
Total in the World	**140,300,516**	**147,144,157**	**Mean: 3.92**	**419,192,917**	**576,280,153**
Near East/World (%)	**2.25**	**2.61**	**-**	**2.40**	**2.66**

Generally speaking, there is limited potential for further increase of the rice area in Egypt. Because all area has to be irrigated and rice is a high water-consuming crop, supply of irrigation water is the most important limiting factor. A number of other factors, such as soil type, climate, also determine suitable areas. Economic factors, such as yield, cost, farm-gate price, and net return affect farmers' decision on whether to cultivate rice or not.

Iran

Rice is the second main crop consumed in Iran, after wheat. The production of paddy[2] rice in Iran is currently around 2,000,000 tons from a cropped area of 533,000 hectares, all of which irrigated. Production units are essentially small with 70% having less than one hectare. Yields from traditional rice genotypes are about 2-4 tons/hectare, in comparison with 5-7 tons for high yield genotypes. Some 75 genotypes are grown in the country. Iran's major rice producing region, within Gilan and Mazandaran provinces north of the country, is located between the Alborz Mountains and the Caspian Sea. This humid region accounts for 73% of the total amount of rice produced in the country, because of heavy rainfall that typically facilitates paddy cultivation and suitable soils. Increased production of rice in Iran stems from the existence of these conditions and increased land utilization, but also

[2] 100 kg of paddy rice yield 60 to 62 kg of milled rice, 20 kg of rice bran and the is waste.

from mechanization, use of chemical fertilizers and insecticides, improved seeds and the introduction of high yielding genotypes. The main factors preventing fundamental development of the agricultural sector, including rice production, are lack of water resource, soil conditions, mode of land ownership, seed quality, production technology and management.

Rice production season in Gilan and Mazandaran begins in May and the planting period lasts slightly more than 6 weeks. Harvest is from September to October, with some areas harvested in late October due to the cooler weather and less rainfall (Shariati, 2003).

Mauritania

Over 90% of the land area of Mauritania is desert and only less than 1% is capable of sustaining crops. The main cereal crops are millet and sorghum which accounted in 1999 for 83% of acreage and 43% of output of cereal crops. Paddy rice, which is grown exclusively on irrigated land, has expanded considerably in recent years. Presently it accounts for 52% of cereal output. Gorgol is the most important production zone in Mauritania with 54.3% of the total harvested area.

Evolution of the cultivated area and production of rice over the past 42 years is shown in Annex 1. Harvests vary considerably depending on rainfall and are subject to attacks by locusts and other pests.

Morocco

Rice production in Morocco began in 1949 with 65 ha and expanded to 7000 ha in 1955. It was destined mainly for exportation. The area dropped in 1956 to 2200 ha, before progressing again since 1972 because of increasing demand in the local market.

Rice production is concentrated in the Gharb region (northwest of the country) on flat heavy soils and is entirely mechanized. The growing season extends from May through November. The average grain yield for the period 1961–1993 varied from 2.5 to 5.9 tons/ha and the cultivated area from 600 ha to 8000 ha. The cropping of rice underwent several constraints which were technical (soil leveling, disease, and low rate of utilization of certified seeds), socio-economic (low rice consumption: 1kg/person/year) and climatic (mainly precipitations). Water availability is the most limiting factor. Low rainfall (450–530 mm) results in water storage in dams, thus limiting the increase of the rice area (Lage, 1997). Currently, the area reserved and equipped for this crop under large-scale irrigation is about 10700 ha, in addition to 1000 - 2000 ha irrigated by private pumping plants (Belabbes, 2003).

The average rice yield is around 4.8 t/ha, whereas average production in the last ten years was about 24,000 tons per year, with a maximum of 44,142 tons in 1993. Short grain rice genotypes are the most cropped in Morocco because of their resistance to diseases, in comparison with long grain genotypes. The latter are early-maturing and have good yielding ability but need good irrigation management and good land leveling.

Pakistan

Pakistan produced 0.69 million tons of rice in 1947, 1.09 million tons in 1962, 3.45 million tons in 1982 and 4.80 million tons in 2001, corresponding to average paddy yields of 0.877, 0.923, 1.742 and 2.021 tons/ha, respectively. Rice cultivation is concentrated mainly in Punjab (59.5%) but there are also other production areas (Ahmed, 2003).

Much of the growth in the irrigated area in Asia since 1980 has resulted from tube-wells. In Pakistan, the area irrigated strictly by canals declined in absolute terms from 1982 to 1995, while tube-well irrigation, either by itself or in conjunction with canals, increased, resulting in more than 100 percent of the growth in total irrigated area over this period. However, the increase in rice productivity in the late 90s was due to the introduction of short cycle genotypes, improved water management, the application of fertilizers and improved plant protection. The rice area in the country increased three-fold from around 0.8 million hectares to about 2.4 million hectares in the last 54 years (Ahmed, 2003).

Turkey

The rice cropped area in Turkey is around 59,000 ha, compared to 9,350,000 ha of wheat and 3,640,000 ha of Barley. The rice area ranged between 40,000 (1991) and more than 70,000 ha since 1961, depending on water availability and government policies. In 2002, it was 60,426 ha[3] in total distributed over 6 major rice-producing zones, of which the Marmara region alone accounted for approximately 62% of the country's total harvested area and produced nearly 50% of the country's total production (Beser, 2003).

Up till 1995, the annual total milled rice production ranged between 150,000 and 200,000 metric tons and was not sufficient for domestic consumption. The gap was covered by imports which reached 200,000 metric tons in 1992, corresponding to more than the total domestic production. Since then, Turkey's rice import continued to increase. Productivity also increased progressively until it reached 360,000 tons in 2001. In 2002, the harvest area was 85,000 ha and production 400,000 metric tons (Annex 1)

Sudan

The aggregate production of cereals in 1999/2000 in Sudan was estimated at 3.14 million tons, including small quantities of maize and rice. Rice is a minor but growing cereal crop with a harvested area that varied from a minimum of 500 ha 1989 to a maximum of 12,600 ha in 1980. The mean harvested area over the period 1961-2002 is just over 4000 ha, for a mean production of nearly 4300 tons (Annex 1). The yield remains one of the lowest in the world, with an average of only 1 ton/ha during the same period. The yield has not improved since the early sixties, except for 2002 where it reached a mean of 3.3 tons/ha. The forecasted rice imports to fill the production gap and cover the needs for 1999/2000 marketing year was estimated at 38,000 tons (FAO, 2002)

[3] The figure was 85,000 ha according to FAO (2003), for a total production of 0.4 million tons.

2.2 Consumption of Rice

Rice is one of the preferred foods by large segments of populations of most of the Near East countries and constitutes a high percentage of the per capita cereal consumption. The total consumption in Egypt in 1999 was estimated at about 2.6 million metric tons. In countries like Morocco and Turkey, rice consumption is very low. In Morocco, it is considered one of the lowest in the world (1.2 kg of rice per capita), which represents a major constraint to the development of rice production in the country. Table 3 shows rice consumption in some rice-producing countries in Near East countries.

Table 3: Rice consumption in selected rice-producing countries of the Near East

Country	**Rice consumption (kg/capita/yr)**
Afghanistan (1996)	19.1
Egypt (1999)	44.2
Iran (2002)	32.0
Morocco (2002)	1.2
Pakistan (1996)	26.1
Turkey (2002)	6-7

3. Rice Irrigation Management in the Near East

Over recent years, the scarcity and competition for water have been increasing worldwide and opportunities for developing new water resources for irrigation became more and more limited. Within agriculture, rice is the dominant irrigated crop, accounting for approximately 30% of the total irrigated area. Over half of the rice area in the world is irrigated. It is the abundant water environment in which rice grows that best differentiates it from all other important crops.

With water becoming increasingly scarce, the future of rice production will therefore depend heavily on developing and adopting strategies and practices that will use water efficiency in irrigation schemes. While this situation applies to many parts of the world, it is particularly crucial for the Near East region where water is among the most limiting factors for development in general and agriculture in particular.

3.1 Rice Irrigation Systems and Practices

Flooding/Basin irrigation is the most common practice for irrigating rice; it is sometimes referred to as paddies or paddy basins. Basin irrigation is favored in moderate to slow-intake soils and deep-rooted, closely spaced crops. The method is also useful when leaching is required to remove salts from the soil profile. It enables conservation of rainfall and reduction in soil erosion by retaining a large part of the rain in the basin to be infiltrated gradually, without loss due to surface runoff. It results in high water application and distribution efficiencies if the desired net depth of irrigation can be estimated adequately and if the size of the irrigation stream is measured properly.

Paddy rice is best grown on clayey soils which are almost impermeable to reduce percolation losses. Rice could also be grown on sandy soils but percolation losses are high unless a shallow water table can be maintained. Such conditions sometimes occur in valley bottoms. Loamy soils are preferred with basin irrigation to avoid waterlogging (permanent saturation of the soil).

Precision land leveling is very important for achieving high water application uniformity and irrigation efficiency with this method. However, when basins are too small, precision equipment for land leveling cannot work effectively. The perimeter dykes need to be well maintained to eliminate breaching and waste, and must be higher for basins than for other surface irrigation methods. To reach maximum levels of efficiency, water inflow per unit width must be as high as possible without causing erosion of the soil.

There are two methods for supplying irrigation water to basins: the direct method and the cascade method (FAO, 1988):

- The direct method: Irrigation water is led directly from the field channel into the basin through siphons, spiles or bundbreaks.
- The cascade method: On sloping land, where terraces are used, the irrigation water is supplied to the highest terrace, and then allowed to flow to a lower terrace and so on. This is a good method to use for paddy rice on clay soils where percolation and seepage losses are low. When long cascades are used for growing rice, it is common practice to allow water to flow continuously into the terraces at low discharge rates. The water demand in the cascade can easily be monitored by observing the drainage flow. If there is no drainage then more water may be required at the top of the cascade. If there is a drainage flow then it is possible to reduce the inflow.

The practices used in the different selected rice-producing countries in the region are described briefly hereafter.

Egypt

Agriculture in Egypt is entirely dependent on irrigation since the mean annual rainfall is only 18 mm, ranging from 0 mm in the desert to about 200 mm in the northern coastal region. With the exception of some aquifers, the Nile River is the sole source of assured water supply for approximately 3.3 million ha of fertile agricultural land, intensively cultivated by crops including cotton, rice and sugarcane in summer. The cropped area in 1995 was over 6 million ha, corresponding to a cropping intensity of 180%.

Basin is the sole common system used for watering rice in Egypt. The method involves dividing a field into small units, so that each unit has a nearly level surface. It is therefore most suited to flat land. Small banks (levees, bunds, ridges or dykes) of earth 30 to 50 cm high are constructed around the area forming the basin, with inlet and outlet controls for water. The basin is filled with water to within about 5-cm depth and the water is retained until it infiltrates into the soil, or the excess is drained off. Basins may be of any size from one square meter to several hectares (Ibrahim, 2003).

The three main types of land tenure systems prevailing in the rice-producing area are owned land, cash rented land, and sharecropping. Owned land accounts for about 68% of the total tenure arrangements and about 75% of the total rice area. Fragmentation is an important feature characterizing the agricultural land holdings in Egypt. About 91% of the holders have less than 2.1 hectares (5 feddans) each and they hold about 52.5% of the total agricultural area. As a result, the majority of rice producers in Egypt are small farmers. Moreover, each holding consists of more than one plot of land (RRTC, 2002).

Iran

Basins of different dimensions are the adopted systems for irrigation rice in Iran. Irrigation is based on a continuous and rotational flooding throughout the growth period so that soil reaches saturation limits, except during harvesting when flooding stops. At the irrigation network level, water is distributed approximately every 4 days on a rotational basis. The depth of water applied each time ranges between 5 and 8 cm.

Under the most advanced management, water depth is adjusted to various growth stages, with high values in the early crop stages and reduced ones in the middle of the growth season, then back to higher levels during flowering, followed by reduced levels at harvest. Other application methods consist of continuous flow with a designated depth (Shariati, 2003).

The experience of using pressurized irrigation systems for irrigating rice in Iran resulted in lower yields and increased costs of production.

Mauritania

Agriculture in Mauritania is concentrated in the Valley of the Senegal River and in the valley of the Gorgol River. Rice is the only crop that can be grown under irrigation on the saline soils of the Senegal River Delta. Surface irrigation is the main irrigation technique used. All these areas are partly irrigated each year mainly through pumping and gravity from the river. In the majority of cases, the small family holdings practice at the same time with irrigated agriculture, flood recession cropping and rainfed agriculture.

Morocco

Rice irrigation in Morocco is through continuous flow basins with gravity supply systems. In large-scale irrigation rice districts, the size of these basins is between 2 and 2.5 hectares. In private districts their size is about 1 hectare.

Rice areas are organized into irrigation sectors. A sector has an area of 2000 - 3000 ha, which is usually dominated by a secondary irrigation canal. A sector is organized into irrigation blocks. Each rice block is delimited by an irrigation tertiary canal on one side and a tertiary open channel drainage canal on the other side. These tertiary canals are earth ditches. In rice sectors, the flow rate (or module) delivered to one farmer is about 45 l/s. This module is usually allocated to an irrigation block where it rotates between the basins of a given block. A tertiary canal usually supplies several blocks (up to 200 ha).

The main advantage of this irrigation system is the large size of the basin (2–2.5 ha), which is one of the largest in the world, that requires maintenance of land leveling and a high flow rate of water supply (45 l/s) to ensure good irrigation efficiency. The main disadvantage is collective water management which requires good organization between farmers. In large irrigation systems, farmers tend to have lower water use efficiency than those in the private districts.

Pakistan

The Indus Basin irrigation system for rice is characterized by a continuous-flow and fixed rotation. Local varieties of rice are grown under floodwater diversion or in humid areas where rainfall is sufficient for growth of rice crops. Three major practices are used for rice irrigation in Pakistan:

- <u>Irrigation of Puddled Fields</u>: Wet plowing (locally called Puddling) helps to reduce seepage losses and provides an environment conducive to the production of rice. Farmers in the Punjab province are practicing it as a part of the production technology. They also use it as a guide for leveling their fields. The process of puddling has been mechanized after the introduction of tractors in the country. Puddling wheels are now attached with tractors. There is no disadvantage of puddling for rice but it disturbs the soil structure, which is a limitation for wheat and other crops.

- <u>Puncho System</u>: Rice is grown under flooded conditions and irrigation water is allowed to flow form one field to the next. The disadvantage of this system is that water is wasted and drainage surplus is increased, which ultimately results in rising groundwater table. The waterlogging in the Sindh province is a major problem affecting productivity of the rice based cropping system. The recent drought and shortage of canal supplies have improved the situation of waterlogging in the Indus basin as the lowering of water table was observed throughout the country. The Indus basin covers more than 566 000 km^2 (or 71% of the territory), comprising the whole of the provinces of the Punjab, Sindh and NWFP and the Eastern part of Balochistan.

- <u>Ponding of Water</u>: Water ponding is practiced both under puddle fields and the Puncho Systems. Research experiments have shown that rice fields are not precisely leveled and thus over-irrigation is needed to maintain the minimum depth of ponded water. Furthermore, ponding is not essential as rice crop can be grown under saturated conditions if, weed control is practiced using weedicides. The recent drought has forced farmers to apply deficit irrigation, which allowed farmers to observe its effects on weed growth, yield, and soil salinization (Ahmed, 2003).

Turkey

In Turkey, irrigation water for rice is from rivers, groundwater and dams, but pumping is only for 5% of the total. Most of the soils in the major rice production areas are sandy-clay. During the rice growing season, flooding on a rotational basis is the main watering method. Part of the water that enters the paddy fields is lost to drainage canals from paddy fields, which explains high values of water use by rice.

In the Marmara Region where 62% of the total rice area is found, the water application method is continuous flooding with a depth of 10-20 cm. The Meric River is the main source for rice irrigation in the Edirne Province. There are also dams and groundwater systems in the Tarkya region. If rainfall is not enough, water is pumped from the Meric River to the dams during winter sessions (Beşer, 2003).

In the Black sea region, rice growers use the Kizihrmak river water for irrigating rice, by pumping water directly into their fields. There are also small dams and rivers and underground water sources used for irrigation.

3.2 Irrigation Performance

As explained above, rice is grown essentially under continuous flow basin irrigation in the Near East. With this system, the water needs are not just evapotranspiration but include also the additional water losses caused by the permanent presence of water in the rice fields. These losses result from downward and lateral percolation as well as from runoff from the flooded fields. The water requirements of rice depend on factors associated to climate, the crop, the soil and the way irrigation is managed; but in general the amounts actually applied by farmers exceed these requirements.

In Asia, research has shown that the average water requirements of rice are around 17000 m^3/ha including soil preparation. In the Philippines and Malaysia, to satisfy both evapotranspiration and infiltration, 12000 to 15000 m^3/ha of water are necessary. In Japan, total rice needs in water between planting and harvesting have been estimated to be between 8000 and 14000 m^3/ha, excluding water use for rice nurseries. In China, the total needs of 8640 to 12800 m^3/ha have been reported. In the United States, 9000 to 25000 m^3/ha of water are used through the rice season in California while 4500 to 9000 m^3/ha are sufficient in Louisiana. Differences in soils and climatic conditions, as well as in on-farm water management practices, explain this important variability.

The Near East Region is also subject to the same variability of water requirements. Several research activities have been carried out under field conditions and proved that rice water consumption changes according to soils conditions and irrigation methods. But it is generally agreed that an abundant and well managed supply of good quality irrigation water is needed for optimum rice production.

For rice water management, practices which minimize irrigation inflow are of a direct interest to farmers. Water saving practices play an important role in total rice productivity by increasing water use/irrigation efficiency and also improving water productivity. When implemented properly, they lead to yield increases (up to 20% for intermittent flooding and other methods). The acceptance by farmers of these practices will of course depend on economic factors (Klemm, 1998).

Since irrigation efficiency and water productivity should be used in conjunction to establish water management strategies and practices to produce more rice with less water, water productivity should also be increased by increasing yield per unit land area; for instance by using better genotypes and improved agronomic practices or by growing the crop during the most suitable period. In addition, in order to increase the efficiency of a domain of interest – be it at the level of the farm, the irrigation network or the basin - it is important to identify losses and minimize them.

The following section discusses water requirements of rice, irrigation management and irrigation efficiency in selected rice-producing countries of the Near East.

Egypt

When irrigation water is available, Egypt has one of the most favorable climates for rice production. With the rice area being fully irrigated, there are no real problems of drought or flooding. The only adverse problem is soil salinity and occasional alkalinity that, to varying degrees, affect about 30% of the rice area. Other problems are limited micronutrient availability, particularly that of zinc.

Under the current practices in Egypt, an average depth of 1,900 mm is normally applied to rice, an amount much higher than for other crops such as cotton (1,380 mm) and maize (1,000 mm). Water for rice irrigation is provided to farmers on a rotation basis consisting of 4 days "on" and 6 days "off". The normal duration of the rice water rotation is from May 1 to October 15.

The replacement of traditional rice varieties with short season genotypes (Giza 177, Sakha 101, Sakha 102) demonstrated potential water saving of 13.9% (305 mm), which is significant. A study was conducted in two branch canals of Kafr El Sheikh Governorate where a farmer cultivated the short- season genotype and the other the traditional one. Results showed that water delivered to the standard canal (long-season rice) equaled 2,190 mm while water delivered to the demonstration canal (short-term rice) equaled 1,885 mm (Omara et al., 2000). The study also found that the consumptive use of rice is about 1,120 mm, which, compared to a water delivery of 2,190 mm, means a system irrigation efficiency of only about 51%. This level of efficiency is very low and indicates a high potential for water conservation through better management at the farm and branch canal levels.

The low irrigation efficiency can be attributed to the fact that, as previously mentioned, throughout most of the growing season extending from May to October, rice fields are submerged under standing water layers of variable depths. The irrigation process reflects the intense need of rice for water diversions. Exposed to temperature in the range of 30 to 40^{o}C, rice field ponds are subject to excessive evapotranspiration in addition to percolation which result in significant rates of water loss. Almost 50% of the amount of water diverted to rice fields is consumed in terms of evapotranspiration and the rest is lost via percolation.

Iran

The estimated net water requirements for rice, based on climatic conditions in Iran, vary between 7000 and 19000 cubic meters per hectare. Table 4 shows the net water requirements estimates using FAO CROPWAT for different rice regions (Shariati, 2003).

Table 4: Estimated water requirements of rice for different regions of Iran

Province	Net Water Requirements (m^3/ha)
Mazandaran	7300-8870
Gilan	7020-7200
Fars	12660-15670
Khuzestan	10360-19180
Golestan	1030-12580
Esfahan	15230-16530

Suitable areas for rice cultivation, primarily in northern Iran bordering the Caspian Sea, including Gilan, Mazandaran, Gorgan and Gonbad, have lower requirements; whereas in the southern and central areas, the requirements are much higher. In addition, soil texture and quality in the Northern provinces result in lower wastage of water through percolation compared to the other provinces, which results in significant differences in water efficiency. Generally speaking, in most northern areas of the country, cultivation of rice in the traditional manner is more suitable and results in a more satisfactory performance, simply because this area is one of the most water abundant regions in Iran. The annual surface runoff in this region is estimated to be 16.8 billion m^3 and the usable groundwater supply is estimated to be 5.3 billion m^3 per year. The average annual rainfall in the region amounts to 63 billion m^3 out of which 43 billion m^3 return to the atmosphere through evapotranspiration (Shariati, 2003)

In Iran, land size and shape range from very small to large plots and about 70 percent of the cultivation is small and non-mechanized, with traditional management, leading to a wide range of investments and productivity. This is also reflected in the income of producers. The average cultivation area is between 0.5 and 5 hectares. From the economical standpoint, mechanization is feasible for plot of two to three hectares, but not applicable for smaller land areas where higher labor requirements and production costs constitute real constrains.

The irrigation efficiency for rice is only about 30-35% and the major water losses consist of wastes in transfer and distribution channels at the farm level, inappropriate application depths and uneven distribution within fields; in addition to some macro and micro policies related to production strategies and water allocation. In the most advanced systems, water depth is adjusted at various growth stages, from higher in the early crop growth stages to reduced water levels in the middle of the growth season, then back to higher levels during flowering and reduced levels at harvest. Special attention is paid to weed control, soil preparation, proper distribution of pesticides and fertilizers and proper harvesting methods (Shariati, 2003).

One of the main problems of rice cultivation and production is the lack of water resources, especially during periods of low rainfall. Irrigation dominates water use in Iran, and surface water storage has been increased through the construction of numerous multi-purpose dams and reservoirs along rivers flowing from the Zagros and Alborz mountains. Despite the abundance of water in this region, the drought of recent years has affected rice production significantly. The 1999/2000 drought wave damaged 24 percent of the rice areas (Shariati 2003).

Morocco

In Morocco, Coeytaux (1956) and Ringuelet (1954) estimated rice water needs at repectively 11000 and 12700 m^3/ha. Bouhache (1981) evaluated them to between 17000 and 22000 m^3/ha. The Gharb ORMVA[4] in 1976 fixed these needs to 17400 m^3/ha and was charging farmers (water tariffs0 based on this volume. Jing (1986) from a Chinese technical mission to the Gharb ORMVA during 1986-1988, estimated rice water needs to be between 10000 and 15000 m^3/ha (ORMVAG, 1988).

Planting is in general with pre-germinated grains sown in watered fields between 15 April and 15 June. Harvesting starts in September and extends to late October.

The monitoring of water delivery in several districts of 300-1800 ha, by means of flumes and flow meters, showed that water consumption at the district scale varies between 15000 and 23000 m^3/ha. Considering an average water use at the field level of 10934 m^3/ha, the conveyance and distribution efficiency was estimated at 47-70%, with an average of 60%, depending mainly on the district size (Clemmens et al., 1987, cited by Belabbes, 2003).

Research carried out during 1993, 1994 and 1996, with the objectives of assessing irrigation management at the field level and evaluating the global efficiency of water conveyance and distribution systems in rice districts, revealed an average of the total water use at the field level of 10934 m^3/ha $\pm$1220, out of which evapotranspiration represents 61,5 % (6720 m^3/ha), deep percolation losses 20,3 % (2220 m^3/ha) and total water supply for flushing and bringing the soil profile to saturation during the first flooding 18.2 % (1990 m^3/ha) (Belabbes et al., 1995, Laiti & Gnenye, 1994).

A wide variability of irrigation management practices at the field level takes place in Morocco. In general, rice is grown with continuous submergence combined with short periods of draining. Intermittent flushes are used in some case. Three different irrigation regimes are identified (Belabbes, 2003):

- Three replenishments of the field, two complete drains and several flushes (28% of the farmers).
- Three replenishments and two complete drains of the field (42% of farmers).
- Two replenishments and one complete drain (30% of the farmers).

The differences between regimes are due to several factors the most important of which is land leveling and water availability. Farmers have to retrieve water to ovoid damaging the small plants that are under water. Siltation in the tertiary canal is also a parameter and farmers at the tail of water delivery systems have less water available so they proceed with a minimum of replenishment and flushing. Finally, a good level of farmers' organization within the tertiary canal helps in achieving a good irrigation of the entire district.

Out of the three irrigation regimes mentioned above, the second is the most satisfactory (Belabbes, 1997). It consists of continuous flooding with two short

[4] Office Regional de Mise en Valeur Agricole or Regional Office for Agricultural Development and Management is an autonomous public entity in charge of agricultural development and management in large-scale irrigated schemes.

periods of complete draining of the basin, the first one after sowing (with pre-germinated grains) and the second at the tillering stage. The different irrigation regimes were tested with regard to water use efficiency (WUE) improvement. The tests showed that WUE can be improved by up to 5.85 kg paddy rice/mm/ha, through better irrigation management in a well leveled land (Belabbes, 1997).

Soil and climatic conditions of the Gharb plain make it a convenient region for rice production. Water availability in the region, downstream of the Sebou river watershed, complements the potential for rice irrigation, especially with the newly built, largest dam of the country. According to the initial irrigation project of the Gharb plain, the potential rice production area was estimated at 24000 ha or more, i.e. twice the area covered at present. However, rice production development is constrained by marketing and commercializing the production. Water shortage resulting from competition between sectors and within the watershed is also pushing the government to review its policy regarding the production of rice.

Pakistan

The net water requirements for rice in Pakistan vary from 1000 to 1300 mm in the sub-humid to arid areas. With an application efficiency of about 75%, gross water requirement vary from 1300 to 1700 mm. In addition to this, the seepage requirement over the rice-growing season is around 30% i.e. 400-550 mm. Therefore, gross irrigation requirements (including seepage) range from 1700 to 2250 mm. Evaporation losses are higher during the initial stages of growth due to the lack of full effective cover. Irrigation application losses are due to unleveled fields and low application efficiency (Ahmad, 1980).

Irrigation efficiency of the Indus Basin irrigated agriculture has been described in segments covering canals, watercourses, field channels and field application sub-systems. The research studies conducted during the last three decades assessed basin-wide efficiency values for these various sub-systems (WAPDA, 1979; PARC-FAO, 1981; Ahmad and Khan, 1990; Ahmad et al. 2001a, 2001b). The acceptable efficiency figures of these sub-systems at the basin-wide level were found to be as described below.

- Basin-wide canal conveyance efficiency is around 75% covering main canals, branch canals, distributaries and minor canals.
- Watercourse conveyance efficiency of the "*Sarkari Khal*" is around 70%. This value is assumed against the overall conveyance efficiency of 60%, accepted both for the watercourse and field channels.
- Field channel conveyance efficiency is around 90% for farm level channels used for both canal and tubewell supplies. Length of farm channels is a function of farm size and normally small compared to watercourses. Thus higher efficiency is assumed for the basin. However, for larger farms, this efficiency is relatively lower.
- Field application efficiency is around 75% covering application and uniformity losses within the field.

For estimating the overall irrigation efficiency of the Indus basin, efficiency values of the four sub-systems can be multiplied using the relationship provided by Ahmad (1991 and 1999). The resulting overall irrigation efficiency at the basin level is around 36%, which is low since 64% of the water is lost before crops consumptively use it (Ahmed, 2003).

Water losses at the farm level are due to unleveled fields and low field application efficiency. There is a potential for improvement by introducing laser leveling and applying water so as to meet crop water requirement. Farmers should reduce the depth of water applied if a desired level of herbicide application is maintained to control weeds. Irrigation practices can also be improved to avoid excessive irrigation by improving puddling or planting on beds. The present use of broad-beds to raise rice crop, where rice is planted on beds and irrigation is through furrows, helps to save 30% of water without any significant decline in crop yield.

Turkey

Net rice water requirements as estimated using the Blaney-Criddle method were found to range between 810 mm and 1625mm in the different rice growing areas of Turkey (Özgenç and Erdoğan, 1988). It is about 1050 mm for Edirne, about 810 mm for Çorum, 1080 mm for Balıkesir and 1300 mm for Diyarbakır. Research carried out in the field revealed that rice water consumption changes according to soil conditions and irrigation methods (Beser, 2003). Moreover, actual water use was found to be higher than the estimated values. Generally, the amounts allocated to irrigation channels are twice the estimated net requirements to account for losses and improper water usage, drainage from paddy fields, etc. Laser leveling reduces water consumption but more water can be saved using intermittent irrigation instead of continuous flooding (Beser, 2003).

In some areas of Turkey, the following practice is applied to better manage water for rice irrigation. Paddy fields are flooded with standing water according to rice plant height. Early in the growth period, the applied water depth is low, and then it is increased gradually with plant height until it reaches 15 cm. When standing water drains and water depth reduces to about 5 cm, additional water is applied. Flooding of paddy fields is done every 7-10 days, depending on soil conditions. Most rice fields have clay soils and allow the use of this suitable water management system.

4. Rice Irrigation Major Constraints

Several water and irrigation-related constraints face the production of rice in the Near East region. Water availability and its management constitute the primary elements that determine success of rice production.

The irrigation efficiency of rice remains generally too low in most rice producing countries of the region. From the consumptive standpoint, it normally takes around 1000-1200 liters of water to produce one kilogram of rice. In practice however and considering the yields achieved, the figure is in the range of 4,000-5,000 liters of water per kilogram of rice. Field level assessments show the current level of efficiency to be 35% or less and can reach 70% or more when drained water is recycled. The potential for improving irrigation efficiency of the existing rice schemes remain very high and constitute an important potential for saving large amounts of water. Even when water is still available, the costs of putting additional land under irrigation and of rehabilitating existing large-scale irrigation schemes are high. It is therefore important to put more emphasis on improving water use efficiency in rice production systems, through the use of appropriate water control and management technology, combined with genetic improvements.

The argument for improving water crop productivity is also justified by water scarcity in many rice producing countries. Competition for water, both between and within sectors, is constraining crop production and jeopardizing food security in these countries where the only available option is to have “more crop per drop” of water used. The scarcity of surface water resources is leading more and more farmers to rely on groundwater for irrigation to produce crops, including rice. At times, the aquifers are not used in a balanced manner which results in their depletion. Fossil groundwater is also used in some countries such as Egypt to produce high water consuming rice.

Poor drainage in rice fields is leading to several environment degradation problems that reduce the production potential of both land and water resources. This includes waterlogging, salinity, toxicity and water pollution by various sources. Poor drainage stems from inappropriate development of irrigation schemes and from their bad management. The social and economic situation of farmers also contributes to the problem. Arid areas are prone to salinization because of the prevailing climatic and soil conditions. Drainage, when combined with adequate irrigation management, allows for the leaching of excess salts. Using saline groundwater for irrigation also results in increasing soil salinity. Most of the countries in the Near East region are facing these problems.

Under the climatic conditions of the Near East region, irrigation water reaches at times temperature values which are not compatible for rice. This problem is faced in Mauritania, Turkey and Pakistan, and is likely to apply to other countries as well. Temperature of irrigation water is important, since crop productivity depends on it to a great extent. It may be too low early in the season or too high late in the season for maximum emergence of rice sown in water. Germination is retarded when water temperature is below 20 °C and roots develop poorly when it is above 30°c, perhaps because of the low oxygen content of warm water.

The opportunity to grow rice or other crops should also be looked at by policy-makers and farmers, both from the standpoint of water availability and allocation and that of economic return. Rice competes with several other important staple crops such as maize, sorghum and millet. In areas where rice is not adapted to the ecology, its yield is often low in comparison with that of other crops; yet farmers continue to practice it for reasons such as satisfying their household food needs. In Sudan for instance, due to the high water demand and the risk of spreading water weeds, farmers started to exclude rice from their rotations (Abdalla et al., 2001)

There are urgent applied research needs for improving efficiency in rice irrigation systems which include methods of accounting for water use and productivity, the economics of water productivity, improved irrigation management, and other important aspects. Advances in genotypic research may lead to rice genotypes that are more resistant to drought and water stress than the current ones. There are already promising hopes with genotypes of dry rice that can grow without continuous flooding conditions. The results of such research could also benefit rice grown under rainfed conditions. Most of present rice genotypes do not have an adequate level of resistance to drought and water stress.

5. Recommendations for Improvement

The issues related to water availability and distribution will be increasingly crucial globally in the coming years. The impact of greater water scarcity on agriculture will be manifested prominently in the rice production sector. It is therefore important to determine how to grow more rice with less water.

Rice, in the 16 rice-producing countries in the Near East Region, is one of the main staple foods and contributes to food security, with varying levels from one country to another. At the same time, it is also among the largest water consuming crops. The irrigation of rice is still traditional and results in the loss of very large amounts of water, with all the consequences and negative impacts on the environment and production potential. These countries will have to make key decisions regarding water allocation and the crops to be practiced, within their strategies to face water shortage. When maintaining this crop is justified, adequate water management is the key for raising its productivity per unit of water. Within the framework of their agriculture and water resource development and management strategies, rice producing countries will need to focus on achieving optimum water productivity, through the introduction of improved technologies and applied research.

Developing improved rice genotypes: through the cultivation of short cycle, high yielding genotypes instead of the traditional ones. The introduction of genotypes/varieties with tolerance to drought, salinity and cold temperature can increase further productivity. *In Egypt* for instance, potential water saving induced by the use of short-season rice is in the order of 305 mm (13%) in comparison with long-season rice. The new genotypes such as Giza 177 and Sakha 101 can save about 10 to 15% of the irrigation water, which corresponds to 1.4 billion m^3 a year. *In Pakistan*, the short duration genotypes, especially Basmati rice, have a yield potential of 30 to 50% higher than the other varieties, for the same amounts of water. *In Morocco*, short grain rice genotypes (Elio) are the most cropped in the Gharb region because of their resistance to diseases (84%), which results in higher productivity per unit of water use.

Efficient rice irrigation management: through a wide range of actions and practices such as shortening irrigation intervals and lowering the applied depths, accompanied with good soil leveling. Land preparation in most rice-producing countries currently lasts for more than a month and accounts for as much as one-third of the water diverted. Reducing the duration and amount of the water used for this operation offers an avenue for important water savings. This might require the use of more field channels and some changes in land preparations. *In Egypt*, irrigation at 4-day intervals resulted in higher yields compared with 6- and 8-day intervals, with corresponding yields of 5.26, 4.72 and 3.92 t/ha, respectively (Zayed, 1997). In addition, it was demonstrated that decreasing the irrigation depth from 75 mm to 50 mm, along with the cultivation of short rice genotypes, could result in saving more than 3570 m^3/ha or 2.4 billion m^3 at the national level.

Improvement of on-farm management: Another option for saving important amounts of water in rice irrigation is through the improvement of water use efficiency at the farm level. Field observations indicate that water losses due to seepage, percolation and surface runoff are high in irrigated rice. Laser land leveling is a relatively new technique that offers a potential for significant increases in water use efficiency. It should be widely tested with the contribution of experienced farmers who could lead its generalization through transfer of technologies and good practices. With unleveled fields, much water is needed to cover the highest parts, which leads to important losses. *In Pakistan*, the techniques of puddling helps to reduce seepage losses and provides and environment conducive for the production of rice. *In Morocco*, studies have proved that the water use efficiency an be improved up to 5.85 kg paddy rice/mm/ha by means of good irrigation management on leveled land. *In Egypt*, the Ministry of Agriculture and Land Reclamation (MALR) is supporting the implementation of subsidized laser techniques as a good tool for land leveling.

Adoption of Water Conservation and Distributions Practices:

1. The introduction of furrow-bed irrigation systems in rice-wheat cropping systems helps to reduce irrigation water requirements by reducing seepage losses. Rice can be grown without flooding so long as moisture stress is avoided. The key to water management in furrow-irrigated rice is to maintain moist soils through frequent irrigation or rainfall. Furrow irrigation avoids flooding the entire field surface by channeling the flow along the primary direction of the field using 'furrows'. Most furrow-irrigated rice fields require 2 to 5 cm of water every three to four days during peak evapotranspiration periods (July and August) and four to eight days in May, June and September. Total water use has been found to be approximately half for furrow-irrigated rice compared to flooded rice. *In Pakistan*, broad beds are now being used to raise rice crop, where rice is planted on beds and irrigation is through furrows. This has helped in saving 30% of water without any significant decline in crop yields.

2. Adopting the Alternate Wet/Dry Irrigation (AWDI). This method of irrigating rice implies that the fields are not kept continuously submerged but are intermittently dried during the rice growing stages. This method can increase the productivity of water at the field level by reducing seepage and percolation during growth period.

3. Adopting a water-efficient method of rice establishment, by using direct seeding, under both wet seeding rice (WSR) and dry seeding rice (DSR). In WSR, pre-germinated seeds are broadcast on saturated and usually puddled soil where land preparation time is very short. DRS consists of sowing non germinated seeds on dry or moist but not puddled soil. *In Pakistan*, direct seeding of rice experiments were conducted but farmers could not adopt this practice mainly due to the shortage of water since farmers reduce the growing season length under transplanted rice conditions and very little amount of water is needed to raise nursery for a period of up to 20 days.

Diversification of crop production: In most irrigation systems, rice monoculture is the dominant practice. It is desirable as it opens opportunities for increasing farmers' income from their limited land resources, when profits from rice culture are very low and declining. A diversified agriculture will be more sustainable in the long run. Present rice culture systems require more water than most other food crops in terms of food and calories produced. There is scope for increasing returns from water by growing diversified crops, especially in areas of water shortage. Farmers should be provided with facilities to exercise crop choice options, which is presently lacking in several systems.

Water distribution strategies: Using water distribution strategies, including rotational water distribution systems, can reduce the amounts of water applied by farmers.

When water is allocated proportionally to the area served, it results in an inadequate water distribution. But in a rotational water distribution, water is provided in turns to the different sections of the main or lateral canals. This enhances water efficiency and productivity as it reduces runoff from the head-end areas and increases yields of tail-ends farms. Another familiar problem is that farmers at the head of the lateral receive ample water, while those at the tail receive too little. Even distribution of water should be guaranteed because when water supply within the irrigation system is unreliable, farmers try to store much more water in the field than needed as insurance against possible shortages in the future. In traditional transplanted rice, farmers prefer to maintain a relatively high depth of water in order to control weeds and reduce the frequency of irrigation. Percolation rate increases as the depth of water standing in the field increases, and hence losses increase. In Egypt, the Ministry of Water Resources and Irrigation (MWRI) has encouraged the water rotation during rice growing season to be 4 days "on" and six days "off" instead of the traditional water rotation of six days "on" and twelve days "off".

Making more effective use of rainfall: Water storage systems have expanded rapidly in the last century, making it possible to increase the area irrigated in the dry season. Water releases from reservoirs must be managed carefully in the wet season to take full advantage of the rainfall and to reduce irrigation inflow requirements. This will consequently reduce seepage and percolation losses. However, farmers should coordinate among themselves in order to adjust their planting schedules. It is desirable to change irrigation schedules during rainy periods to use rainfall more effectively. Developing and adopting new irrigation schedules for preparing land using early season rainfall could make it possible to conserve water in reservoirs, allowing more opportunity for increasing the irrigated area during the dry season.

Upgrading Farmers' awareness: More attention should be directed towards upgrading awareness, among farmers and the public at large, on the importance of water. A particular focus should be on Water Users' Associations (WUA), water media and NGOs that deal with water use in agriculture. Farmers' organization must also be expanded, as this arrangement can be used as a vehicle for improving irrigation and productivity of rice. These organizations must be encouraged and their capacity should be enhanced so that they can undertake work, such as watercourse improvement and precision land leveling, leading ultimately towards the provision of all water and non-water inputs and marketing of the produce. There is also a need for strengthening the managerial capacity of farmers and cooperation between them. Studies have proven that without addressing the managerial capacity of farmers, it is unlikely that increasing the control potential of an irrigation system will lead to improved performance

Country Policy on Water Resources: There is a need to address the issue of water pricing for canal water supplies, electricity tariff and diesel fuel prices. Balancing of price is needed to add value to the pumped and canal water, so that farmers can start effective and efficient use of water. Subsidized water does not encourage its saving by farmers. There is also a need for rationalization of water rates for canal water supplies so that these are charged to some extent on the volume of water use between rice and other crops.

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Annex 1

Evolution of Harvested Area and Yield of Rice in the Near East Region during the period 1961-2002 (FAOSTAT, 2003).

Afghanistan

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)	*Year*	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1961	210,000	1.52	318990	**1981**	174,000	2.24	390004
1962	210,000	1.52	318990	**1982**	165,500	2.20	364001
1963	210,000	1.52	318990	**1983**	155,000	2.26	350006
1964	220,000	1.73	380006	**1984**	149,000	2.24	333998
1965	220,000	1.73	380006	**1985**	141,000	2.25	316996
1966	222,000	1.52	336996	**1986**	150,000	2.24	336000
1967	206,000	1.92	395994	**1987**	162,000	2.00	324000
1968	206,000	1.95	402009	**1988**	180,000	1.91	343008
1969	206,000	1.98	406994	**1989**	170,000	1.88	320008
1970	202,000	1.81	366004	**1990**	175,000	1.90	333008
1971	200,000	1.75	350000	**1991**	173,000	1.94	334997
1972	210,000	1.90	400008	**1992**	175,000	1.71	300003
1973	210,000	2.00	420000	**1993**	175,000	1.71	300003
1974	210,000	2.00	420000	**1994**	180,000	1.90	342000
1975	210,000	2.07	434994	**1995**	170,000	2.29	389997
1976	210,000	2.13	447993	**1996**	175,000	1.94	340008
1977	210,000	1.90	400008	**1997**	180,000	2.22	399996
1978	210,000	2.04	428001	**1998**	180,000	2.50	450000
1979	206,000	2.13	439007	**1999**	140,000	2.00	280000
1980	191,000	2.17	415005	**2002**	135,000	2.87	388004
				MEAN	**187,088**	**1.99**	**371912**

Algeria

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)	*Year*	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1961	2,090	4.55	9512	**1982**	420	2.86	1200
1962	2,000	4.00	8000	**1983**	450	2.67	1200
1963	1,512	4.40	6659	**1984**	450	2.67	1200
1964	1,310	3.83	5014	**1985**	450	2.67	1200
1965	1,900	2.91	5530	**1986**	460	2.70	1240
1966	1,920	2.89	5550	**1987**	480	2.71	1300
1967	1,710	2.67	4558	**1988**	530	2.79	1480
1968	1,950	3.13	6110	**1989**	530	2.79	1480
1969	1,970	3.41	6711	**1990**	550	2.80	1540
1970	1,370	1.58	2166	**1991**	560	2.68	1500
1971	670	2.34	1568	**1992**	570	2.63	1500
1972	1,070	2.07	2218	**1993**	570	2.63	1500
1973	1,220	2.01	2447	**1994**	570	2.63	1500
1974	1,020	2.47	2520	**1995**	570	2.63	1500
1975	580	2.76	1600	**1996**	600	2.50	1500
1976	500	2.56	1279	**1997**	200	1.50	300
1977	570	2.47	1409	**1998**	200	1.50	300
1978	260	1.12	291	**1999**	200	1.50	300
1979	400	2.50	1000	**2000**	200	1.50	300
1980	420	2.86	1200	**2001**	200	1.50	300
1981	420	2.86	1200	**2002**	200	1.50	300
				MEAN	**805**	**2.59**	**2084**

Azerbaijan

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1992	1,000	0.60	600
1993	1,000	1.10	1100
1994	1,000	1.00	1000
1995	2,000	1.88	3750
1996	2,186	3.87	8468
1997	2,343	4.62	10825
1998	2,416	4.80	11608
1999	3,574	4.48	15998
2000	4,450	5.02	22336
2001	3,787	4.85	18365
2002	3,407	4.88	16640
MEAN	**2,469**	**3.37**	**8328**

Egypt

Year	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)	*Year*	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)
1961	226	1.14	5.05	**1982**	431	2.44	5.67
1962	349	2.04	5.84	**1983**	423	2.44	5.77
1963	403	2.22	5.51	**1984**	414	2.24	5.41
1964	404	2.04	5.04	**1985**	389	2.31	5.95
1965	356	1.79	5.03	**1986**	423	2.45	5.77
1966	355	1.68	4.73	**1987**	413	2.41	5.83
1967	452	2.28	5.04	**1988**	352	2.13	6.06
1968	507	2.59	5.11	**1989**	413	2.68	6.48
1969	502	2.56	5.1	**1990**	436	3.17	7.27
1970	480	2.6	5.43	**1991**	462	3.45	7.46
1971	478	2.53	5.3	**1992**	511	3.91	7.65
1972	481	2.51	5.21	**1993**	539	4.16	7.72
1973	419	2.27	5.43	**1994**	579	4.58	7.91
1974	442	2.24	5.07	**1995**	589	4.79	8.14
1975	442	2.42	5.48	**1996**	590	4.9	8.29
1976	453	2.3	5.08	**1997**	651	5.48	8.42
1977	437	2.27	5.2	**1998**	518	4.47	8.64
1978	435	2.35	5.41	**1999**	655	5.82	8.88
1979	439	2.51	5.72	**2000**	659	6	9.1
1980	408	2.38	5.83	**2001**	563	5.23	9.28
1981	402	2.24	5.57	**2002**	613	5.6	9.14
				MEAN	464	2.94	6.33

Iran

Year	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)	*Year*	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)
1961	280	0.6	2.14	**1982**	483	1.61	3.32
1962	300	0.85	2.84	**1983**	429	1.22	2.83
1963	300	0.86	2.87	**1984**	442	1.48	3.36
1964	322	0.92	2.87	**1985**	479	1.78	3.71
1965	360	1.02	2.84	**1986**	471	1.78	3.79
1966	429	1.1	2.56	**1987**	527	1.8	3.42
1967	343	0.96	2.8	**1988**	467	1.42	3.04
1968	358	0.98	2.74	**1989**	519	1.85	3.57
1969	364	1.02	2.8	**1990**	524	1.98	3.78
1970	378	1.06	2.79	**1991**	582	2.36	4.05
1971	344	1.05	3.04	**1992**	596	2.36	3.96
1972	377	1.2	3.18	**1993**	588	2.28	3.88
1973	434	1.33	3.07	**1994**	563	2.26	4.01
1974	436	1.31	3.01	**1995**	566	2.3	4.07
1975	461	1.43	3.1	**1996**	600	2.68	4.47
1976	413	1.57	3.79	**1997**	563	2.35	4.17
1977	404	1.4	3.47	**1998**	615	2.77	4.51
1978	386	1.53	3.95	**1999**	587	2.35	4
1979	381	1.25	3.27	**2000**	534	1.97	3.69
1980	462	1.31	2.84	**2001**	515	1.99	3.87
1981	459	1.62	3.54	**2002**	550	2.12	3.85
				MEAN	457	1.55	3.4

Iraq

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)	*Year*	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1961	25,000	2.74	68453	**1982**	57,625	2.84	163401
1962	40,000	2.83	113100	**1983**	48,900	2.26	110499
1963	55,000	2.60	143215	**1984**	39,150	2.78	108700
1964	65,000	2.84	184353	**1985**	52,525	2.83	148898
1965	65,000	2.75	178432	**1986**	50,200	2.81	141198
1966	65,000	2.80	182085	**1987**	70,000	2.80	195902
1967	103,000	3.06	314923	**1988**	50,475	2.79	140598
1968	109,000	3.24	353498	**1989**	72,750	3.19	231803
1969	106,000	3.00	318000	**1990**	79,200	2.89	228801
1970	75,000	2.40	180203	**1991**	85,925	2.20	189104
1971	109,075	2.81	306697	**1992**	95,000	1.89	179997
1972	94,000	2.85	268003	**1993**	110,000	1.87	205997
1973	63,960	2.45	156619	**1994**	163,000	2.35	383001
1974	31,415	2.21	69289	**1995**	175,000	1.80	315000
1975	29,880	2.03	60540	**1996**	120,000	2.25	270000
1976	52,407	3.12	163358	**1997**	121,000	2.02	243997
1977	63,485	3.14	199241	**1998**	128,000	2.34	300006
1978	54,717	3.14	171997	**1999**	130,000	1.38	179998
1979	58,700	2.69	157797	**2000**	60,000	1.00	60000
1980	55,450	3.01	166899	**2001**	100,000	0.90	90000
1981	54,500	2.98	162197	**2002**	100,000	0.90	90000
				MEAN	**78,199**	**2.49**	**195060**

Kazakhstan

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1992	117,000	3.99	467006
1993	109,300	3.69	403000
1994	104,300	2.71	282997
1995	84,100	2.19	184448
1996	86,500	2.62	226241
1997	82,800	3.08	255347
1998	73,400	3.22	236069
1999	71,000	2.81	199297
2000	72,100	2.97	214303
2001	69,200	2.87	198701
2002	65,733	3.03	199092
MEAN	**85,039**	**3.02**	**256512**

Kyrgyzstan

Year	Harvested Area (ha	Yield (ton/ha)	Production (tons)
1992	1,900	1.84	3500
1993	2,500	1.08	2700
1994	3,000	1.43	4300
1995	4,500	1.49	6700
1996	5,400	1.70	9200
1997	6,100	1.92	11700
1998	5,500	2.00	11023
1999	6,100	2.47	15066
2000	6,229	3.05	18991
2001	5,545	2.99	16557
2002	6,008	3.17	19029
MEAN	**4,798**	**2.10**	**10094**

Mauritania

Year	Area Harv (Ha)	Yield (ton/ha)	Production (tons)	*Year*	Area Harv (ha)	Yield (ton/ha)	Production (tons)
1961	300	1.67	500	**1982**	4,000	5.00	20000
1962	300	1.67	500	**1983**	4,100	5.37	22000
1963	350	1.71	600	**1984**	4,553	4.39	20000
1964	350	2.00	700	**1985**	5,000	5.00	25000
1965	350	1.86	650	**1986**	6,600	5.00	33000
1966	350	2.00	700	**1987**	11,290	4.69	52900
1967	300	1.33	400	**1988**	12,230	4.17	50949
1968	738	0.70	514	**1989**	13,650	4.03	55067
1969	612	0.81	497	**1990**	15,551	3.33	51796
1970	1,098	1.25	1370	**1991**	14,818	2.81	41679
1971	1,500	0.91	1370	**1992**	12,721	3.99	50719
1972	2,000	1.25	2500	**1993**	19,758	3.29	64925
1973	815	3.68	3000	**1994**	16,570	2.74	45400
1974	1,000	3.00	3000	**1995**	13,418	3.94	52813
1975	1,036	3.71	3840	**1996**	17,425	3.83	66748
1976	1,187	3.34	3960	**1997**	21,765	3.72	80942
1977	1,600	2.25	3600	**1998**	25,100	4.06	101901
1978	1,700	1.94	3300	**1999**	21,790	2.38	51878
1979	2,670	3.48	9300	**2000**	17,983	4.24	76199
1980	3,377	3.20	10800	**2001**	18,000	3.73	67216
1981	3,489	4.30	15000	**2002**	16,975	4.00	67900
				MEAN	**7,581**	**3.09**	**23420**

Morocco

Year	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)	*Year*	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)
1961	5	0.015	3	**1982**	1	0.004	3.64
1962	5	0.017	3.4	**1983**	2	0.004	2.34
1963	4	0.020	5	**1984**	2	0.005	2.52
1964	5	0.025	5	**1985**	0.6	0.002	2.88
1965	5	0.021	4.2	**1986**	5	0.020	4.55
1966	6	0.025	4.51	**1987**	9	0.049	5.5
1967	5	0.028	5.09	**1988**	8	0.033	4.45
1968	8	0.041	5.26	**1989**	0.7	0.004	6.3
1969	9	0.051	5.8	**1990**	0.8	0.003	4.18
1970	8	0.040	5	**1991**	6	0.025	3.84
1971	1	0.003	2.7	**1992**	7	0.022	3.07
1972	3	0.014	4.48	**1993**	11	0.054	5
1973	3	0.010	3.87	**1994**	11	0.070	6.5
1974	4	0.012	3.22	**1995**	0.7	0.003	4.96
1975	6	0.029	4.71	**1996**	9	0.053	5.8
1976	5	0.018	3.39	**1997**	9	0.032	3.73
1977	6	0.024	3.84	**1998**	4	0.020	5.51
1978	9	0.022	2.44	**1999**	8	0.035	4.56
1979	6	0.019	3.22	**2000**	6	0.025	4.5
1980	6	0.029	4.87	**2001**	8	0.037	4.9
1981	5	0.019	3.72	**2002**	5	0.017	3.29
				MEAN	5	0.023	4.26

Pakistan

Year	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)	*Year*	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)
1961	1,214	1.69	1.39	**1982**	1,978	5.17	2.61
1962	1,186	1.64	1.39	**1983**	1,999	5.01	2.51
1963	1,286	1.79	1.39	**1984**	1,999	4.97	2.49
1964	1,356	2.03	1.49	**1985**	1,863	4.38	2.35
1965	1,393	1.97	1.42	**1986**	2,066	5.23	2.53
1966	1,410	2.05	1.45	**1987**	1,963	4.86	2.48
1967	1,420	2.25	1.58	**1988**	2,042	4.8	2.35
1968	1,555	3.05	1.96	**1989**	2,107	4.83	2.29
1969	1,622	3.6	2.22	**1990**	2,113	4.89	2.32
1970	1,503	3.3	2.19	**1991**	2,097	4.86	2.32
1971	1,456	3.39	2.33	**1992**	1,973	4.67	2.37
1972	1,480	3.5	2.36	**1993**	2,187	5.99	2.74
1973	1,512	3.68	2.44	**1994**	2,125	5.17	2.43
1974	1,604	3.47	2.16	**1995**	2,162	5.95	2.75
1975	1,710	3.93	2.3	**1996**	2,251	6.46	2.87
1976	1,749	4.11	2.35	**1997**	2,317	6.5	2.8
1977	1,899	4.42	2.33	**1998**	2,424	7.01	2.89
1978	2,026	4.91	2.42	**1999**	2,515	7.73	3.07
1979	2,035	4.82	2.37	**2000**	2,377	7.2	3.03
1980	1,933	4.68	2.42	**2001**	2,114	5.82	2.75
1981	1,976	5.14	2.6	**2002**	2,201	6.34	2.88
				MEAN	1,862	4.32	2.32

Somalia

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)	*Year*	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1970	350	2.86	1000	**1987**	3,600	3.33	12000
1971	500	2.80	1400	**1988**	5,000	2.40	12000
1972	870	2.99	2600	**1989**	6,500	3.03	19700
1973	550	2.91	1600	**1990**	5,000	3.00	15000
1974	570	2.98	1700	**1991**	4,000	2.50	10000
1975	1,600	2.06	3300	**1992**	4,000	3.75	15000
1976	1,800	2.00	3600	**1993**	2,000	2.50	5000
1977	4,400	1.82	8000	**1994**	1,100	1.50	1650
1978	9,800	1.16	11400	**1995**	1,200	1.67	2000
1979	4,800	2.58	12400	**1996**	1,200	1.67	2000
1980	5,900	2.73	16100	**1997**	1,200	1.67	2000
1981	5,700	3.42	19500	**1998**	1,200	1.67	2000
1982	6,000	3.17	19000	**1999**	1,400	1.43	2000
1983	1,000	3.90	3900	**2000**	1,500	1.33	2000
1984	1,300	3.23	4200	**2001**	2,500	1.60	4000
1985	2,600	4.08	10600	**2002**	2,500	1.60	4000
1986	3,200	3.72	11900	**MEAN**	**2,258**	**1.98**	**4465**

Sudan

Year	Area Harv (ha)	Yield (ton/ha)	Production (tons)	*Year*	Area Harv (ha)	Yield (ton/ha)	Production (tons)
1961	1,370	1.41	1931	**1982**	8,000	0.50	4000
1962	535	1.77	949	**1983**	2,520	0.99	2500
1963	1,024	1.06	1082	**1984**	2,100	0.95	2000
1964	1,890	0.51	963	**1985**	1,800	1.06	1900
1965	1,295	0.86	1120	**1986**	1,500	1.07	1600
1966	469	0.84	394	**1987**	1,200	1.00	1200
1967	2,339	0.76	1785	**1988**	1,200	1.00	1200
1968	1,615	0.60	975	**1989**	500	1.00	500
1969	3,314	0.88	2905	**1990**	800	1.25	1000
1970	5,123	1.19	6098	**1991**	800	1.38	1100
1971	5,041	1.19	6000	**1992**	1,300	0.92	1200
1972	5,041	0.99	5000	**1993**	1,600	0.94	1500
1973	5,461	1.10	6000	**1994**	2,000	0.83	1650
1974	6,179	1.17	7200	**1995**	1,630	0.74	1200
1975	7,244	0.99	7184	**1996**	2,940	0.68	2000
1976	9,452	1.27	12000	**1997**	2,940	0.68	2000
1977	11,762	1.11	13001	**1998**	3,780	0.53	2000
1978	8,400	0.95	8000	**1999**	9,240	1.19	11000
1979	10,000	0.80	8000	**2000**	5,460	1.28	7000
1980	12,600	0.63	8000	**2001**	5,500	1.27	7000
1981	10,500	1.14	12000	**2002**	4,762	3.31	15748
				MEAN	**4,101**	**1.04**	**4275**

Tajikistan

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1992	10,000	2.02	20184
1993	12,400	1.83	22699
1994	13,000	1.54	20001
1995	12,000	2.01	24089
1996	12,000	1.73	20722
1997	15,000	2.94	44162
1998	15,000	2.69	40289
1999	17,464	2.71	47326
2000	19,920	4.12	81979
2001	14,225	2.80	39777
2002	10,000	2.90	29000
MEAN	**13,728**	**2.48**	**34037**

Turkey

Year	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)	*Year*	Area Harv (1000*ha)	Production (million tons)	Yield (ton/ha)
1961	59	0.23	3.95	**1982**	77	0.35	4.52
1962	81	0.28	3.4	**1983**	70	0.32	4.5
1963	55	0.22	3.94	**1984**	64	0.28	4.38
1964	35	0.17	4.76	**1985**	60	0.27	4.52
1965	50	0.22	4.33	**1986**	55	0.28	5
1966	65	0.25	3.85	**1987**	53	0.28	5.19
1967	60	0.23	3.89	**1988**	51	0.26	5.15
1968	45	0.21	4.56	**1989**	66	0.33	5
1969	57	0.21	3.74	**1990**	46	0.23	4.96
1970	66	0.27	4.04	**1991**	40	0.2	4.95
1971	65	0.29	4.49	**1992**	43	0.22	5
1972	51	0.2	3.99	**1993**	45	0.22	5.02
1973	60	0.27	4.45	**1994**	41	0.2	4.94
1974	58	0.25	4.31	**1995**	50	0.2	4
1975	55	0.25	4.57	**1996**	55	0.28	5.1
1976	54	0.26	4.88	**1997**	55	0.28	5
1977	58	0.28	4.75	**1998**	60	0.32	5.25
1978	70	0.32	4.52	**1999**	65	0.34	5.23
1979	75	0.38	5	**2000**	58	0.35	6.03
1980	52	0.24	4.58	**2001**	59	0.36	6.1
1981	73	0.33	4.54	**2002**	85	0.4	4.71
				MEAN	58	0.27	4.64

Turkmenistan

Year	Harvested Area (ha)	Yield (ton/ha)	Production (tons)
1992	28,000	2.28	63823
1993	38,600	2.27	87800
1994	37,000	2.49	92001
1995	29,000	2.71	78599
1996	32,000	1.28	40800
1997	32,000	0.84	26899
1998	20,000	0.69	13700
1999	30,000	1.11	33300
2000	70,000	0.39	27300
2001	35,000	1.12	39099
2002	42,000	1.07	44999
MEAN	**35,782**	**1.48**	**52829**

Uzbekistan

Year	Harvested Area (ha	Yield (ton/ha)	Production (tons)
1992	182,020	2.96	538907
1993	180,700	3.01	544594
1994	167,000	2.98	498295
1995	165,900	1.97	327603
1996	185,000	2.43	449994
1997	195,300	1.99	388803
1998	148,400	2.33	346306
1999	164,200	2.56	420795
2000	124,900	1.24	154801
2001	55,000	1.23	67799
2002	59,900	2.39	143101
MEAN	**148,029**	**2.28**	**337965**